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Free daily newspapers: too many incentives to print?

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Abstract. We consider a model in which a free daily newspaper distributes news to readers and sells ad-space to advertisers, having private information about its readership. Depending on the type of readers in the market, the newspaper's may have a "plentiful and seeking" audience or a "lacking and avoiding" audience. We find that if the readers are plentiful and seeking, the newspaper prints an excessive number of copies. The rationale for this over-printing strategy lies on the newspaper's need to send a credible signal to the advertisers that there are plentiful and seeking readers in the market. When the readers are lacking and avoiding, the newspaper chooses the socially optimal tirage (does not try to cheat the advertisers).

Keywords: Two-sided markets, Asymmetric information, Free press.

JEL Classification Numbers: D82, D86, L82.

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1 Introduction

Motivation and leading research questions

The boom of freely distributed newspapers is one of the most striking changes taking place in the press industry. The first modern freely distributed newspaper was released in Sweden in 1995 (the free daily "Metro") and in less than ten years, the market of freely distributed papers has developed in a spectacular way. The circulation figures of free daily newspapers are impressive and they illustrate quite well the rise of free daily press. According to the World Association of Newspapers, in 2001, the total circulation of freely distributed newspapers was already close to ten million daily copies (see Bakker, 2002). Six years later, in 2007, the total circulation of free dailies was substantially higher, with more than forty million copies of free dailies being printed every day (Bakker, 2007). More recently, the market of free dailies is starting to stabilize as the market of free daily newspapers starts to reach its maturity in some regions (like Europe).

Like any other newspaper, free dailies can be viewed as a platform between readers and advertisers. Analogously to paid press, the industry of free daily newspapers exhibits a two-sided market structure (Anderson and Coate (2005), Dukes and Gal-Or (2003), Gabszewicz, Laussel and Sonnac (2001, 2002, 2004), Furhoff (1973), Gustaffson (1978) and others). To the side of readers, free dailies supply news, editorial content and advertising content. To the side of advertisers, free dailies provide the "eyeballs" of their readers.

The specifics of the free dailies (in relation to paid press) lie on the strategy that they use to bring both sides of the market on board. Within the business model adopted by freely distributed papers, readers are totally subsidized by advertisers. To obtain greater advertising profits, free dailies give up making any profits on their readers. Free distribution widens their potential audience, making them more attractive to advertisers. When buying an ad-insertion from a free daily, potential advertisers are ultimately interested in reaching the largest possible audience. The larger is the number of "eyeballs" captured by free dailies, the higher is advertisers' marginal revenue from buying an ad-insertion in these newspapers. Thus, having a greater audience, free dailies are able to charge higher ad-rates and/or sell ad-insertions to a larger number of firms.

In the light of the free dailies' business model, the benefit of bringing an additional copy to the market corresponds to the additional advertising revenues generated by this copy (the audience of the newspaper becomes larger, which makes the newspaper more attractive to advertisers). The cost of bringing this additional copy in the market corresponds to the cost of printing it and distributing. When the number of copies that a free daily brings to the market (tirage) is such that the marginal benefit of bringing the last copy to the market is equal to its marginal cost, the free daily's tirage is said to be socially efficient (or Pareto optimal).

In a scenario of complete and symmetric information, as printing is costly and both the free daily and the advertisers are fully informed about the daily's readership, a freely distributed newspaper never has incentives to over-print (nor under-print).

However, in the real markets, a scenario of perfect and complete information is hard to find. Advertisers are frequently less informed than the newspaper about its readership. In the case of paid press, as readers must pay for the newspaper, advertisers can infer the newspaper's audience from its circulation (no reader would be willing to pay for the newspaper, if it was not planning to read it). However, in the case of freely distributed dailies, readers do not pay for the newspaper and, therefore, even if the newspaper has been delivered in the reader's hands, she/he may simply prefer to drop it in the garbage instead of reading it. Hence, in the market of free dailies, it is common to observe a mismatch between the number of people to whom the newspaper is delivered and the effective number of the readers of the newspaper (who are the only ones that are exposed to the newspaper's ad-insertions).

Since the newspaper is able to observe, more easily than the advertisers, the number of leftovers at distribution points and the number of vendors that are needed to distribute all the copies, it is reasonable to assume that the newspaper is better informed than the advertisers about the size and/or the characteristics of its readership. Consequently, the assumption of perfect and symmetric information is very often inappropriate in the context of free dailies and therefore, it is not guaranteed that free dailies' tirage coincides with the socially efficient tirage levels.

A free daily may be interested in deviating from the socially optimal tirage level to manipulate advertisers' beliefs about the size and the characteristics of its readership. As long as the cost of bringing extra-copies to the market (production cost and distribution cost) is sufficiently small, free dailies may adopt over-printing strategies in order to induce advertisers to over-estimate the newspaper's audience and increase their willingness to pay for the ad-insertions.

In this paper, we aim to study if the business models adopted by free dailies have endogenous mechanisms favouring over-printing strategies in a context of asymmetric information.[1]

Literature overview

The paper is closely related to the recent and flourishing literature dealing with the analysis of the two-sided structure of media industries (see, for example, Anderson and Coate (2005), Dukes and Gal-Or (2003) and Gabszewicz, Laussel and Sonnac (2001, 2002)). It adds to this literature by introducing the possibility of asymmetric information between advertisers and a freely distributed newspaper.

