

Pricing Information Goods: Free vs. Pay Content

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June 4, 2004

Abstract

We analyze the incentives of an online content provider to introduce both free content and pay content when consumers are uncertain about the quality of content. Free content acts as a partially informative signal; the more free content is available, the higher the probability for a consumer to discover the true quality of content. On the other hand, as the total amount of content is fixed, the higher the proportion of free content, the lower the quantity of, hence the willingness to pay for pay content. A unique intuitive separating equilibrium emerges in which a low quality seller offers no free content and sets the perfect information optimal price, whereas a high quality seller offers free content to signal the quality of its content and sets a price lower than the price of perfect information.

Keywords: Experience goods; Internet; quality uncertainty; signalling.

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1 Introduction

Various types of content are available on the Internet: business news, general news, entertainment content, games, music, etc. At the beginning of the World Wide Web, content used to be offered for free, but since 2002, content providers have begun to charge for content. According to the Online publishers association (OPA, 2004), US consumers spent \$1.56 billion for online content in 2003, a 18.8% increase over 2002.

Some content providers - like the Wall Street Journal online - offer only paid content.¹ Others offer only free content - as the French journal Libération did for a while. However, most often, online content providers offer both free and paid content. For instance, the online journal Salon.com offers roughly half of its content for free, and the other half to its subscribers (\$30 per year).² The French newspaper Le Monde also provides some of its articles for free, but full access to content is available only to its subscribers.

In this paper, we provide a theoretical framework to explain why some content providers offer free content, whereas some others do not. Our intuition is that high quality content providers signal their quality by offering free content.

We analyze the incentives of an online content provider to introduce free content when consumers are uncertain about the quality of content. We assume that free content discloses information about the quality of content to potential consumers, though it does not give perfect information. We assume further that the more free content is available, the more accurate is the signal about the quality of content. Hence, free content is equivalent to a partially informative advertisement, since it allows consumers to discover the quality of the good with some probability.

Moreover, we assume that consumers derive utility only from the first consumption of content. This assumption implies that when it provides a proportion of a fixed amount of content for free, a seller decreases the willingness to pay for the whole content. This is consistent with what we observe in the markets for experience goods. For instance, in the press industry, readers with low willingness to pay for information tend to visit only the free sites to get informed. For a book, the possibility to read the best excerpts can reduce the desire to read the book, hence the willingness to pay (this might be true for a film, too). In the software industry, every Internet user can download an "Acrobat reader" for free, and read pdf files using this software. However, Acrobat Reader does not allow users to create pdf files. One has to purchase the full "Acrobat" software for that. On the one hand, free access to one feature of the software ("read") may lead users to purchase the other feature ("write"), because they can evaluate the quality of the software. But on the other hand, it lowers the willingness to pay for the full set of features ("read"+"write").

¹Headlines are free, but full articles can only be accessed by subscribers. The WSJ had 646,000 subscribers in June 2002.

²In 2002, Salon.com had only 39,500 subscribers for a total number of free users of 3,6 million. Free users have to watch an advertisement before reading the article.

Due to the two effects of free content of consumers' preferences, a high quality supplier faces the following trade-off. On the one hand, if he provides a large proportion of free content, he signals the quality of its content more accurately. On the other hand, he reduces the amount of content which may be paid for by consumers.

Consumers also obtain information by observing the strategy of the seller. Indeed, consumers receive two signals: the price and the proportion of free content offered by the seller. We determine the perfect Bayesian equilibria of this game.

We show that a high quality seller provides free content in any separating equilibrium. Price is not sufficient to signal quality. This result contrasts with the result of Moraga-Gonzales [2000] who shows that informative advertising never occurs in any separating equilibrium, hence that the price suffices to signal quality. In our model, free content is not only an informative signal for some consumers (i.e., those consumers, for which the signal is informative), but also a signal of quality for all consumers. Hence, a high quality seller has incentives to send this additional signal.

Moreover, we show that there is a unique separating equilibrium which survives the intuitive criterion of Cho and Kreps [1987]. At the equilibrium, a low quality seller provides no free content and sets the perfect information optimal price, whereas a high quality seller offers free content to signal its quality and sets a price, which is lower than the perfect information optimal price. As free content reduces the willingness to pay for paid content, the high quality content provider has to lower its price compared to the same setting with perfect information. An interesting implication of this result is that, if the quality of the good is high, uncertainty about the quality of content implies higher consumer surplus.

