The Ownership of Data*

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Abstract

We study the effect of property rights over the use of data on market outcomes. For this, we consider a model in which a website offers a service to a set of heterogeneous users and usage generates valuable data but data extraction entails a privacy cost to users. When data extraction is contractible, the trade-off between data monetization and privacy restricts the share of users for which data is indeed monetized. When data extraction is not contractible, both the firm and users prefer the users (the firm) to own the rights for low (high) values of data. We then extend our analysis in allowing the rights to be traded ex-post and discuss how this impacts both efficiency and rent sharing.

KEYWORDS: Ownership, information revelation, data, imperfect competition

JEL CLASSIFICATION: D82, D83, D86, L12, L19, L49

1 INTRODUCTION

The rise of the internet has been accompanied by a heated debate on how data should be used and controlled. Nowadays, large firms specialise in collecting, processing and re-selling personal data to firms that operate in various markets. From an economic viewpoint, one of the most fundamental questions is whether and how property rights should be defined over the use of personal data. This question is particularly interesting given the special characteristics of personal data. For instance, who should own the property

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rights over the collection and distribution of data, firms or consumers? How should one regulate the data industry?

This question has been largely debated among policy makers, particularly in Europe. The regulation of data management rests on two pillars (see Duch-Brown, Martens, and Mueller-Langer (2017)). First, the Database Directive (1996) that gives full protection to an original database that is the result of a creative human effort. Note that this protection does not apply to the content but to the structure (as with copyrights). Furthermore, since most databases are generated by machines, it is hard to acquire a clear viewpoint on how this is implementable. Second, the recent General Data Protection Regulation (GDPR), building on the Data Protection Directive (1995), does not allow the creation of a full market for rights, based on the idea that these rights are not tradable (privacy is viewed as a basic human right). Nonetheless, the GDPR defines rights that are tradable as, for instance, the need for informed consent, the right to access and extract data, the right to be forgotten, and some duties for data holders and controllers. At a first sight, the GDPR seems to prevent any processing of data without the consent of the individual who generated this data. In reality, it does not prevent firms to process data since Article 6 opens the door for a very subjective assessment of the lawfulness of processing.[1] Moreover, the GDPR applies to personal data defined as "*any information relating to an identified or identifiable natural person*". In various cases, it is rather unclear what is "personal" and "non-personal". Furthermore, anonymized datasets can potentially be de-anonymised. In short, the GDPR puts considerable constraints on collection, aggregation and processing of data by firms although it does not prevent the questioning regarding the consequences of a clearer and more precise allocation of rights over data.

To study questions like those above, we develop a simple two-period model in which a monopolistic firm (website) interacts with a set of heterogeneous consumers (users). The website offers a service and sets subscription fees that users need to pay before acquiring access to the service. The fees consumers pay depend on their usage and a user's type determines the fee-intensity combination that she prefers. Key in our analysis is that usage in the first period generates data that can be potentially exploited in the second

[1] Article 6 states, among others, that processing of data is lawful if "... *is necessary for the purposes of the legitimate interests pursued by the controller or by a third party, except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data, in particular where the data subject is a child.*".

period. We model this through a single parameter that allows a stark characterisation of the effect of changes in the value of data on market outcomes. Although data generates value that can be monetised, the collection and process of data entails a privacy cost to users. We define property rights as the ability to control the amount of data collected and processed.

As a benchmark, we suppose that any data collected and processed is contractible. This implies that each user selects a contract that specifies the combination of usage, data to be collected and monetised by the firm, and subscription fee. We show that users with low willingness to pay for the service opt for low usage, have low privacy cost and are more willing to have their data collected and monetised by the firm. Contrastingly, users with high willingness to pay for the service opt for high usage, have high privacy cost and are reluctant to allow the firm to collect and monetise their data. This result can be better understood by analysing the fundamental trade-off faced by the firm. The firm can either foster usage but restrict the processing and monetisation of data or limit usage and rely on the processing and monetisation of data. For high types the firm prefers to foster usage; for low types it prefers to rely on data monetisation.

We then assume that data collection and processing is not contractible. In such world, property rights matter. We assume that the party that owns the rights is unable to commit ex-ante to an ex-post level of data extraction and monetisation. If the firm owns the rights, nothing prevents it from collecting and processing the data of all users which deters users to opt for high usage; if the users own the rights, and conditionally on being unable to directly monetise any generated data, they dissent any data collection and hence opt for high usage. We show that the regime in which consumers own the rights is optimal when the value of data is low whereas the regime in which the firm owns the rights is optimal when the value of data is high. The intuition is that, when the firm owns the rights, users rationally anticipate that any information generated in the first period will be exploited by the website in the second period. As a consequence, they opt for low usage, a distortion that is independent of the value of data. We establish that the higher the value of data, the lower the subscription fee set by the website and the larger the users' base (i.e., more users subscribe to the website). For relatively low values of data, both the website and the users prefer consumers to own the data. Because the firm does not experience large gains by monetising the data but users suffer the cost of privacy, the cost of distorted usage offsets the value of data and both the firm and users prefer the latter to own the rights. For relatively high values of data, the firm is willing to compensate the users to opt for high usage. In this case, the decrease in the subscription fees alongside the increased value of data offset the cost of privacy of users and both the firm and users prefer the firm to own the rights.

We then extend the analysis to allow for a market for rights. This means that, when the firm owns the rights, it can sell these to the users in which case the former is incapable of collecting and monetising data. When the users have the rights, they can sell these to the firm in which case the latter can process and monetise any data generated by their usage. We assume that the market for rights opens ex post, that is, it opens after the generation of data. We further assume that the firm proposes a single price at which trade of rights occurs.

In either regime, we derive the optimal price for data and characterise the set of types who trade. We show that when the firm owns the rights, low types do not trade and hence opt for low usage, whereas high types trade and opt for high usage. For low (high) values of data, the cut-off type who trades is higher (lower) than the cut-off type who prefers her data being processed in the benchmark case. Both the firm and users benefit when a market for rights exists relative to the case in which a market does not exist. When the users own the rights, low types trade and hence opt for low usage whereas high types do not trade and hence opt for high usage. For sufficiently low values of data, no trade occurs. When the value of data is intermediate, two possible usage schedules exist: low usage and high usage. In some cases, bunching of types in the optimal usage schedule arises in which a set of intermediate types opts for the same amount of usage.

We find that, when trade of rights is permitted, the regime in which consumers own the rights is optimal when the value of data is low. This is because, when the value of data is low and consumers own the rights there is no trade whereas when the firm owns the rights some trade occurs but this does not offset the loss in welfare due to the decrease in usage due to the privacy cost. When the value of data is high, the regime in which the firm owns the rights is optimal. For, although some trade of rights occurs even in the regime in which consumers own the rights, this mostly concerns the low types and does not offset the loss in the welfare of high types when the firm does not own the rights. Hence, we conclude that even when trade of rights is permitted, welfare increases but the main trade-off between the two regimes remains.