Our paper also contributes to the huge literature dealing with signalling and economic decisions in a context of asymmetric information (Spence (1973), Rothschild and Stiglitz (1976), Wilson (1977), Myerson (1983), Cho and Kreps (1987)). When developing the formal model to introduce asymmetric information in the market of freely distributed papers, we borrow a lot from Maskin and Tirole (1992). They study a principal-agent relationship in which the principal is more informed than the agent about a variable that directly affects the agent's payoff. Their model is, therefore, particularly suitable to study the interaction between advertisers and the freely distributed newspaper: the latter is better informed than the former about its readership, which is a key determinant of the advertisers' benefits associated with the ad-insertions.

Method

To investigate whether the business model of free dailies leads to over-printing or not, we build on the work of Maskin and Tirole (1992) to develop a theoretical model that explicitly takes into consideration the informational asymmetry between advertisers and freely distributed dailies. To keep our analysis as simple as possible, we consider the case of a monopoly market, in which the monopolist free daily provides advertising space to a group of advertisers that is less informed than the newspaper about its readership. In particular, we consider that the newspaper's readership can be one of two types: "plentiful and seeking" readers or "lacking and avoiding" readers. While the newspaper is able to

[1]Our research question was partly inspired by some recent events related to the so-called "London freesheet war". This "war" refers to the very aggressive competition between two free dailies in London: the London Lite and the London Paper, with both newspapers being accused of following anti-competitive and predatory strategies. From our viewpoint, one of the most striking episodes of this war occurred in April 2007, when London Lite argued that London paper vendors were dumping copies of the paper they were distributing in the garbage (over-printing strategy).

observe the type of demand, the advertisers are not (adverse selection problem).

Being uncertain about the type of readers in the market, the advertisers try to infer from the newspaper's tirage whether the free daily's readership is "plentiful and seeking" or, on the contrary, "lacking and avoiding". In this scenario, an adverse selection problem arises since the newspaper may have incentives to over-print to make the advertisers believe that the readership is "plentiful and seeking". In the light of this adverse selection problem, advertisers may not believe that the newspaper's readership is "plentiful and seeking" when they observe that the tirage of the newspaper is relatively high.

We study to which extent the free daily newspaper uses the tirage as a signal to advertisers about the type of readers in the market, and we investigate to which extent the over-printing problem is relevant, if the newspaper uses tirage as a signal.

The interaction between the free daily and the advertisers is analyzed within a principal-agent setting. We consider a game with the following structure. First, nature selects the type of readers in the market, which becomes private information of the newspaper (principal). Advertisers remain uncertain about the true type of readers in the market. Having private information about the characteristics of the readers, the newspaper proposes a contract which specifies a tirage and an advertising rate. The advertisers (agents) decide whether or not to accept the contract proposed by the newspaper, taking into consideration their priors regarding the type of readers in the market as well as any additional information conveyed by the proposed tirage and advertising rate.

To characterize the equilibrium contracts proposed by the free paper contingent on its readership, we rely on the concept of Perfect Bayesian Equilibrium (PBE), following the method suggested by Maskin and Tirole (1992).

Main findings

The first contribution of the paper is to shed light on the adverse selection problems that may arise when a freely distributed newspaper is better informed than advertisers about its readership. If the newspaper's cost of bringing additional copies to the market is sufficiently small, it becomes impossible for advertisers to infer whether a high tirage is due to the newspaper's large readership, or if it is just a strategy used by the newspaper to making them believe that the readership is "plentiful and seeking", when in reality it is "lacking and avoiding".

The second contribution of the paper is to show that when these adverse selection issues arise, the newspaper will use its tirage as a signal to advertisers about the true readership. Our model unveils that, in this case, the unique Perfect Bayesian Equilibrium in pure strategies that survives the intuitive criterion (Cho and Kreps, 1987) corresponds to the least-cost separating contract, whose characteristics are the following: when the free daily's readership is "lacking and avoiding", the paper chooses the socially optimal tirage (no distortion at the bottom); otherwise, the paper chooses an excessive tirage, signalling to the advertisers, credibly, that the readership is "plentiful and seeking" (distortion at the top).

The rest of the paper is organized as follows. Section 2 presents the basic ingredients of the model. Section 3 presents the symmetric information case, as a benchmark. Section 4 characterizes the optimal contract under asymmetric information. Section 5 concludes the paper with some remarks.

2 The model

We consider a monopolist newspaper, whose activity consists in producing news that are freely distributed to readers and in selling "eyeballs" to advertisers.

The readership of the freely distributed newspaper is denoted by $R(\theta, T)$, where $T \geq 0$ stands for the publicly observable number of copies that the newspaper decides to print and distribute, and $\theta \in \{\theta_L, \theta_H\}$ is a parameter that describes whether the readers in the market are "lacking and avoiding" (L) or "plentiful and seeking" (H).

The larger the tirage, the larger is the readership of the newspaper (because readers have lower searching costs), but this effect is decreasing with the tirage of the newspaper. For a given tirage, the readership is higher when the readers are plentiful (H) than when they are lacking (L).

Assumption 1 (Readership)

$$R(\theta, 0) = 0, \quad R_T(\theta_H, T) > R_T(\theta_L, T) > 0 \quad \textit{and} \quad R_{TT}(\theta, T) < 0.$$

On the other side of the market (advertising), the newspaper sells ad-space to N homogeneous advertisers. The payoff obtained by the representative advertiser is:

$$V(\theta, T) - p. \tag{1}$$

The reservation payoff of the advertisers is zero.