Our paper is related to two strands of the economic literature. In media economics, free content helps media firms to attract audiences, which generate advertising revenues. In this context, a firm trades off between charging consumers for the good and providing the good at a low price (maybe, even for free), in order to maximize its audience, hence its advertising revenues. Baye and Morgan [2000] propose a simple model with a double source of revenues to explain why traditional and modern mass media derive the bulk of their revenues from advertising rather than subscriptions. Gabszewicz, Laussel and Sonnac [2004] study the impact of the attitude of consumers towards advertising on the strategy of a monopolist. Ferrando, Gabszewicz, Laussel and Sonnac [2004] introduce competition in this type of setting. Models with a double source of revenues have also been used to describe the behavior of service providers in the Internet. Lethiais [2001] uses a model of a double source of revenues to study competition between service providers in the Internet. Barros, Kind, Nilssen and Sorgard [2002] analyze a model of media competition when the firms are advertiser-supported and consumers dislike advertising. In particular, they analyze the incentives for Internet portals to form alliances with their advertisers.

Our paper is also, of course, related to the literature about experience goods.

First, revealing information may influence the decision of consumers to buy the good or not. Grossman [1981], Crémer [1984], Lewis and Sappington [1994] and Che [1996] study whether firms should provide information to consumers about the goods prior purchase. Gaudeul [2003] examines extends this type of analysis, when two firms sell two vertically differentiated products.

The decision to reveal information can also be perceived by the consumer as a signal of quality. Milgrom [1981], Okuno-Fujiwara and alii [1990] study the incentives for a firm to disclose information about its product. In their papers, the disclosure of information influences the decision to buy, not only because consumers acquire information on the value of the good, but also because it acts as a signal of quality.

Advertising may be considered as a way either to reveal information about the good, or to convince consumers that the good is of high quality. Nelson [1970, 1974], Milgrom and Roberts [1986] and Kihlstrom and Riordan [1984] study the incentives for a monopolist to invest in non informative advertising. They show, in a context of repeated purchases, that, even if advertising reveals no information about the quality of the good, firms will advertise because it can modify buyers' perception of the quality of the good. Linnemer [2002] constructs a static model in which a monopolist can signal its quality through both its price and its investment in non informative advertising. He shows that, combined with price, advertising appears to be a useful signal of quality which allows a high quality firm to make greater profit than when only price is used to signal quality.

Finally, advertising may also be informative: sellers can distribute free samples or propose demonstrations of their product. Moraga-Gonzalez [1997] presents a price signalling model with informative advertising, in which the seller chooses the proportion of the consumers to which he sends a signal, which is costly but completely informative. In his paper, the consumer receives two signals from the seller: the price of the good (which acts as a non informative signal) and the informative signal, which reveals the true quality of the good. He determines, in a static context, the conditions for advertising to arise in equilibrium.

The paper is organized as follows. In Section 2, we begin by providing an empirical analysis of the strategies of online content suppliers. Our model is introduced in Section 3. We devote Section 4 to the determination of the demand for content. In Section 5, we determine the separating and pooling perfect Bayesian equilibria of the game. Finally, concluding remarks and possible extensions are presented in Section 6.

2 Online content strategies

Since the beginning of the Internet, content has been offered mainly for free, and content providers have been deriving advertising revenues. Various studies showed that consumers were reluctant to purchase online content, in particular because they felt that online payment was insecure, and that paid content was

not attractive enough.³ Exceptions - like the Wall Street Journal online - were rare.

However, since 2002, paid content has been developing on the Internet. In this section, we provide some empirical evidence of this trend. To begin with, we analyze the market for paid content. Then, we rely on some case studies to show that very often, content providers offer both free content and paid content.

2.1 The market for paid content

According to the Online publishers association (OPA, 2004), US consumers spent \$1.56 billion for online content in 2003, a 18.8% increase over 2002. Table 1 shows the online content spending by category of content.⁴ The top three categories in the OPA study are personals & dating, business content, and entertainment & lifestyle. They account for 64% of all consumer spending.