☐ **Related Literature.** Our work is first related to the literature on property rights. Following Coase (1960) or more formally Dasgupta, Hammond, and Maskin (1979), it is well known that with full contracting possibilities, ownership rights do not matter. This leads us to introduce some contractual incompleteness - in our case the inability to commit ex-ante on the degree of data extraction and monetization - to have a meaningful comparison between different property rights regimes. Now also that, as in Grossman and Hart (1986), the ownership rights will be defined as residual rights.

Our contribution is also linked to the literature on privacy, albeit imperfectly. Hermalin and Katz (2006) links privacy and the right to compel information revelation or conceal information and shows that, with complete contracting, the outcome is the same in both cases. In a model of monopoly price discrimination, the authors show that more or less privacy may benefit or hurt consumers. Note that in this approach, there is only one market whereas we have two separate markets since the information revealed in the first one is used in the second. In this sense, this approach is related to the literature on dynamics pricing on the Internet (see Acquisti (2006)).

Jones and Tonetti (2018) emphasized the non-rivalry aspect of Data and the gains under consumers' control.

At last, there are some connections between our setting and the standard two-sided market approach (see Rochet and Tirole (2003), and Armstrong (2006)). Indeed, the model is similar to a platform model where we focus on the analysis of one side. Still, we can see how the pricing strategy changes on one side - number of users, price for the service - when the money one can make increases on the other side.

The next section of the paper presents our model. Section 3 analyzes the case of full contractibility on data extraction. In Section 4, the two regimes of property rights, firm's rights, and user's right are compared. In Section 5, we introduced the possibility of rights transferability whereas Section 6 concludes.

2 The Model

■ **Agents.** We consider a bilateral relationship between a firm (a *website*) and a unit mass of consumers (the *users*). The firm provides a service and users each decide on their consumption level q, where $q \geq 0$. One can think of q as the time a user spends on the website; hence, for future convenience, we refer to q as *usage* and assume throughout that this is verifiable by a court of law and hence contractible. Crucial in what follows is that users have different valuations over usage. In particular, the gross utility of a user from usage q is given by

$$u(\theta, q) = \theta q - q^2/2 \tag{1}$$

where θ denotes the type of the user. We assume that θ is distributed in $[0, \bar{\theta}]$, where $\bar{\theta} > 0$, according to the cumulative distribution function $F(\theta)$ that has full support and is twice continuously differentiable with $f(\theta) = F'(\theta)$ and $0 < f(\theta) < \infty$ for every θ. Let

$$h(\theta) \equiv (1 - F(\theta))/f(\theta)$$

denote the *inverse hazard rate*; to make the problem well-behaved, we impose the following standard assumption[2]

Assumption 1. *$h(\theta)$ is decreasing in θ and $F(\theta)/f(\theta)$ is increasing in θ.*

Unless otherwise stated, it is assumed that θ is a user's private information and that the outside option of every user is zero.

□ **Data-Extraction: Costs and Benefits.** A specific feature of our analysis is that usage in one period generates valuable information that can be exploited in subsequent periods. For instance, in a dynamic framework, the way agents interact in one period affects their behavior in subsequent periods as it has been highlighted in several articles.[3] Such potential dynamics have been at the center of recent discussions on the economics of the internet.[4] In this paper, we assume that the interaction between the firm and a user creates potential informational value that depends on the data that is extracted, denoted by $e \in [0, 1]$. The net informational value that is generated from data extraction e is given by

$$b(e, \theta) = \alpha e q(\theta) \tag{2}$$

where $\alpha > 0$ measures the importance of the market for data relative to the market for the service provided by the firm. This can further depend on the competition on the market

[2] A distribution that satisfies this assumption is the uniform distribution over $[0, \bar{\theta}]$. To sharpen intuition, we fully characterise the solution of the model for this distribution.

[3] See for instance the literature on dynamic pricing (e.g., Fudenberg and Tirole (2000)) or rachet effects (e.g., Freixas, Guesnerie, and Tirole (1985)).

[4] See for instance Fudenberg and Villas-Boas (2012).

for data, that is the extent to which the information generated by the service is substitute to or complement with other forms of information owned by other firms.

Athough data extraction creates value, it is costly for users who value their privacy.[5] We assume that when a user makes usage q and a share e of data is extracted, the user suffers a disutility equal to

$$c(e, q) = eq^2 \tag{3}$$

This multiplicative form expresses the idea that the cost that consumers incur from data extraction depends both on their actions (q) and on how these actions are transformed into valuable information (e). Moreover, the complementarity between usage intensity and data extraction presumes that a user with higher usage has a higher marginal cost of data extraction.

3 Contractible Data Extraction

We consider two benchmarks in either of which data extraction is contractible. In the first benchmark, the type of a user is known to the firm; in the second benchmark, the type of a user is her private information. Note that due to the assumption of contractible usage, if data extraction is also contractible, the contract offered by the firm is a standard complete contract. Under asymmetric information such a contract entails the usual rent-extraction/efficiency trade-off as we show below.

■ **Symmetric Information Benchmark.** We start by assuming that the firm observes the type of a user. In this case, the firm can exercise perfect (i.e., first-degree) price discrimination and extract the entire surplus from every type. Profit maximisation entails that for every θ usage is found as the solution to the following maximisation programme

$$\max_{(q,e)\in\mathbb{R}_+\times[0,1]} \theta q - q^2/2 - eq^2 + \alpha eq$$

This programme is linear in e, hence, at the optimum, either the firm chooses to extract all the data $(e = 1)$ or no data at all $(e = 0)$. The optimal usage schedule and the associated welfare is summarised in the following proposition.

[5]Sources of this cost include among others, the potential disutility from advertisement (e.g., Becker and Murphy (1993)) or price discrimination (e.g., Acquisti and Varian (2005)).

Proposition 1. *Under symmetric information and complete contracting, the firm offers to type θ usage $q^*(\theta) = (\alpha + \theta)/3$ with full data extraction for $\theta < \theta^*$ or usage $q^*(\theta) = \theta$ and with no data extraction for $\theta \geq \theta^*$, where*

$$\theta^* \equiv \alpha/(\sqrt{3} - 1) \tag{4}$$

The associated welfare (i.e., profit) is $W^*(\theta) = (\theta + \alpha)^2/6$ for $\theta < \theta^*$ and $W^*(\theta) = \theta^2/2$ for $\theta \geq \theta^*$.

Note that within this framework, the firm faces a trade-off between extracting no data but maximising usage and raising the price for its service, or extracting all the data but decreasing usage due to the privacy cost. For high-value consumers higher usage is preferred to data extraction; for low-value consumers the opposite holds. Note also that, the higher the value of information (measured by α), the higher the share of consumers for whom the firm extracts data (θ^* increases). Needless to say, the usage schedule characterised above corresponds to the socially efficient usage schedule in every Pareto efficient allocation.[6]

One last remark deserves discussion. Consider the transfer of type $\theta < \theta^*$ to the firm

$$t^*(\theta) = (\theta^2 - \alpha^2)/6$$

To the extent that $\theta < \alpha$, this transfer is clearly strictly negative which implies that low-value users are subsidised by the firm to join the website simply because the latter can generate profits from using their data.[7]

□ **Asymmetric Information Benchmark.** We now consider the more realistic case according to which a user's type is her private information. The firm can offer different contracts that condition the price paid to usage and data extraction. Due to the Revelation Principle, it is without loss of generality to focus on direct revelation mechanisms in which users report their type to the mechanism and a pre-defined price-usage-extraction triplet is implemented.[8] Let $(t(\theta), q(\theta), e(\theta))_\theta$ denote the mechanism offered to users; then, the indirect utility of type θ by truthfully announcing her type is given by

$$U(\theta) = \theta q(\theta) - (q(\theta))^2/2 - t(\theta) - e(\theta)q^2(\theta) \tag{5}$$

[6]This is a result of the quasi-linear utility.