We assume that, for a given tirage, the advertisers' expected return from buying ad-space is higher when the readers are plentiful (H) than when they are lacking (L).

We also assume that the larger is the readership of the newspaper, the larger is the advertisers' expected return from investing in ad-space, and that this effect is decreasing with the number of copies printed by the newspaper.[2]

Assumption 2 (Advertising return)

$V(\theta, 0) = 0, \;\; V_T(\theta_H, T) > V_T(\theta_L, T) > 0 \;\; \textit{and} \;\; V_{TT}(\theta, T) \leq 0.$

The profits of the monopolist newspaper are equal to the revenues from selling ad-space to advertisers net of the newspaper's production and distribution costs:

$$\pi(\theta, T, p) = Np - c(\theta, T).$$

We assume that there are no fixed costs, and that the marginal cost of printing and distributing is positive and increasing with the tirage.

We also assume that when the readers are avoiding (L), the marginal distribution cost of the newspaper is higher than when readers are seeking (H).

Assumption 3 (Production cost)

$c(\theta, 0) = 0, \;\; c_T(\theta_L, T) > c_T(\theta_H, T) > 0 \;\; \textit{and} \;\; c_{TT}(\theta, T) > 0.$

Finally, we make the following assumptions to guarantee that the solution is interior, i.e., that the tirage is strictly positive and finite.

[2] Assuming that V is a concave function of R yields these assumptions on V.

Assumption 4 (Interior solution)

$$NV_T(\theta_L, 0) > c_T(\theta_L, 0) \quad \text{and} \quad \lim_{T\to\infty} [NV_T(\theta_H, T) - c_T(\theta_H, T)] < 0.$$

The timing of the game is the following:

1. Nature selects the type of readers in the market, selecting $\theta = \theta_L$ with probability q_L and $\theta = \theta_H$ with probability $q_H = 1 - q_L$.

2. The newspaper privately observes the type of readers in the market, θ_i, and proposes a contract (T_i, p_i) to the advertisers.

3. The N advertisers accept (or reject) the contract proposed by the newspaper.

4. The newspaper prints and distributes T_i copies, the readership is $R(\theta_i, T_i)$, the payoff of the newspaper is $Np_i - c(\theta_i, T_i)$ and the payoff of the representative advertiser is $V(\theta_i, T_i) - p_i$.

Before investigating the characteristics of the contract proposed by a newspaper with private information, we describe (in the following section) the market outcome in the case of symmetric information.

3 Benchmark: Symmetric information

In the case of symmetric information, the type of readers in the market is common knowledge of the newspaper and the advertisers.

This section investigates what are the characteristics of the optimal contract proposed by the newspaper, which depends on the type of readers that is observed. To this end, we rely on backward-induction techniques to solve the symmetric information version of the game previously described.

Given a proposal (T_i, p_i) and the value of θ_i (which, in the context of symmetric information, is common knowledge), the payoff of the representative advertiser is:

$$V(\theta_i, T_i) - p_i,$$

and advertisers accept the contract (T_i, p_i) if and only if:

$$V(\theta_i, T_i) - p_i \geq 0.$$

In the first stage, the newspaper maximizes its profit subject to the advertisers' participation constraint. The problem of the newspaper is:

$$\max_{(T_i, p_i)} \{Np_i - c(\theta_i, T_i)\} \quad \text{s.}t. \quad p_i \leq V(\theta_i, T_i).$$

Since the newspaper (principal) has all the bargaining power, it is able to capture all the surplus from advertisers. Hence, the advertisers' participation constraints are binding:

$$p_i^{SI} = V(\theta_i, T_i).$$

Therefore, the problem of the newspaper can be written as an unconstrained maximization problem:

$$\max_{T_i} \{NV(\theta_i, T_i) - c(\theta_i, T_i)\}.$$

The solution to this problem is given by the first order condition:

$$NV_T(\theta_i, T_i) = c_T(\theta_i, T_i),$$

because the second order condition,

$$NV_{TT}(\theta_i, T_i) - c_{TT}(\theta_i, T_i) < 0,$$

is always verified.[3]

Therefore, when $i = L$, the symmetric information contract is given by:

$$\begin{aligned} T_L^{SI} &: \quad NV_T\left(\theta_L, T_L^{SI}\right) = c_T\left(\theta_L, T_L^{SI}\right); \\ p_L^{SI} &= V\left(\theta_L, T_L^{SI}\right). \end{aligned}$$

[3]Recall that we are assuming that $V_{TT} < 0$ and $c_{TT} > 0$.

Analogously, when $i = H$, the symmetric information contract is:

$$T_H^{SI} \quad : \quad NV_T\left(\theta_H, T_H^{SI}\right) = c_T\left(\theta_H, T_H^{SI}\right);$$
$$p_H^{SI} \quad = \quad V\left(\theta_H, T_H^{SI}\right).$$

The optimality conditions show that, in the symmetric information benchmark, advertisers obtain their reservation payoffs, as the monopolist newspaper extracts all their surplus. Furthermore, the newspaper's tirage is socially efficient. Regardless of the type of readers in the market, the newspaper's tirage assures a perfect balance between the social marginal benefit of printing an additional copy, $NV_T\left(\theta_i, T_i^{SI}\right)$, and the corresponding marginal cost, $c_T\left(\theta_i, T_i^{SI}\right)$.