Content category	Examples	Spending in 2003 (\$ in millions)
Business content	Business news, business research	334.1
Community directories	Virtual communities like IMDB.com	87.0
Credit help	Access to consumer credit records	36.6
Entertainment & lifestyle	Digital multimedia, erotica, humor	214.0
Games	Games played through web browsers	73.0
General news	CNN.com, LeMonde.fr	87.5
Greeting cards		40.6
Personal growth	Motivational sites	90.7
Personals & dating	Dating sites	449.5
Research	Consumer research, people research	108.6
Sports	Sports news, fantasy sports, etc.	38.2

Table 1: content spending by category (source: OPA, 2004).

³According the Pew Internet & American Life Project, in 2001, 17% only of US Internet users were willing to purchase online content. The two main factors to persuade consumers to buy content online are higher security and better content (source: PaymentOne, 2003).

⁴The OPA study excludes the following categories: pornographic sites, gambling sites, software purchases, illegal drug-related sites, Internet service providers, business services, online games with non-web browser-based interface.

Consumers According to OPA (2003), 10.5% of Internet users purchased online content in the first quarter of 2003. This is lower than the 17% of US Internet users who declared in 2001 that they were willing to purchase online content (according to Pew Internet & American Life Project, 2001).

The population of paid content purchasers has a relatively higher income than the population of Internet users.⁵ For instance, 24.8% of paid content purchasers against 20.5% of Internet users have an income of \$100,000 or more. This might be consistent with our assumption that purchasers of paid content are consumers with high willingness to pay.

Paid content purchasers are also extremely heavy Internet users. According to OPA, in 2003, they spent 115% more time online than the average Internet user. But this might be due to the fact that they are 14% more likely to have a broadband connection than the average Internet user. More surprisingly, though compared to Internet users, paid content purchasers make more e-commerce purchases, the average amount per buyer is lower.

Pricing Subscriptions represent 89% of total paid content revenues, whereas single payments represent only 11%. However, the proportion of content spending by pricing model varies among content categories. For Sports, General News, and Credit Help, the proportion of single purchase to subscriptions sales is greater than 20%. For Research and Games, it is higher than 40%.

The average single payment amount was \$21.7 in 2003, whereas the average monthly subscription amount was \$11.

2.2 Free vs. paid content

Even though paid content develops, most online content providers offer both free and paid content. Below, we propose a few brief case studies which illustrate this observation. We also analyze the motivations to propose free content.

2.2.1 Online press

In the online press, there is no typical business model. At one extreme, some providers offer all content for free. At the other extreme, some providers - like the Wall Street Journal online - offer no free content. The French newspaper Libération is a good illustration of this variety of content strategies. When it started to operate online, Libération offered all content for free. In October 2001, the journal decided to charge for content; only breaking news were proposed for free. But in 2002, Libération changed its strategy again and offered all content for free. Finally, since 2004, Libération has been providing a selection of articles for free, whereas the whole newspaper can be purchased online in pdf format.

When the online journal charges for content, the types of content which are sold to consumers varies a lot. Some newspapers, like Libération, only sell the newspaper in digital (pdf) format. The price of the pdf version is typically lower

⁵In the following, we use data of OPA (2003).

than the price of the paper version. For instance, another French journal, *Le Monde*, is sold 1 euro in pdf format against 1.20 euro for the paper version.

Other online journals propose "premium" (i.e., higher quality) content to their online subscribers. For instance, for 5 euros per month, *Le Monde* offers a digital version of the newspaper (in pdf or html format), e-mail alerts, weather information, specific multimedia content (photos, videos), etc.⁶ The online US journal *Salon.com* has adopted the reverse content strategy; the quality of free content is degraded by ads, pop ups and a slower download speed compared to the site available to subscribers. Besides, *Salon.com* offers additional benefits to its subscribers, which are not available in the free site (like access to *Wired* magazine or audio downloads).

In these examples, the role of free content, when available, is to attract audiences, to help consumers evaluate the quality of content, and to generate advertising revenues.

2.2.2 Portals

Portals offer a large range of services to Internet users, such that search tools, information services, webmail access, web pages, etc. Portals can be "independent" (like Yahoo! or MSN) or attached to an Internet Service Provider (ISP). For instance, in France, *Wanadoo.fr* is the portal of the leading ISP, *Wanadoo*. Most of the revenues of portals are advertising revenues. However, some portals, like *Yahoo.com*, have begun to charge for content. For instance, in the fourth quarter of 2003, pay services represented 12.8% of Yahoo! total revenues (i.e., \$85.2 million out of a total revenue of \$663.9 million).