[7]If one allows only positive transfers from the users to the firm, then the firm will exclude any consumer with value $\theta < \alpha$.

[8]See Laffont and Martimort (2002) for details.

Using, by now, standard techniques, one can show that the mechanism is incentive compatible only if

$$q(\theta) \text{ is increasing in } \theta$$

and

$$\dot{U}(\theta) = q(\theta) \tag{6}$$

By integrating Eq. (6), one obtains

$$U(\theta) = U(\underline{\theta}) + \int_0^\theta q(\tau)d\tau \tag{7}$$

which represents the information rent of type θ in an incentive-compatible mechanism. As expected, in an optimal mechanism, the firm leaves zero rents to the lowest type (i.e., $U(\underline{\theta}) = 0$); hence, the transfer of type θ in the mechanism is given if in Eq. (7), we substitute Eq. (5)

$$t(\theta) = \theta q(\theta) - (q(\theta))^2/2 - e(\theta)q^2(\theta) - \int_0^\theta q(\tau)d\tau \tag{8}$$

Therefore, the expected profit of the firm is

$$\int_0^{\bar{\theta}} \big(t(\theta) + \alpha e(\theta)q(\theta)\big) f(\theta)d\theta$$

which, by substituting Eq. (8) and re-arranging terms, is equal to[9]

$$\int_0^{\bar{\theta}} \Big\{(\theta - h(\theta))q(\theta) - q^2(\theta)e(\theta) - (q(\theta))^2/2 + \alpha e(\theta)q(\theta)\Big\} f(\theta)d\theta \tag{9}$$

Therefore, the objective of the firm is to select controls $(q(\theta), e(\theta))_\theta$ to maximize (9) subject to the monotonicity condition and the feasibility constraints that for every θ, $q(\theta) \geq 0$ and $e(\theta) \in [0, 1]$.

As in the symmetric information benchmark, the firm's objective function is linear in e which implies that one needs only consider two-cases: $e = 1$ and $e = 0$.

[9]Note that by integration by parts

$$\int_0^{\bar{\theta}} \Big(\int_0^\theta q(\tau)d\tau\Big) f(\theta)d\theta = \int_0^{\bar{\theta}} (1 - F(\theta))q(\theta)d\theta$$

- **Case 1**. For $e = 1$, the firm solves

$$\max_{(q(\theta))_\theta} \int_0^{\bar{\theta}} \Big\{(\theta - h(\theta))q(\theta) + (\alpha - q(\theta))q(\theta) - (q(\theta))^2/2\Big\} f(\theta) d\theta$$

The first-order condition from pointwise maximisation lead to an optimal usage

$$q_1(\theta) = (\theta + \alpha - h(\theta))/3 \tag{10}$$

which is increasing in θ due to Assumption 1 and strictly increasing in α. Let θ_1 be such that

$$q_1(\theta_1) = 0 \tag{11}$$

Therefore, $q_1(\theta) \geq 0$ if and only if $\theta \geq \theta_1$.

- **Case 2**. For $e = 0$, the firm solves

$$\max_{(q(\theta))_\theta} \int_0^{\bar{\theta}} \Big\{(\theta - h(\theta))q(\theta) - (q(\theta))^2/2\Big\} f(\theta) d\theta$$

The first-order condition from pointwise maximisation lead to an optimal usage given by

$$q_2(\theta) = \theta - h(\theta) \tag{12}$$

which is increasing in θ due to Assumption 1. Let θ_2 be such that

$$q_2(\theta_2) = 0 \tag{13}$$

Therefore, $q_2(\theta) \geq 0$ if and only if $\theta \geq \theta_2$.

Note that $q_1(\theta)$ and $q_2(\theta)$ are each increasing in θ, with a standard distortion that reflects the trade-off between rent extraction and efficiency. Nonetheless, two points deserve attention. First, when the firm extracts data, there is an additional marginal benefit equal to α. Second, because the firm needs to compensate users for the cost of privacy, there is an additional cost. As the consumer's privacy cost is convex: (i) the usage of those types whose data is extracted is lower than those types whose data is not extracted, and, (ii) higher types suffer a higher privacy cost.

By inspection of Eqs. (10) and (12), one can see that for $\alpha > 2\bar{\theta}$, $q_1(\theta) > q_2(\theta)$ for every θ; hence, we impose the following assumption

Assumption 2. $\alpha \leq 2\overline{\theta}$

Based on the analysis above, one can see that the optimal usage schedule consists of two parts. For $\theta \in [\theta_1, \hat{\theta}]$, $q_1(\theta)$ is optimal and is accompanied by full data extraction; for $\theta \in [\hat{\theta}, \overline{\theta}]$, $q_2(\theta)$ is optimal and the firm does not extract any data.[10] The cut-off type $\hat{\theta}$ above which no data is extracted is characterised as a solution to the following equation

$$\underbrace{(\hat{\theta} + \alpha - h(\hat{\theta}))^2/6}_{\text{Profit if data is extracted}} = \underbrace{(\hat{\theta} - h(\hat{\theta}))^2/2}_{\text{Profit if no data is extracted}}$$

which, by employing (12), is equivalent to

$$q_2(\hat{\theta}) = \alpha/(\sqrt{3} - 1) \tag{14}$$

It proves useful when we study markets for rights to implicitly define $\hat{\theta}$ through $q_1(\theta)$. This can be done by employing (10) to obtain

$$q_1(\hat{\theta}) = \alpha/(3 - \sqrt{3}) \tag{15}$$

The optimal mechanism is summarised in the following proposition.

Proposition 2. *Under asymmetric information and complete contracting, the optimal mechanism entails no usage or data extraction for $\theta \leq \underline{\theta}_1$; usage $q_1(\theta) = (\theta + \alpha - h(\theta))/3$ and full data extraction for $\underline{\theta}_1 < \theta \leq \hat{\theta}$; usage $q_2(\theta) = \theta - h(\theta)$ and no data extraction for $\theta > \hat{\theta}$.*

The optimal usage schedule is depicted on the following graph for the uniform distribution. For future notational convenience, let $\theta 12$ be defined such that $q_1(\theta_{12}) = q_2(\theta_{12})$ which is equivalent to

$$q_2(\theta_{12}) = \alpha/2 \tag{16}$$

Several remarks are in order. First, recall that under symmetric information, the cut-off type above which the firm extracts data is given by $\theta^* = \alpha/(\sqrt{3} - 1)$. Given that, due to Assumption 1, $h(\theta)$ is decreasing in θ, it is clear that $\hat{\theta} > \theta^*$. This implies that there is more data extraction under asymmetric information than under symmetric information. Intuitively, because, to control the information rents, usage is distorted downwards for every type under asymmetric information relative to the symmetric information benchmark, the cost of privacy is lower for every type and hence the firm is able to extract data

[10] Note that $q_1(\theta)$ and $q_2(\theta)$ are both increasing which means that the mechanism is incentive compatible.