Figure 1 identifies the equilibrium contracts proposed by the newspaper in the case of symmetric information. The solid lines identify the optimal contract when the type of readers in the market is H, while the dashed lines identify the optimal contract when it is L. The symmetric information contracts are efficient, being located at tangency points (equality between the marginal cost and the marginal benefit of an additional copy).

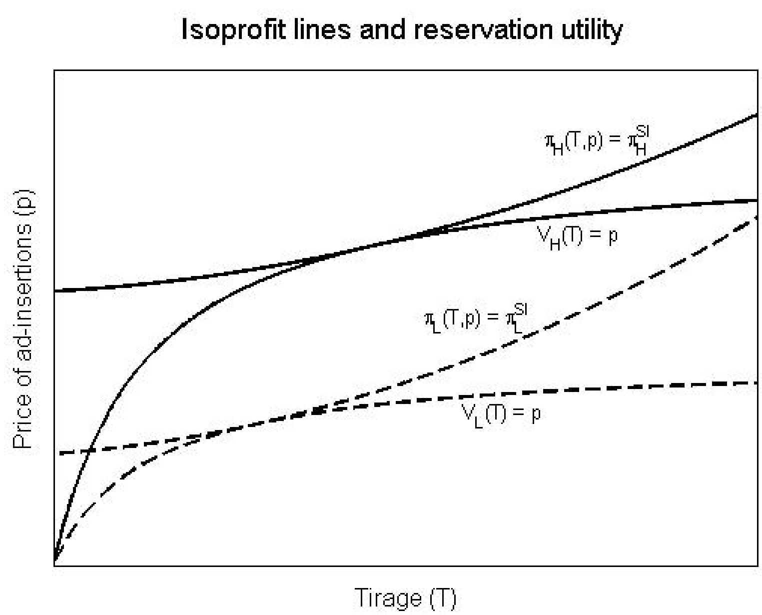

Figure 1: Optimal contracts under symmetric information.

Figure 1 also illustrates the fact that, when the type of readers in the market is H, the newspaper prints more copies and charges higher advertising rates than when the type of readers in the market is L. From the assumptions $c_T(\theta_H, T) < c_T(\theta_L, T)$ and $V_T(\theta_H, T) > V_T(\theta_L, T)$, it follows that $T_H^{SI} > T_L^{SI}$. This, in turn, implies that $V(\theta_H, T_H^{SI}) > V(\theta_L, T_L^{SI})$ and $p_H^{SI} > p_L^{SI}$.

We now turn to the case of asymmetric information, in which the type of readers in the market is private information of the newspaper.

4 Asymmetric information

This section introduces asymmetric information about readers' characteristics. At the moment of contracting, the newspaper is better informed than the advertisers. While the newspaper observes the true value of θ, the advertisers only know the prior probability distribution of θ.

4.1 Deviation from the symmetric information contract

With asymmetric information, the contracts proposed by the newspaper may not be the contracts $\left(T_L^{SI}, p_L^{SI}\right)$ and $\left(T_H^{SI}, p_H^{SI}\right)$ derived in the previous section. When the type of readers in the market is θ_L, the newspaper may have incentives to deviate from $\left(T_L^{SI}, p_L^{SI}\right)$ to $\left(T_H^{SI}, p_H^{SI}\right)$, particularly if advertisers believe that the type of readers in the market is θ_H when the contract $\left(T_H^{SI}, p_H^{SI}\right)$ is offered to them.

The following Proposition (proved in the Appendix) identifies in which circumstances asymmetric information about the type of readers in the market originates deviations from the optimal contracts $\left(T_L^{SI}, p_L^{SI}\right)$ and $\left(T_H^{SI}, p_H^{SI}\right)$.

Proposition 1 (Deviation)

When the type of the readers in the market is private information of the newspaper and advertisers believe that $\theta = \theta_i$ when confronted with contract $\left(T_i^{SI}, p_i^{SI}\right)$, then: (i) for $\theta = \theta_H$, the newspaper prefers contract $\left(T_H^{SI}, p_H^{SI}\right)$ over contract $\left(T_L^{SI}, p_L^{SI}\right)$; (ii) for $\theta = \theta_L$, the newspaper is better-off by deviating from contract $\left(T_L^{SI}, p_L^{SI}\right)$ to contract $\left(T_H^{SI}, p_H^{SI}\right)$ if and only if:

$$c\left(\theta_L, T_H^{SI}\right) - c\left(\theta_L, T_L^{SI}\right) < N\left[V\left(\theta_H, T_H^{SI}\right) - V\left(\theta_L, T_L^{SI}\right)\right]. \tag{2}$$

If condition (2) is violated, the newspaper does not deviate neither for $\theta = \theta_H$ nor for $\theta = \theta_L$. Therefore, the asymmetric information outcome coincides with the symmetric information benchmark. When $\theta = \theta_L$, the newspaper does not prefer $\left(T_H^{SI}, p_H^{SI}\right)$ because of the high cost of printing and distributing additional copies. It does not pay off to make advertisers believe that the state of the nature is $\theta = \theta_H$.

In the rest of the paper, we seek to characterize the optimal contract assuming that condition (2) holds.