Some services are offered both in a free version and a vertically differentiated paid version. For instance, *Yahoo.com* offers a free mail account with Web access and a 4Mb storage, whereas its basic premium mail account service gives a 25Mb mailbox, POP access and other benefits for \$19.79 per year. Vertical differentiation between the free and the pay version increases the willingness to pay and softens the cannibalization between the two versions. Vertical differentiation occurs either because the quality of the pay version is enhanced or because the quality of the free version is degraded. One example of quality degradation is Yahoo!'s home page service. In the free home page offer, Yahoo! incorporates ads to the user's web site. To get an ad-free site (and other benefits like a higher disk space for files, own domain name, etc.), one needs to subscribe to the pay service (the basic offer is charged \$8.95 a month plus a setup fee of \$15).

In these two examples, the free service allows consumers to evaluate the quality of the service; consumers with high willingness to pay for the enhanced service can then switch to the premium service. Actually, most often, the services of Yahoo! are proposed in both free and pay versions or a trial period is offered for free. Examples include: fantasy sports (a free version is available

⁶The subscription to the online version of the journal is cheaper than the subscription to the paper version, which is greater than 15 euros per month.

with less features), bill pay service (basic plan with a limited number of billers), Yahoo by phone (first month of service free).

Some portals of Internet Service Providers (ISP) also propose paid services. For instance, in France, Wanadoo, proposes more than 100 paid services.⁷ Examples are: education services (English lessons, ...), entertainment services, information services, professional services. Most of these paid services are not available in a free basic version.⁸ In this case, the free services are used to attract audiences. Audiences generate advertising revenues, and some visitors might decide to purchase paid services. However, free content does not help consumers to evaluate the quality of paid content; it merely attracts audiences.

The portals of television channels in France have adopted the same strategy. They propose paid Internet services related to popular television programs (like "Star Academy", and "Qui veut gagner des millions"). Free content serves to attract audiences for advertisers, and also to promote the programs and brand of the television channels.

2.2.3 Financial information

In 2001, in France, most online financial information services proposed only free services, and derived revenues from advertising. As the advertising market shrank, most sites switched to a mixed business model; basic services are free but consumers are charged for premium services. Basic financial information services target consumers with low willingness to pay and allow consumers with a high willingness to pay to evaluate the quality of service. Premium services offer a higher quality of service (real time information, personalized advice, etc.).

In 2002, one site, Serial-Traders, proposed only paid content. The price of the service was relatively low compared to other sites (15 euros per month, compared to 90 euros per month for Boursorama). However, this site had the lowest number of subscribers in 2002 (10,000 subscribers, compared to 750,000 for Boursorama, for instance). It seems also that the quality of service was low; indeed some services proposed by Serial-Traders were offered for free by other sites. Eventually, Serial-Traders stopped its activity in April 2002.

These case studies show that online content providers have adopted different content strategies. At one the other extreme, some content providers offer only free content, which attract audiences and generate advertising revenues. At the other extreme, some content providers propose only paid content, and derive subscription revenues. Between these two extreme cases, some content providers use a mixed content strategy; they provide both free and paid content. In the following section, we construct a model which formalizes this type of strategy.

⁷This service are available at <http://servicesalacarte.wanadoo.fr>.

⁸Some pay services (like weather information) are available both for free and as a paid service. But the free and the paid service do not appear on the same page, and Wanadoo does not indicate what is the differentiation between the two versions.

3 The model

3.1 Supply

A monopolist offers a *set* of information goods, in which each element has the same true quality, denoted q . For instance, this set could be an online newspaper with different articles about politics, economics, sport, people, etc. It could also be a book composed of different pages or a music CD made of different music titles. Quality can be either low ($q = q_L$) or high ($q = q_H$), where $q_H > q_L > 0$. The seller observes the quality, but buyers don't. We assume that the set of information goods is composed of a continuum of goods, and we normalize its size to 1. We assume further that $q_H \leq 2q_L$, i.e., that the high quality is not too high relative to the low quality.

The seller offers a proportion $\alpha \in [0, 1]$ of his content for free. After the decision relative to free content has taken place, the seller chooses the price p of its content. We denote s_χ a strategy of a seller of true quality $\chi = L, H$, hence $s_\chi = (\alpha_\chi, p_\chi)$.