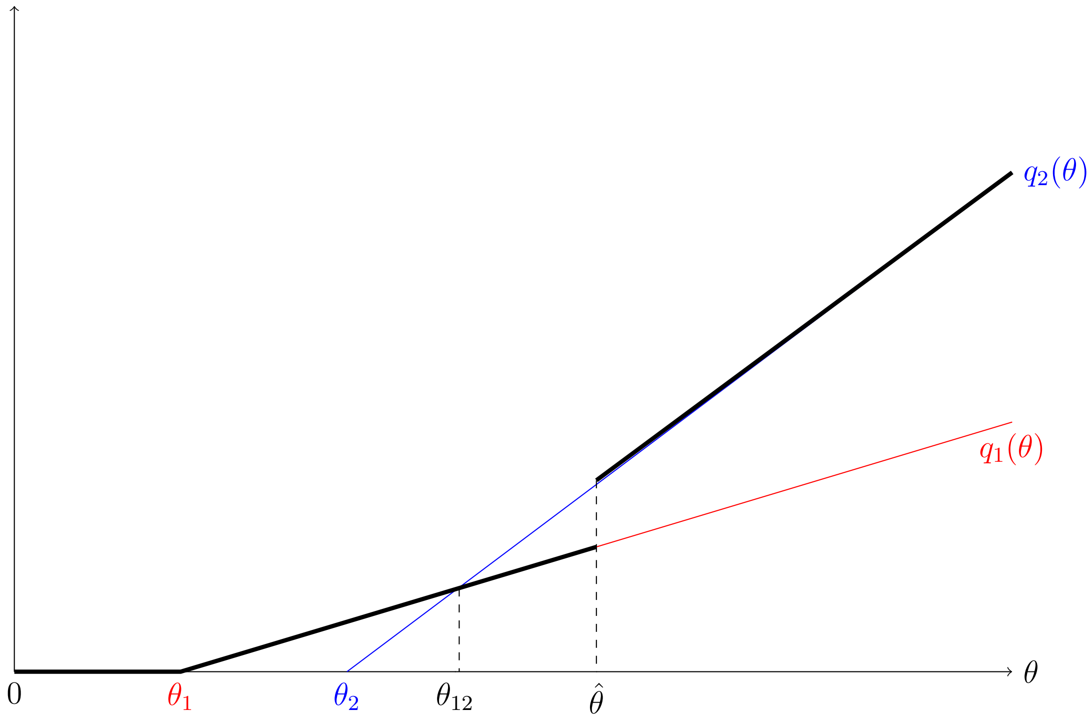

Figure 1: The optimal mechanism under uniform distribution.

from a larger share of consumers. Along the same lines, it is straightforward from inspection of Eq. (15) that $\hat{\theta}$ in increasing in α. This implies that the more profitable the market for data is, the larger the share of consumers from which the firm extracts data.

Second, $q_1(\theta)$ is increasing in α for every θ: the firm accommodates a larger share of consumers (i.e., θ_1 decreases). This mechanism is reminiscent of two-sided markets in which increases in the value in one side of the market are accompanied by increases in the size of the other side. In our case, the higher the value of data, the stronger the firm's incentive to accommodate a larger share of consumers in the primary market. For a sufficiently high α, the firm accommodates all consumers. This is the case when $\alpha > 1/f(0)$. Similarly to the symmetric information benchmark, in this case, the optimal mechanism entails subsidisation of consumers to join the website and generate data.[11]

Last, since $\hat{\theta}$ is increasing in α, for sufficiently high α, the optimal mechanism entails data extraction for all types. This is summarised in the following corollary that proves useful when we study markets for rights.

[11] See Amelio and Jullien (2012) for problems and solutions related to subsidisation of consumers.

Corollary 1. *Under either symmetric or asymmetric information and complete contracting, the optimal mechanism entails data extraction for all types if and only if* $\alpha \geq (\sqrt{3}-1)\bar{\theta}$.

4 Non-Contractible Data Extraction - The Effect of Ownership

Thus far, we studied environments in which the firm was able to commit on how information generated by the users would be used. This entails perhaps little realism especially due to the fact that consumers can bearly inspect how information that is generated by usage is exploited. For instance, even when a consumer faces a bad online experience, it is difficult to pinpoint which sort of usage was at fault (e.g., price discrimination, privacy breach, spam).[12] For this reason, it seems more appropriate to study the relationship between users and firms by assuming that the the firm can commit to the service it sells –that is the usage q– but not to how it will use the data generated by usage.

Due to this contractual incompleteness, we study two different ownership regimes: in the first regime, consumers own the right over the generated data; in the second regime, the firm owns the right over the generated data. We assume that the choice over whether data is extracted takes place *ex post* –that is after usage. In what follows, we compare the two regimes in terms of firm's profit and consumer welfare.

■ **Consumers Own the Rights.** Suppose first that consumers own the right to control any information that is extracted and monetised from their usage; then, provided that they are unable to reap a share of the value of data and that any use of data entails a privacy cost, they have no incentive to consent of any use of their data when this has been generated. Rationally expecting such a behaviour *ex post*, the firm proposes a mechanism that maximises its profit only from the service it provides in the primary market. Based on the analysis in Section 3, this implies that the optimal usage schedule is zero for $\theta \leq \theta_2$ and $q_2(\theta)$ for every $\theta > \theta_2$.

To accommodate the comparison between the two regimes, let Π_C and CS_C denote the firm's profit and consumers' surplus respectively when the usage schedule is $q_2(\theta)$ for every θ; then

$$\Pi_C = \frac{1}{2}\int_{\theta_2}^{\bar{\theta}} (q_2(\theta))^2 f(\theta) d\theta$$

[12] See Jullien, Lefouili, and Riordan (2018) for details.

and

$$CS_C = \int_{\theta_2}^{\bar{\theta}} q_2(\theta)(1 - F(\theta))d\theta$$

□ **The Firm Owns the Rights.** Suppose now that the firm owns the right over the data generated by users' activity. Given that monetising this information is costless for the firm *ex post*, the firm fully extracts and monetises the data generated by all users. Rationally expecting such exploitation by the firm *ex post*, users adjust their usage accordingly to avoid the privacy cost. Based on the analysis in Section 3, this implies that the optimal usage schedule is zero for $\theta \leq \theta_1$ and $q_1(\theta)$ for every $\theta > \theta_1$. Let Π_F and CS_F denote the firm's profit and the consumers' surplus respectively when the usage schedule is $q_1(\theta)$ for every θ; then

$$\Pi_F = \int_{\theta_1}^{\bar{\theta}} \frac{1}{6}(q_1(\theta))^2 f(\theta)d\theta$$

By differentiating the profit with respect to α, and employing the Envelope Theorem, one obtains that

$$\frac{d\Pi_F}{d\alpha} = \frac{1}{3}\int_{\theta_1}^{\bar{\theta}} q_1(\theta)f(\theta)d\theta$$

which is always strictly positive. Note also that, for $\alpha = 0$, $q_1 = q_2/3$ and $\Pi_F = \frac{1}{3}\Pi_C$, which implies that there exists α_F such that $\Pi_F \geq \Pi_C$ if and only if $\alpha \geq \alpha_F$.