4.2 The optimal contract

If the newspaper has private information about the characteristics of the readers, and if condition (2) holds, the symmetric information contracts are not optimal. Regardless of the type of readers, the newspaper always prefers the contract $\left(T_H^{SI}, p_H^{SI}\right)$. Anticipating this behavior, advertisers do not believe that $\theta = \theta_H$ when the contract $\left(T_H^{SI}, p_H^{SI}\right)$ is offered to them. They reject, therefore, such contract.

The probabilities that the advertisers use to compute the contract's expected payoff are their interim beliefs about the type of readers, conditional on the contract (T, p) that is offered by the newspaper. The advertisers' interim beliefs are denoted by $\mu(T,p) = [\mu_L(T,p), \mu_H(T,p)]$, with $0 \leq \mu_i(T,p) \leq 1$ and $\mu_L(T,p) + \mu_H(T,p) = 1$.

The newspaper and the advertisers have a principal-agent relationship with an informed principal and common values.[4] To characterize the optimal contract for each type of readers, we will seek a Perfect Bayesian Equilibrium of the game that satisfies the Cho-Kreps intuitive criterion.[5]

Below, $A(T, p, \mu)$ denotes a strategy of the representative advertiser, which consists in accepting or rejecting a contract, (T, p), when holding some interim beliefs, μ.

Definition 1 (Equilibrium)

A vector of strategies, $\{(T_L^*, p_L^*), (T_H^*, p_H^*), A(T, p, \mu)\}$, and an interim beliefs function,

[4]The party that proposes the contract has superior information (informed principal), and this information enters the objective function of the other party (common values).

[5]The intuitive criterion of Cho and Kreps (1987) excludes unreasonable interim beliefs out of the equilibrium path.

$\mu(T,p)$, constitute a pure-strategy equilibrium when: (i) the strategies (T_L^*, p_L^*), (T_H^*, p_H^*) and $A(T,p,\mu)$ are optimal, given the interim beliefs function, $\mu(T,p)$; (ii) the interim beliefs in equilibrium, $\mu(T_L^*, p_L^*)$ and $\mu(T_H^*, p_H^*)$, are obtained using Bayes' rule; and (iii) the interim beliefs out of equilibrium satisfy the Cho-Kreps intuitive criterion.

It is possible to conceive two kinds of equilibria: *separating* and *pooling*. In a separating equilibrium, the characteristics of the contract offered by the newspaper depend on the type of readers in the market, i.e., $(T_L^*, p_L^*) \neq (T_H^*, p_H^*)$. Therefore, by observing the contract proposed by the newspaper, advertisers are able to infer the type of the readers in the market. In this case, interim beliefs correspond to revelation: $\mu(T_L^*, p_L^*) = (1,0)$ and $\mu(T_H^*, p_H^*) = (0,1)$.

In a pooling equilibrium, the contract that is proposed by the newspaper is independent of the type of the readers in the market, i.e., $(T_L^*, p_L^*) = (T_H^*, p_H^*) = (\overline{T}, \overline{p})$. In this case, the contract proposed by the newspaper does not convey any additional information. Hence, the interim beliefs are equal to the prior beliefs: $\mu(\overline{T}, \overline{p}) = (q_L, q_H)$.

We will show that the optimal contracts, (T_L^*, p_L^*) and (T_H^*, p_H^*), correspond to the *least-cost separating equilibrium*, which can be obtained by sequentially solving the following optimization programs:

$$\max_{(T_L, p_L)} \left[N p_L - c\left(\theta_L, T_L\right)\right] \quad \text{s.t.} \tag{Prog. I}$$

$$p_L \leq V\left(\theta_L, T_L\right) \tag{IR}$$

and

$$\max_{(T_H, p_H)} \left[N p_H - c\left(\theta_H, T_H\right)\right] \text{ s.t.} \tag{Prog. II}$$

$$p_H \leq V\left(\theta_H, T_H\right); \tag{IR}$$

$$N p_H - c\left(\theta_L, T_H\right) \leq N p_L^* - c\left(\theta_L, T_L^*\right), \tag{ICC}$$

where (T_L^*, p_L^*) solves Program I.

Proposition 2

The unique pure-strategy equilibrium is the least-cost separating equilibrium.

Proof: The proof follows directly from the results obtained by Maskin and Tirole (1992).

We can apply their Proposition 2, because the sorting assumption holds (see Claim 1 in the Appendix) and the reservation utility of the advertisers is independent of θ. Therefore, in our game, the *Rotschild-Stiglitz-Wilson allocation relative to the reservation allocation* is the *least-cost separating allocation.*

Since the least-cost separating allocation is interim efficient relative to some strictly positive beliefs (see Claim 3 in the Appendix), by their Theorem 1 and Proposition 7, it is the unique equilibrium allocation. ■

4.3 Characterization of the equilibrium contract

We have shown that the unique pure-strategy equilibrium is the least-cost separating equilibrium, illustrated in Figure 2, and characterized below (see Claim 2 in the Appendix).