3.2 Consumers

Let μ denote the consumer belief about the quality of content; consumers believe that quality is *low* with probability μ and that it is *high* with probability $1 - \mu$, where $\mu \in [0, 1]$. The expected quality of content conditional on the belief μ is $E_\mu[q] = \mu q_L + (1 - \mu)q_H$. At the beginning of the game, consumers have the same prior belief, ρ , about the quality of content.

Each consumer has a taste θ for quality. The taste parameter θ is uniformly distributed on the interval $[0, 1]$. A consumer of type θ who pays price p for a quantity x of content of (expected) quality q will receive utility of

$$U = \theta qx - p.$$

If available, consumers can use free content prior to deciding whether to purchase the content or not. We assume that consumers incur no cost in doing so. When a consumer consumes free content, he obtains information on the quality of content. He can get either one of the three following signals: $\sigma = H$ (quality is high), $\sigma = L$ (quality is low), $\sigma = N$ (no information). Quality evaluation outcomes are governed by the following signal structure:

$$\begin{aligned} \Pr\{L|q\} &= \begin{cases} \gamma & \text{if } q = q_L \\ 0 & \text{if } q = q_H \end{cases}, \\ \Pr\{H|q\} &= \begin{cases} 0 & \text{if } q = q_L \\ \gamma & \text{if } q = q_H \end{cases}, \\ \Pr\{N|q\} &= 1 - \gamma. \end{aligned}$$

We assume that γ is a function of α , i.e. of the part of content freely offered, and that $\gamma(\alpha) \in [0, 1]$, $\gamma(0) = 0$, $\gamma(1) = 1$, $\gamma'(\alpha) > 0$ and $\gamma''(\alpha) \leq 0$. The concavity of $\gamma(\alpha)$ means that consumers learn marginally less about a given

content as they use more of it. A higher proportion α of free content, hence a higher γ , corresponds to more precise information on the quality of content. Consumers obtain no information when $\alpha = 0$ (no free content) and perfect information when $\alpha = 1$ (all content is free).

3.3 Timing

The timing of the game is as follows:

1. The supplier chooses the proportion of free content $\alpha \in [0, 1]$, and the price of content $p \geq 0$.
2. The consumers observe α and p , revise their beliefs on quality if possible, then choose whether or not to purchase the content.

We look at the perfect Bayesian equilibria (PBE) of this game. Remark that, in this setting, consumers obtain information about the quality of content through two different channels. First, the strategy of the seller might convey information and signal the true quality of the seller. Second, consumers can obtain information by consuming the free content.

4 Demand

In this section, we determine the demand conditional on a belief μ . Assume that the supplier provides both free and pay content, that is $\alpha \in (0, 1)$. Each consumer has four possible strategies:

- He can visit the free site first, then
 - if he anticipates a net gain from consuming the pay content, he buys the pay content (strategy FP),
 - otherwise, he stops (strategy F).
- The consumer can visit the pay site first (strategy P).
- The consumer can visit no site (strategy N).

By eliminating the dominated strategies, we show the following result.

Lemma 1 *The consumer always uses free content.*

Proof. We show that there are only two non dominated strategies: F and FP.

Firstly, note that strategy F dominates strategy N. Indeed, any consumer is better off consuming the free content (strategy F) than consuming nothing (strategy N), since with strategy F the consumer gets $E(U^F) = \theta\alpha E_\mu[q]$, which is strictly positive, whereas he gets $E(U^N) = 0$ with strategy N.

Secondly, we find that strategy FP dominates strategy P. To see that, remark that strategy FP is equivalent to strategy P if the consumer does not modify its purchase decision after consuming the free content. However, if he discovers that quality is low, the consumer has the possibility of not purchasing the content, which shows that $E(U^{FP}) \geq E(U^P)$. ■

Lemma 1 implies that consumers always evaluate quality. This has two implications. First, consumer choice is reduced to whether or not to buy the pay content. Second, given that there is free content, a fraction of consumers will discover the true quality. Hence, we have to analyze the purchase decision, given the true quality q .⁹