The corresponding consumer surplus is given by

$$CS_F = \int_{\theta_1}^{\bar{\theta}} q_1(\theta)(1 - F(\theta))d\theta$$

By differentiating the consumers' surplus with respect to α, one obtains that

$$\frac{dCS_F}{d\alpha} = -\frac{d\theta_1}{d\alpha}(1 - F(\theta_1)q_1(\theta_1) + \int_{\theta_1}^{\bar{\theta}} h(\theta)\frac{dq_1(\theta)}{d\alpha}f(\theta)d\theta$$

which is strictly positive because $d\theta_1/d\alpha < 0$ and $dq_1(\theta)/d\alpha > 0$. Note also that for $\alpha = 0$, $q_1(\theta) = q_2(\theta)/3$ and $CS_F = \frac{1}{3}CS_C$, which implies that there exists α_C such that $CS_F \geq CS_C$ if and only if $\alpha \geq \alpha_C$. The analysis is summarised in the following proposition.

Proposition 3. *There exist α_F and α_C such that*

- *The firm's profit is higher when it owns the rights than when consumers own the rights if and only if $\alpha \geq \alpha_F$.*

- *The consumers' surplus is higher when the firm owns the rights than when the consumers own the rights if and only if* $\alpha \geq \alpha_C$*.*

Under the regime in which the firm owns the rights, the firm suffers from a commitment problem: due to the contractual incompleteness, the firm is unable to commit not to use ex post the data that is generated by usage. Rationally anticipating that, consumers prefer to restrict usage to avoid the privacy cost. Therefore, the firm offers an incentive-compatible usage schedule that entails usage that is distorted downwards for all types. For relatively low values of α, the cost of the distortion in usage offsets any benefit from monetising the data and consequently both the firm and consumers prefer consumers to own the rights; for relatively high values of α, the opposite holds hence both the firm and consumers prefer the firm to own right.

5 Markets for Data

■ **Timing of Events.** We now consider the possibility of the firm and consumers trading the rights over the generated data. When the firm owns the rights, consumers can purchase these and regain control over any information related to them or forbid the diffusion of any information related to them. When the consumers own the rights, the firm can purchase these and be able to monetise the data.

In what follows, we assume that the price at which the firm and consumers trade rights is unique, although we continue to assume that the firm can offer a contract that conditions the price for the service on the usage of a consumer.[13] We further assume that the market for rights opens after any data has been generated –that is after users consume. The timing of the game is as follows: In the first period, the firm proposes a menu of contracts that conditions the price for the service on usage; in the second period, usage takes place; in the third period, the firm chooses a price at which trade of rights takes place; in the fourth stage, the firm monetises the data only for those consumers for which it has the rights to do so. The timing of the game is summarised in Figure 2. We solve the game by backward induction.

Due to the contractual incompleteness, ownership of rights matters; hence, we examine two regimes. In the first regime, the firm owns the rights over the data generated by

[13]Below we elaborate further of the implications of the assumption that there is a unique price and examine alternative assumptions.

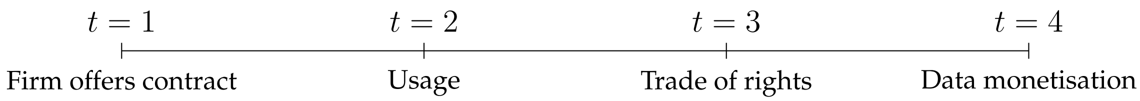

Figure 2: Timing of the game.

consumers; in the second regime, consumers own the rights over the data generated by them. As we did above, we examine the allocation that results after trade and compare the corresponding firm's profit and consumers' surplus with those found above.

□ **The Firm owns the rights**. Given that the market for rights opens after users consume, we take for the moment the mechanism $(q(\theta), t(\theta))_\theta$ offered by the firm as given. We further assume that consumers have been truthful in the mechanism (this will be the case in equilibrium). Suppose that the firm offers price P in which it is willing to sell; then, the users who are willing to buy at this price are those users whose privacy cost exceeds the price. Let θ_F denote the type for who $P = q^2(\theta_F)$ (we examine conditions under which an interior solution exists below); every type $\theta \geq \theta_F$ has a higher privacy cost than the price to buy the rights and hence is willing to buy. The optimal price chosen by the firm is found as the solution to the following programme

$$\max_P \int_0^{\theta_F} \alpha q(\theta) f(\theta) d\theta + \int_{\theta_F}^{\bar{\theta}} P f(\theta) d\theta$$

Provided that $P = q^2(\theta_F)$, determining the optimal price is equivalent to determining θ_F. The first-order condition for profit maximisation is

$$\alpha q(\theta_F) f(\theta_F) - q^2(\theta_F) f(\theta_F) + 2q(\theta_F)\dot{q}(\theta_F)(1 - F(\theta_F)) = 0 \tag{17}$$

which is equivalent to

$$q(\theta_F) f(\theta_F)(\alpha - q(\theta_F) + 2\dot{q}(\theta_F) h(\theta_F)) = 0 \tag{18}$$

Because $\alpha + 2\dot{q}(\theta_F)h(\theta_F) > 0$, the cut-off type is such that $q(\theta_F) > 0$. Suppose that the problem is concave –we examine *ex post* when this is indeed concave– then, θ_F is characterized as a solution to

$$\alpha - q(\theta_F) + 2\dot{q}(\theta_F) h(\theta_F) = 0$$

Let us now study the problem consumers face in the second period. We assume that the cut-off θ_F –and therefore the price P– is perfectly anticipated by the users when they choose their usage; then, type's θ utility is given by

$$U(\theta) = \begin{cases} \theta q(\theta) - q^2(\theta)/2 - t(\theta) - q^2(\theta) & \text{if } \theta < \theta_F \\ \theta q(\theta) - q^2(\theta)/2 - t(\theta) - P & \text{if } \theta \geq \theta_F \end{cases}$$

Note that for $\theta < \theta_F$, the environment is equivalent to that in which the firm owns the rights and no trade of rights is possible. Therefore, the firm's optimal usage schedule is $q_1(\theta)$. For $\theta \geq \theta_F$, the environment is equivalent to the environment in which the consumers own the rights and no trade of rights is possible. Therefore, the firm's optimal usage schedule is $q_2(\theta)$. This means that in equilibrium P is chosen such that $P = (q_2(\theta_F))^2$ and $t(\theta)$ is adjusted in a way that type θ_F is indifferent between trading in the market for rights or not. Based on this observation, one can more precisely characterize θ_F as a solution to

$$q_2(\theta_F) = \alpha + 2\dot{q}_2(\theta_F)h(\theta_F) \tag{19}$$

Note that because $q(\theta_F)f(\theta_F) > 0$, to examine whether the problem of the firm in period three is concave, it suffices to show that $q_2(\theta) - 2\dot{q}_2(\theta)h(\theta)$ is increasing in θ. The first derivative of this function with respect to θ is given by

$$\dot{q}_2(\theta) - 2\ddot{q}_2(\theta)h(\theta) - 2\dot{q}_2(\theta)h'(\theta)$$