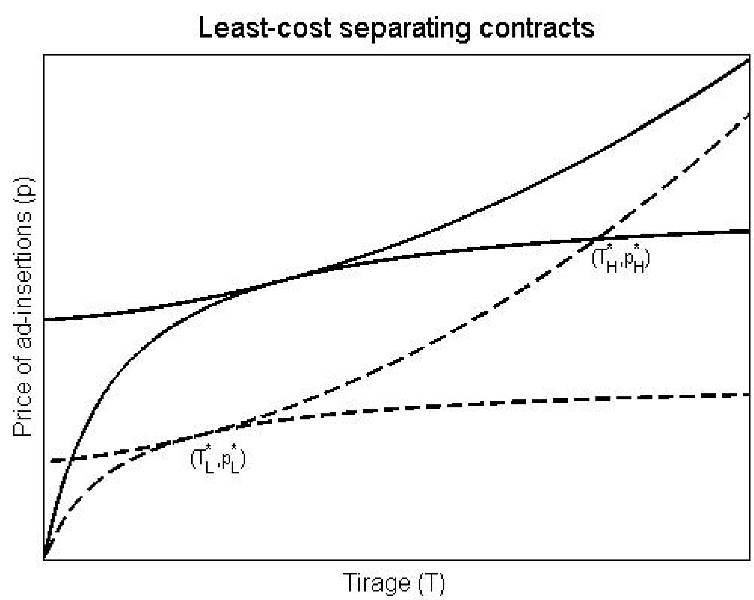

Figure 2: Optimal contracts under asymmetric information.

No distortion at the bottom

When the readers are "lacking and avoiding", the optimal contract with asymmetric information, (T_L^*, p_L^*), coincides with the symmetric information contract. The newspaper captures all the surplus, as the advertising rate is $p_L^* = V(\theta_L, T_L^*)$. The tirage, T_L^*, is socially eficient, $NV_T(\theta_L, T_L^*) = c_T(\theta_L, T_L^*)$.

Distortion at the top

Under condition (2), when the type of readers in the market is θ_H, the newspaper proposes an excessive tirage, relatively to the symmetric information case, $T_H^* > T_H^{SI}$. This credibly signals to the advertisers that the readers are plentiful and seeking. The resulting profit of the newspaper is lower than in the case of symmetric information, while the advertisers remain with their reservation utility, $p_H^* = V(\theta_H, T_H^*)$.

5 Concluding remarks

We have investigated whether free daily newspapers have incentives to print an excessive number of copies in order to convince the advertisers that the readership of the newspaper is larger than it actually is.

Our framework is a principal-agent model in which the newspaper, knowing whether the potential readership is low or high, proposes a contract to the advertisers which stipulates the tirage and the price of advertisements. We have found that the newspaper chooses an excessive tirage when the demand is high, to convince the advertisers that the demand is, in fact, high. When the demand is low, the newspaper chooses the socially optimal tirage, as in the case of symmetric information.

Besides shedding some light on a relevant economic issue, we expect that this work may have contributed to the incorporation of asymmetric information in the study of two-sided markets. Here, we have considered a degenerate scenario, in which one side of the market (advertisers) cares about the other (readers), but not vice-versa. More general scenarios should be considered in future work, in order to study the case of paid press and to investigate how the readers' attitude toward advertising may damped or enhance the incentives of the newspaper to over-print.

6 Appendix

Proof of Proposition 1: The tirage T_H^{SI}, with $T_H^{SI} > T_L^{SI}$, is optimal for $\theta = \theta_H$, therefore:

$$NV\left(\theta_H, T_H^{SI}\right) - c\left(\theta_H, T_H^{SI}\right) > NV\left(\theta_H, T_L^{SI}\right) - c\left(\theta_H, T_L^{SI}\right). \tag{3}$$

Since, by assumption, $V\left(\theta_H, T_L^{SI}\right) > V\left(\theta_L, T_L^{SI}\right)$, from (3) it follows that:

$$NV\left(\theta_H, T_H^{SI}\right) - c\left(\theta_H, T_H^{SI}\right) > NV\left(\theta_L, T_L^{SI}\right) - c\left(\theta_H, T_L^{SI}\right),$$

or, equivalently:

$$N\left(p_H^{SI} - p_L^{SI}\right) > c\left(\theta_H, T_H^{SI}\right) - c\left(\theta_H, T_L^{SI}\right) > 0.$$

This implies that, for $\theta = \theta_H$, the newspaper always obtains higher profits with contract $\left(T_H^{SI}, p_H^{SI}\right)$ than with contract $\left(T_L^{SI}, p_L^{SI}\right)$. With asymmetric information, the contract is still accepted by the advertisers (as they believe that $\theta = \theta_H$).

Since advertisers believe that $\theta = \theta_H$ when confronted with $\left(T_H^{SI}, p_H^{SI}\right)$, then, for $\theta = \theta_L$, the newspaper deviates from $\left(T_L^{SI}, p_L^{SI}\right)$ to $\left(T_H^{SI}, p_H^{SI}\right)$ if and only if:

$$NV\left(\theta_H, T_H^{SI}\right) - c\left(\theta_L, T_H^{SI}\right) > NV\left(\theta_L, T_L^{SI}\right) - c\left(\theta_L, T_L^{SI}\right),$$

yielding condition (2). ■

Claim 1 *When the marginal cost of printing is higher for $\theta = \theta_L$ than for $\theta = \theta_H$, the sorting assumption of Maskin and Tirole (1992) holds.*

Proof: (i) The values of T and p can be any real number.[6]

(ii) The advertisers' payoff increases with T and decreases with p at a rate that is greater than some $\epsilon > 0$. The profit of the newspaper is such that $\pi_T(\theta, T, p) = -c_T(\theta, T) < -\epsilon$ and $\pi_p(\theta, T, p) = N > \epsilon$.