Demand for a low quality provider To begin with, assume that the supplier provides low quality content, i.e., $q = q_L$. With probability γ a consumer of type θ discovers that quality is low; he then purchases the pay content if and only if

$$\theta(1 - \alpha)q_L - p \geq 0.$$

Indeed, the consumer derives utility from consuming the remaining content (in quantity $1 - \alpha$) of quality q_L . Solving this condition for θ yields the equivalent condition $\theta \geq \theta_L^*$, where

$$\theta_L^* = \frac{p}{(1 - \alpha)q_L}.$$

With probability $1 - \gamma$ the consumer does not discover the true value of q ; he decides to purchase the pay content if and only if $\theta(1 - \alpha)E_\mu(q) - p \geq 0$. Solving this inequality for θ yields $\theta \geq \theta^*(\mu)$, where

$$\theta^*(\mu) = \frac{p}{(1 - \alpha)E_\mu(q)}.$$

Note that $\theta^*(\mu) \leq \theta_L^*$, as $E_\mu(q) \geq q_L$. Besides, $\theta^*(\mu)$ increases with μ , which means that, logically, the more consumers think that quality is low (i.e., the higher μ), the lower the demand for pay content.

To summarize, consumers of type θ such that $\theta \geq \theta_L^*$ purchase the pay content whether they discover the quality of the pay content or not. Consumers of type θ such that $\theta \in [\theta^*(\mu), \theta_L^*)$ purchase the pay content only if they do not discover that $q = q_L$ (which occurs with probability $1 - \gamma$). Finally, consumers of type θ such that $\theta < \theta^*(\mu)$ do not purchase the pay content in any case. Therefore, when $q = q_L$ the demand for pay content conditional on the belief μ is given by

$$D(q_L, \mu, \alpha, p) = \begin{cases} 1 - \theta^*(\mu) - \gamma(\alpha) \times (\theta_L^* - \theta^*(\mu)) & \text{if } \theta_L^* < 1 \\ (1 - \gamma(\alpha)) \times (1 - \theta^*(\mu)) & \text{if } \theta^*(\mu) < 1 < \theta_L^* \\ 0 & \text{if } \theta^*(\mu) > 1 \end{cases} . \quad (1)$$

⁹If there were an opportunity cost of using free content, consumers with low taste for quality (hence, content) might consume no content, and consumers with high taste for content might purchase the pay content without using free content.

The demand function shows that a low quality seller is harmed by the revelation of the true quality. The higher the fraction of free content α , hence the higher $\gamma(\alpha)$, the lower the demand for the seller. Besides, demand decreases when μ increases.

Demand for a high quality provider Now suppose that $q = q_H$. With probability γ a consumer of type θ discovers that $q = q_H$; he purchases the pay content if and only if $\theta(1 - \alpha)q_H - p \geq 0$, or $\theta \geq \theta_H^*$, where

$$\theta_H^* = \frac{p}{(1 - \alpha)q_H}.$$

With probability $1 - \gamma$ the consumer does not discover the true value of q ; he decides to purchase the pay content if and only if $\theta(1 - \alpha)E_\mu(q) - p \geq 0$, i.e., if and only if $\theta \geq \theta^*(\mu)$.

Note that $\theta_H^* \leq \theta^*(\mu)$, as $E_\mu(q) \leq q_H$. To summarize, consumers of type θ such that $\theta \geq \theta^*(\mu)$ purchase the pay content whether they discover the quality of the pay content or not. Consumers of type θ such that $\theta \in [\theta_H^*, \theta^*(\mu))$ purchase the pay content only if they discover that $q = q_H$ (which occurs with probability γ). Finally, consumers of type θ such that $\theta < \theta_H^*$ do not purchase the pay content. Therefore, when $q = q_H$ the demand for pay content conditional on the belief μ is given by

$$D(q_H, \mu, \alpha, p) = \begin{cases} 1 - \theta^*(\mu) + \gamma(\alpha) \times (\theta^*(\mu) - \theta_H^*) & \text{if } \theta^*(\mu) \leq 1 \\ \gamma(\alpha) \times (1 - \theta_H^*) & \text{if } \theta^*(\mu) > 1 > \theta_H^* \\ 0 & \text{if } \theta_H^* > 1 \end{cases} . \quad (2)$$

In contrast with a low quality seller, a high quality seller always benefits from the revelation of its true quality. Indeed, the higher α , hence the higher $\gamma(\alpha)$, the higher the demand for the seller. However, when the belief (μ) that quality is low increases, demand for pay content decreases.

5 The equilibria

In this section, we characterize the perfect Bayesian equilibria of the game. We start by determining the optimal price for a given belief μ and a given proportion α of free content. Then, we determine the separating and pooling perfect Bayesian equilibria of the game.