We know, from incentive compatibility, that $\dot{q}_2 \geq 0$ and, from Assumption 1, that $h'(\theta) \leq 0$. Note also that, from (12), $\ddot{q}_2(\theta) = -h''(\theta)$. Therefore, if $h(\theta)$ is convex or "not too concave", the problem is indeed concave.[14]

[14]Note that this condition is local and true for the usage schedule q_2. One can easily show that θ_F characterised above is a global maximum. One potential problem is the discontinuity in the usage schedule at θ_F. To show that the firm cannot gain by selecting a different price, all is required is to show that for every $\theta < \theta_F$

$$-q_1(\theta) + \alpha + 2\dot{q}_1(\theta)h(\theta) > 0$$

which can be re-written as

$$\alpha - \frac{1}{3}\Big(q_2(\theta) + \alpha - 2\dot{q}_2(\theta)h(\theta)\Big) > 0$$

If $h(\theta)$ is decreasing and "not too concave", the left-hand side is a decreasing function of θ. Moreover, for $\theta = \theta_F$, we obtain

$$\alpha - \frac{1}{3}\Big(q_2(\theta_F) + \alpha - 2\dot{q}_2(\theta_F)h(\theta_F)\Big) = \alpha - \frac{1}{3}\Big(\alpha - 2\dot{q}_2(\theta_F)h(\theta_F) + \alpha - 2\dot{q}_2(\theta_F)h(\theta_F)\Big) = \alpha/3 > 0$$

Hence, θ_F is indeed a global maximum.

Perhaps as expected, for a sufficiently high α, the firm would be unwilling to sell rights to any of the consumers. This is because for a sufficiently high α the benefit the firm earns by monetising the data always offsets the price the highest value consumer is willing to pay. Using (19), it is only straightforward that this is the case insofar $\alpha \geq \bar{\theta}$. Therefore, one obtains the following corollary.

Corollary 2. *Suppose that the firm owns the rights and a market for rights exists; then, the firm monetises the data of all users (i.e., no trade of rights occurs) if and only if* $\alpha \geq \overline{\theta}$.

We can now compare θ_F with the thresholds we found under under complete contracting.

Proposition 4. *Suppose that the firm owns the rights and a market for rights exists; then –relative to the asymmetric information/full commitment benchmark– there is more data extraction when* α *is low and less data extraction when* α *is high.*

Proof. Suppose that $\alpha = 0$, then by using equation (19), it is clear that $\theta_F > \theta_2$. Recall that in the asymmetric information/full commitment benchmark, $\hat{\theta} = \theta_2$ for $\alpha = 0$. Therefore, for sufficiently low α, $\theta_F > \hat{\theta}$. Moreover, from the Implicit Function Theorem, the derivative of $\hat{\theta}$ with respect to α is given by

$$\frac{d\hat{\theta}}{d\alpha} = \frac{(1+\sqrt{3})/2}{1 - h'(\hat{\theta})}$$

which, due to Assumption 1, is strictly positive; the derivative of θ_F with respect to α is given by

$$\frac{d\theta_F}{d\alpha} = \frac{1}{(1 - h'(\theta_F)) - 2(1 - h'(\theta_F))h'(\theta_F) + 2h''(\theta_F)h(\theta_F)}$$

which, due to Assumption 1, is also strictly positive. Because $(1+\sqrt{3})/2 > 1$, and provided that $h(\theta)$ is convex or "not too concave", $d\theta_F/d\alpha < d\hat{\theta}/d\alpha$. In Corollary 1 we established that, under full commitment, for $\alpha > (\sqrt{3}-1)\bar{\theta}$, the firm monetises the data of all types; in Corollary 2, we established that, when the firm owns the rights and trade is possible, for $\alpha > \bar{\theta}$, the firm monetises the data of all types. Hence, given that $\sqrt{3} - 1 > 1$, there exists some sufficiently high α such that $\hat{\theta} > \theta_F$. □

Put differently, Proposition 4 states that for a relatively low α, the cut-off type above whom no data is monetised is higher when trade of rights is possible and the firm owns the rights than under asymmetric information and complete contracting, whereas the opposite is true for high α. This result is better understood by analysing the fundamental trade-off the firm faces when it decides the price at which it is willing to sell rights. Because the firm lacks commitment power, the price it is willing to sell rights depends on the profit from monetising the data *vs* the price users are willing to pay to protect their privacy. Consider first a low α. Under complete contracting, the firm would prefer to extract data only for the lowest types, if at all; under incomplete contracting and the possibility of sell rights, the firm is tempted to raise the price of rights (ex post) to sell to the highest types who face a high privacy cost. This results to θ_F being above $\hat{\theta}$. Consider now a high α. Under complete contracting, the firm would prefer to extract data from as large a share of consumers as possible; under incomplete contracting and the possibility of sell rights, the firm is tempted to decrease the price of rights (ex post) to have the highest types purchasing. This leads to θ_F being below $\hat{\theta}$.

We now discuss how the firm's profit and consumers' surplus compare to the cases analysed above. Consider first the firm's profit. As expected, this is maximum under complete contracting. If a complete contract cannot be written, then the firm's profit when trade is not possible is always lower than when trade is possible. Indeed, the firm could set the price of rights prohibitively high such that no type buys and hence earn a profit equal to the profit when trade of rights is not possible. The possibility of trade partially restores the commitment problem and, hence, increases the firm's profit.

Consider now the consumers' surplus. As we have argued above, this is increasing in the usage schedule. Therefore, to compare the surpluses in the different cases, it suffices to compare the usage schedules. Given that there are only two usage schedules, q_1 and q_2, it is sufficient to compare only the cut-off types in the different cases. It is rather straightforward that consumers' surplus is higher when trade is possible than when trade is not possible. Moreover, for $\theta_F < \hat{\theta}$ –that is for high α– consumers' surplus when trade is possible is higher than in the asymmetric information/complete contracting benchmark. We summarise these results in the following corollary.

Corollary 3. *Suppose that the firm owns the rights; then,*

(i) the firm's profit under complete contracting is higher than that under incomplete contracting and trade of rights, which is higher than that under incomplete contracting and no trade of rights,

(ii) the consumers' surplus under incomplete contracting and trade of rights is higher than that under incomplete contracting and no trade of rights, and, for a sufficiently high α, higher than that in the asymmetric information/complete contracting benchmark.