(iii) Given any $\bar{u}$ and $\bar{v}$, there exists a finite solution to the problem:

[6] Assumption 4 guarantees that we always obtain a strictly positive tirage.

$$\max_{(T,p)} \pi^H(T,p) \ \text{ s.t. } \ \pi^L(T,p) \leq \bar{v} \ \text{ and } \ V(\theta_H,T) - p \geq \bar{u},$$

which is equivalent to:

$$\max_{(T,p)} \{Np - c(\theta_H,T)\} \ \text{ s.t. } \ p = \min\{\tfrac{1}{N}\left[c(\theta_L,T) + \bar{v}\right], V(\theta_H,T) - \bar{u}\}.$$

To prove this, we only need to check that it is optimal to select a finite T. From Assumption 4, we know that, for T greater than some T_0, the restriction that is binding is $p = V(\theta_H,T) - \bar{u}$. Ignoring the other restriction, the problem becomes:

$$\max_{T} \{NV(\theta_H,T) - N\bar{u} - c(\theta_H,T)\}.$$

The first order condition, $NV_T(\theta_H,T) = c_T(\theta_H,T)$, holds (by Assumption 4) at a finite value of T, denoted T_1. Therefore, it cannot be optimal to increase T above $\max\{T_0,T_1\}$.

(iv) $c_T(\theta_L,T) > c_T(\theta_H,T) \ \Rightarrow \ -\pi_T(\theta_L,T,p) > -\pi_T(\theta_H,T,p)$.

Since $\pi_p(\theta_L,T,p) = \pi_p(\theta_H,T,p) = 1$, we have: $\frac{-\pi_T(\theta_L,T,p)}{\pi_p(\theta_L,T,p)} > \frac{-\pi_T(\theta_H,T,p)}{\pi_p(\theta_H,T,p)}$. ■

Claim 2 *The least-cost separating allocation is such that:*

(i) When $\theta = \theta_L$, the least cost separating contract (T_L^*, p_L^*) coincides with the symmetric information contract. The advertising rate is $p_L^* = V(\theta_L, T_L^*)$ and the tirage, T_L^*, is such that $NV_T(\theta_L, T_L^*) = c_T(\theta_L, T_L^*)$;

(ii) When $\theta = \theta_H$, the newspaper has a higher profit, $\pi^{H*} = \pi^{L*} + c(\theta_L, T_H^*) - c(\theta_H, T_H^*)$, while the advertisers remain with their reservation utility, $p_H^* = V(\theta_H, T_H^*)$. There is an excess of tirage relatively to the symmetric information case, $T_H^* > T_H^{SI}$.

(iii) $0 < \frac{c_T(\theta_L,T_H^*) - c_T(\theta_H,T_H^*)}{c_T(\theta_L,T_H^*) - NV_T(\theta_H,T_H^*)} < 1$.

Proof: (i) Follows directly from the definition of least-cost separating allocation.

(ii) Under condition (2), the ICC restriction in Program II is binding.

Suppose that the IR condition in Program II is not binding. The problem becomes:

$$\max_{T_H} \{Np_L^* + c(\theta_L,T_H) - c(\theta_L,T_L^*) - c(\theta_H,T_H)\}.$$

This would yield $T_H = 0$ and $p_H > 0$, violating the IR condition. Therefore, both restrictions are binding. The newspaper has a higher profit if $\theta = \theta_H$ while the advertisers remain with their reservation utility:

$$NV(\theta_H, T_H^*) - c(\theta_L, T_H^*) = NV(\theta_L, T_L^*) - c(\theta_L, T_L^*),$$

$$p_H^* = V(\theta_H, T_H^*).$$

With both restrictions, the Lagrangian of Problem II is:

$$\mathcal{L} = Np_H - c(\theta_H, T_H) - \lambda_1 \left[Np_H - NV(\theta_H, T_H) \right] - \lambda_2 \left[Np_H - c(\theta_L, T_H) - Np_L^* + c(\theta_L, T_L^*) \right].$$

The first order conditions are:

$$\frac{\partial \mathcal{L}}{\partial p_H} = 0 \quad \Rightarrow \quad \lambda_1 + \lambda_2 = 1,$$
$$\frac{\partial \mathcal{L}}{\partial T_H} = 0 \quad \Rightarrow \quad -c_T(\theta_H, T_H) + \lambda_1 NV_T(\theta_H, T_H) + \lambda_2 c_T(\theta_L, T_H) = 0,$$

where $\lambda_1 > 0$ and $\lambda_2 > 0$ (both restrictions are binding).

Therefore:

$$-\lambda_1 c_T(\theta_H, T_H) - (1 - \lambda_1) c_T(\theta_H, T_H) + \lambda_1 NV_T(\theta_H, T_H) + (1 - \lambda_1) c_T(\theta_L, T_H) = 0 \;\Leftrightarrow$$

$$\Leftrightarrow \; NV_T(\theta_H, T_H) - c_T(\theta_H, T_H) = \frac{1 - \lambda_1}{\lambda_1} \left[c_T(\theta_H, T_H) - c_T(\theta_L, T_H) \right] < 0,$$

which implies that T_H^* is greater than T_H^{SI}.

(iii) We also have:

$$\lambda_1 = \frac{c_T(\theta_L, T_H^*) - c_T(\theta_H, T_H^*)}{c_T(\theta_L, T_H^*) - NV_T(\theta_H, T_H^*)},$$

with $0 < \lambda_1 < 1$. ■

Claim 3 *The RSW allocation relative to the reservation allocation,* $[(T_L^*, p_L^*), (T_H^*, p_H^*)]$, *is interim efficient relative to some strictly positive beliefs,* $(\hat{q}_L, \hat{q}_H)$.

Proof: According to Maskin and Tirole (1992), the allocation $[(T_L^*, p_L^*), (T_H^*, p_H^*)]$ is interim efficient relative to beliefs $(\hat{q}_L, \hat{q}_H)$ if it solves the following optimization problem for some vector of positive weights (w_L, w_H), with $0 \leq w_L \leq 1$ and $w_H = 1 - w_L$:

$$\max_{(T_H,p_H),(T_L,p_L)} \left[w_L \pi^L(T_L, p_L) + w_H \pi^H (T_H, p_H)\right] \text{ s.t.} \tag{Prog. IE}$$

$$\pi^L(T_L, p_L) \geq \pi^L(T_H, p_H), \tag{ICC of type L}$$

$$\pi^H(T_H, p_H) \geq \pi^H(T_L, p_L), \tag{ICC of type H}$$

$$\hat{q}_L V(\theta_L, T_L) + \hat{q}_H V(\theta_H, T_H) - \hat{q}_L p_L - \hat{q}_H p_H \geq 0. \tag{IR}$$

To see that the ICC of type H is not binding, subtract from it the ICC of type L:

$$\begin{aligned} \pi^H(T_H, p_H) - \pi^L(T_H, p_H) &\geq \pi^H(T_L, p_L) - \pi^L(T_L, p_L) \Rightarrow \\ \Rightarrow c(\theta_L, T_H) - c(\theta_L, T_L) &\geq c(\theta_H, T_H) - c(\theta_H, T_L), \end{aligned}$$

which is true (since marginal cost is lower when $\theta = \theta_H$) for any $T_H \geq T_L$.

It is straightforward to see that the *least-cost separating allocation* satisfies all the restrictions. We now show that it satisfies the first order conditions.

The Lagrangian is:

$$\begin{aligned} \mathcal{L} = \; & w_L \pi^L(T_L, p_L) + w_H \pi^H (T_H, p_H) + \lambda_1 \left[\pi^L(T_L, p_L) - \pi^L(T_H, p_H)\right] + \\ & + \lambda_2 \left[\pi^H(T_H, p_H) - \pi^H(T_L, p_L)\right] + \\ & + \lambda_3 \left[\hat{q}_L V(\theta_L, T_L) + \hat{q}_H V(\theta_H, T_H) - \hat{q}_L p_L - \hat{q}_H p_H\right]. \end{aligned}$$

With $\lambda_2 = 0$, for p_H and p_L, we have:

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial p_H} = 0 \; &\Leftrightarrow \; w_H N - \lambda_1 N - \lambda_3 \hat{q}_H = 0 \Leftrightarrow \lambda_3 = \frac{N\left(w_H - \lambda_1\right)}{\hat{q}_H}; \\ \frac{\partial \mathcal{L}}{\partial p_L} = 0 \; &\Leftrightarrow \; w_L N + \lambda_1 N - \lambda_3 \hat{q}_L = 0 \Leftrightarrow \lambda_3 = \frac{N\left(w_L + \lambda_1\right)}{\hat{q}_L}. \end{aligned}$$

Since $w_L = 1 - w_H$, this implies that $\lambda_1 = w_H - \hat{q}_H$ and $\lambda_3 = N$.

For T_L and T_H, we have:

$$\frac{\partial \mathcal{L}}{\partial T_L} = 0 \quad \Leftrightarrow \quad -(w_L + \lambda_1) c_T(\theta_L, T_L) + \lambda_3 \hat{q}_L V_T(\theta_L, T_L) = 0;$$
$$\frac{\partial \mathcal{L}}{\partial T_H} = 0 \quad \Leftrightarrow \quad -w_H c_T(\theta_H, T_H) + \lambda_1 c_T(\theta_L, T_H) + \lambda_3 \hat{q}_H V_T(\theta_H, T_H) = 0.$$

Replacing $\lambda_1 = w_H - \hat{q}_H$ and $\lambda_3 = N$:

$$\begin{aligned} N V_T(\theta_L, T_L) &= c_T(\theta_L, T_L); \\ \hat{q}_H \left[N V_T(\theta_H, T_H) - c_T(\theta_L, T_H) \right] &= w_H \left[c_T(\theta_H, T_H) - c_T(\theta_L, T_H) \right]. \end{aligned}$$

Let $k = \dfrac{c_T(\theta_L, T_H^*) - c_T(\theta_H, T_H^*)}{c_T(\theta_L, T_H^*) - N V_T(\theta_H, T_H^*)}$.

From Claim 2, we know that $[(T_L^*, p_L^*), (T_H^*, p_H^*)]$ verifies the first condition, and that $0 < k < 1$. It verifies the second condition for $w_H = \dfrac{\hat{q}_H}{k}$.

If $\hat{q}_H$ is sufficiently low, we have $w_H \leq 1$, which means that the least-cost separating allocation is interim efficient relative to beliefs $(\hat{q}_L, \hat{q}_H)$.[7] ■

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[7] When the prior beliefs are such that $q_H \leq k$, then the least-cost separating allocation is interim efficient relative to the prior beliefs. In this case, it is the single allocation that satisfies conditions (i) and (ii) in Definition 1, rendering condition (iii) redundant.

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