□ **The Consumers Own the Rights**. We continue to assume that the firm is the party that sets the price for trading rights in period three.[15] We proceed likewise the regime in which the firm owns the rights. We take the mechanism $(q(\theta), t(\theta))_\theta$ offered by the firm as given and assume that consumers have been truthful in the mechanism (this will be the case in equilibrium). Suppose that the firm offers price P at which it is willing to buy the rights; then, the users interested in selling are those for whom $P \geq q^2(\theta)$. Let $\underline{\theta}_C$ denote the cut-off type below whom all types sell; for $0 < \underline{\theta}_C < \bar{\theta}$, type $\underline{\theta}_C$ is such that $q^2(\underline{\theta}_C) = P$. As we explained in the previous regime, choosing the price P is equivalent to choosing the cut-off $\underline{\theta}_C$; hence, the firm solves the following problem

$$\max_{\underline{\theta}_C} \int_0^{\underline{\theta}_C} \Big(\alpha q(\theta) - q^2(\underline{\theta}_C)\Big) f(\theta) d\theta$$

The first-order condition for profit maximisation is given by

$$\alpha q(\underline{\theta}_C) f(\underline{\theta}_C) - q^2(\underline{\theta}_C) f(\underline{\theta}_C) - 2\dot{q}(\underline{\theta}_C) q(\theta_{CT}) F(\underline{\theta}_C) = 0 \tag{20}$$

which can be re-written as

$$q(\underline{\theta}_C) f(\underline{\theta}_C) \Big\{\alpha - q(\underline{\theta}_C) - 2\dot{q}(\underline{\theta}_C) F(\theta_{CT}) / f(\underline{\theta}_C)\Big\} = 0 \tag{21}$$

Since $\alpha + \dot{q}(\underline{\theta}_C) q(\underline{\theta}_C) F(\underline{\theta}_C) > 0$ for all $\alpha > 0$, we know that that $\underline{\theta}_C$ is such that $q(\underline{\theta}_C) > 0$. Suppose that the problem is concave –we examine *ex post* when this is indeed concave– then, $\underline{\theta}_C$ is characterized as a solution to

$$q(\underline{\theta}_C) = \alpha - 2\dot{q}(\underline{\theta}_C) F(\underline{\theta}_C) / f(\underline{\theta}_C)$$

This cut-off is rationally anticipated by the consumers in period two; then, type's θ utility is given by

$$U(\theta) = \begin{cases} \theta q(\theta) - \frac{q^2(\theta)}{2} - t(\theta) - q^2(\theta) + P & \text{if } \theta \leq \underline{\theta}_C \\ \theta q(\theta) - \frac{q^2(\theta)}{2} - t(\theta) & \text{if } \theta > \underline{\theta}_C \end{cases}$$

[15] Alternatively, one could assume that the consumers set the price. Nonetheless, in this case, one needs to characterise the objective of consumers which, given that they are heterogeneous, is not trivial. Assuming that the firm sets the price simplifies the analysis considerably and allows us to focus on our principal question which is the effect of ownership on outcomes.

Note that, for $\theta \leq \underline{\theta}_C$, the environment is the same as that in which the firm owns the rights; hence, the usage schedule is given by $q_1(\theta)$. For $\theta > \underline{\theta}_C$, the environment is the same as that in which the consumers have the rights and trade is not possible; hence, the usage schedule is given by $q_2(\theta)$. This means that P will be chosen such that $P = q_1^2(\underline{\theta}_C)$ and the firm will adjust $t(\theta)$ such that type $\underline{\theta}_C$ is indifferent between selling her rights or not. We can then characterise $\underline{\theta}_C$ as the solution to

$$q_1(\underline{\theta}_C) = \alpha - 2\dot{q}_1(\underline{\theta}_C)F(\underline{\theta}_C)/f(\underline{\theta}_C) \tag{22}$$

Given that $q_1(\underline{\theta}_C)f(\underline{\theta}_C) > 0$, to examine whether the problem of the firm in period three is concave, it suffices to show that $q_1(\theta) + 2\dot{q}_1(\theta)F(\theta)/f(\theta)$ is increasing in θ. The first derivative of this function with respect to θ is given by

$$\dot{q}_1(\theta) + 2\ddot{q}_1(\theta)F(\theta)/f(\theta) + 2\dot{q}_1(\theta)(F(\theta)/f(\theta))'$$

Due to incentive compatibility, $\dot{q}_1(\theta) \geq 0$. Moreover, from Assumption 1, $(F(\theta)/f(\theta))' > 0$ and $\ddot{q}_1(\theta) = -h''(\theta)$ Therefore, if $h(\theta)$ is convex or "not too concave", the problem is concave.

Intuitively, for a sufficiently low α, the firm is unwilling to buy the rights from any consumer. This is explained by the fact that, when the firm buys at price P, it gains on the types for which $\alpha q_1(\theta) > P$ and loses on the others. For a sufficiently low α, the firm's losses on the low types are not offset by its gains on the high types and the firm prefers not to buy from any consumer. The following corollary characterise conditions under which the firm does not buy the rights of any consumer.

Corollary 4. *Suppose that the consumers own the rights and a market for rights exists; then, the firm does not monetise the data of any consumer (i.e., no trade occurs) if and only if*

$$\alpha < 2\dot{q}_1(\theta_1)F(\theta_1)/f(\theta_1)$$

Consider now the case where α is as high as is required for the firm to set a price at which consumers sell. There are two cases to be considered.

The first case is when $\underline{\theta}_C \geq \theta_{12}$.[16] Then, it is true that $q_1(\underline{\theta}_C) < q_2(\underline{\theta}_C)$ and there is an upward jump in the usage schedule at $\underline{\theta}_C$. To compare θ_{CT} and $\hat{\theta}$, it suffices to evaluate the sign of the first derivative of the ex post profit function of the firm (i.e., the profit from

[16]Recall that $\dot{\theta}$ is such that $q_1(\dot{\theta}) = q_2(\dot{\theta})$.

buying rights) at θ. If this is positive, then the firm would like to increase the price; if this is negative it would like to decrease it. Recall from (15) that $q_1(\hat{\theta}) = \alpha/(3-\sqrt{3})$; then, by replacing $\underline{\theta}_C$ by $\hat{\theta}$ in (21), one obtains

$$\hat{\theta} \lesseqqgtr \underline{\theta}_C \Leftrightarrow \alpha(2-\sqrt{3})/(3-\sqrt{3}) \lesseqqgtr 2\dot{q}_2(\hat{\theta})F(\hat{\theta})/f(\hat{\theta})$$

The second case is when $\underline{\theta}_C < \theta_{12}$. Ideally, the firm would like to decrease the usage schedule for some intermediate types. This is not be possible due to incentive compatibility and hence some *bunching of types* arises. To characterise the set of bunching, let $\bar{\theta}_C$ be such that $q_2(\bar{\theta}_C) = q_1(\underline{\theta}_C)$. Then the usage schedule is such that

$$q(\theta) = \begin{cases} 0, & \text{if } \theta \in [0, \theta_1] \\ q_1(\theta), & \text{if } \theta \in [\theta_1, \underline{\theta}_C] \\ q_1(\underline{\theta}_C), & \text{if } \theta \in [\underline{\theta}_C, \bar{\theta}_C] \\ q_2(\theta), & \text{if } \theta \in [\bar{\theta}_C, \bar{\theta}] \end{cases} \tag{23}$$

This means that the price P is given by $P = q_1^2(\underline{\theta}_C)$ and all the types below or equal to $\bar{\theta}_C$ sell their rights to the firm. The ex ante profit of the firm is

$$\int_{\theta_1}^{\underline{\theta}_C} \Big((\alpha+\theta)q(\theta) - q^2(\theta)/2 - q^2(\underline{\theta}_C) - h(\theta)q(\theta)\Big)dF(\theta)$$
$$+ \int_{\underline{\theta}_C}^{\bar{\theta}_C} \Big((\alpha+\theta)q(\underline{\theta}_C) - q^2(\underline{\theta}_C)/2 - q^2(\underline{\theta}_C) - h(\theta)q(\underline{\theta}_C)\Big)dF(\theta)$$
$$+ \int_{\bar{\theta}_C}^{\bar{\theta}} \Big(\alpha q(\theta) - q^2(\theta)/2 - h(\theta)\Big)dF(\theta)$$

To characterize the cut-offs, we look at the ex-post profit maximisation; this is given by

$$\max \int_{\theta_1}^{\underline{\theta}_C} \Big(\alpha q(\theta) - q^2(\underline{\theta}_C)\Big)f(\theta)d\theta + \int_{\underline{\theta}_C}^{\bar{\theta}_C} \Big(\alpha q(\underline{\theta}_C) - q^2(\underline{\theta}_C)\Big)f(\theta)d\theta$$

The first order condition for profit maximisation is given by

$$\frac{d\bar{\theta}_C}{d\underline{\theta}_C}(\alpha - q_1(\underline{\theta}_C)) - 2\dot{q}_1(\underline{\theta}_C)\frac{F(\underline{\theta}_C)}{f(\bar{\theta}_C)} = 0$$

Using the fact that $q_1(\underline{\theta}_C) = q_2(\bar{\theta}_C)$, one obtains that $d\bar{\theta}_C/d\underline{\theta}_C = \dot{q}_1(\underline{\theta}_C)/\dot{q}_2(\bar{\theta}_C)$ and the first-order condition can be re-written as

$$q_2(\bar{\theta}_C) = \alpha - 2\dot{q}_2(\bar{\theta}_C)F(\bar{\theta}_C)/f(\bar{\theta}_C) \tag{24}$$

We can now compare the consumers' surplus under the different regimes.

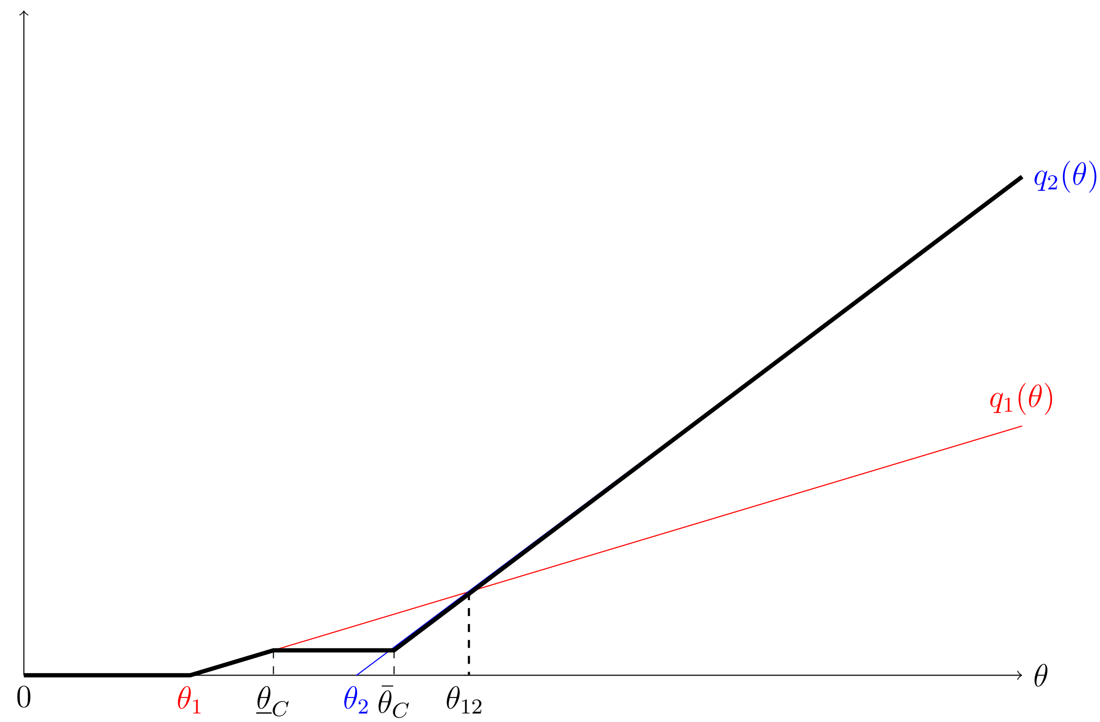

Figure 3: The optimal mechanism when consumers own the rights and $\theta_C < \theta_{12}$.

Proposition 5. *Suppose that a market for rights exists; then, the regime that is optimal for the consumers is the regime in which consumer's own the rights when α is low and the regime in which the firm owns the rights when α is high.*

Proof. For $\alpha = 0$, consumers never sell when they own the rights whereas the firm sells when it owns the rights. Note hovever that for $\alpha = 0$, $q_1(\theta) = q_2(\theta)/3$ and $\theta_1 = \theta_2$. The consumers' surplus in the two regimes is given respectively by

$$CS_{FT} = \int_{\theta_1}^{\theta_F} \frac{q_2(\theta)}{3}(1 - F(\theta))d\theta + \int_{\theta_F}^{\bar{\theta}} q_2(\theta)(1 - F(\theta))d\theta$$

and

$$CS_{CT} = CS_C = \int_{\theta_1}^{\bar{\theta}} q_2(\theta)(1 - F(\theta))d\theta$$

It is rather straightforward that $CS_{CT} > CS_{FT}$, and, by continuity, the inequality continues to hold for α sufficiently low.

Suppose now that $\alpha = 2\bar{\theta}$; then $q_1(\theta) \geq q_2(\theta)$ for all types. We also know that in this case the firm will not sell when it owns the rights. The consumers' surplus is then given by

$$CS_{FT} = \int_{\theta_1}^{\overline{\theta}} q_1(\theta)(1-F(\theta))d\theta$$

We know that with user's rights, it is given either by $q_1(\theta)$ or by $q_2(\theta)$. This means that the usage level is lower of equal to q_1. Since $CS \int_{\underline{\theta}_1}^{\overline{\theta}} q(\theta)(1-F(\theta))d\theta$, then it is direct that consumers are bettor off with firm's right than with user's rights. And by continuity, this is also true for some values of α below $2\bar{\theta}$. □

The conclusion of this section is that a market for rights affects the cut-off types above which one regime dominates the other from consumers' point of view consumers. Nevertheless, the main trade-off remains. In particular, for sufficiently low α, the firm prefers consumers to own the rights to alleviate its commitment problem; for sufficiently high α, both the firm and consumers prefer the firm to own the rights such that more value is generated.

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