5.1 Price determination

In this subsection we determine the optimal price of pay content, when the proportion α of free content is given, and the belief μ is fixed. This analysis will be useful to characterize the equilibria of the game. Let $\Pi(q, \mu, \alpha, p)$ denote the profit of a supplier of true quality q . For $\alpha \in (0, 1)$, the supplier has the following maximization problem,

$$\max_p \Pi(q, \mu, \alpha, p) = pD(q, \mu, \alpha, p). \quad (3)$$

We distinguish two cases: $q = q_L$ and $q = q_H$.

Optimal price for a low quality provider ($q = q_L$) We insert (1) into the maximization program (3) of the supplier. Solving this program yields:

Lemma 2 *If $q = q_L$ and $\alpha \in (0, 1)$, the profit maximizing price is*

$$p^*(q_L, \mu, \alpha) = \frac{(1 - \alpha) q_L E_\mu(q)}{2[q_L + \gamma(E_\mu(q) - q_L)]}.$$

Proof. See Appendix 1. ■

Inserting $p^*(q_L, \mu, \alpha)$ into $\Pi(q_L, \mu, p, \alpha)$, we obtain the supplier profit,

$$\Pi(q_L, \mu, \alpha, p_\mu^*(q_L, \alpha)) = \frac{(1 - \alpha) E_\mu(q) q_L}{4[q_L + \gamma(E_\mu(q) - q_L)]}. \quad (4)$$

Equation (4) shows that the higher the proportion of free content α , the lower the profit of the seller. Indeed, for a low quality seller, providing free content has two negative effects on the willingness to pay for content. First, as we have already seen, providing free content reveals to some consumers that quality is low, hence the average expected quality decreases. Second, it reduces the quantity of pay content.

Optimal price for a high quality provider ($q = q_H$) When quality is high, demand is given by equation (2). We solve the maximization program of the supplier and we obtain the optimal price as a function of α .

Lemma 3 *If $q = q_H$ and $\alpha \in (0, 1)$, the profit maximizing price is*

$$p^*(q_H, \mu, \alpha) = \frac{(1 - \alpha) E_\mu(q) q_H}{2[q_H - \gamma(q_H - E_\mu(q))]}.$$

Proof. See Appendix 2. ■

Inserting $p^*(q_H, \mu, \alpha)$ into $\Pi(q_H, \mu, p, \alpha)$, we obtain the supplier profit,

$$\Pi(q_H, \mu, \alpha, p_\mu^*(q_H, \alpha)) = \frac{(1 - \alpha) E_\mu(q) q_H}{4[q_H - \gamma(q_H - E_\mu(q))]} \quad (5)$$

A larger proportion α of free content has two opposite effects on the willingness to pay. On the one hand, a higher quantity of free content reduces the amount of pay content which decreases the willingness to pay. This corresponds to the factor $1 - \alpha$ in equation (5). On the other hand, free content gives, with probability $\gamma(\alpha)$, the information that quality is high, which makes a fraction of consumers revise their beliefs. This increases the average willingness to pay.

Perfect information For further comparison, it is useful to derive the equilibrium in perfect information. If quality is low, we have $\mu = 1$, and the profit maximizing proportion of free content and price are $\hat{\alpha}_L = 0$ and $\hat{p}_L = q_L/2$; the low quality seller obtains $\hat{\pi}_L = q_L/4$. If quality is high, we have $\mu = 0$, and profit is maximized for $\hat{\alpha}_H = 0$ and $\hat{p}_H = q_H/2$; the high quality seller obtains $\hat{\pi}_H = q_H/4$.

Since consumers observe the quality of content perfectly, free content has no positive effect on the willingness to pay (through the revelation of the quality of content); only its negative effect operates (it diminishes the quantity of pay content). Hence, the seller offers no free content, and charges the profit maximizing price, which depends on the quality of content.

5.2 Separating equilibria

Assume that there is a separating equilibrium, such that a low quality seller plays strategy s_L , a high quality seller plays strategy s_H , and $s_L \neq s_H$. Since he observes the strategy played by the seller, a consumer can infer whether it is a low or a high quality provider. Let $\mu(s)$ denote the revised belief after the observation of the strategy s of the seller. We have therefore $\mu(s_L) = 1$ and $\mu(s_H) = 0$.

Inserting $\mu(s_L) = 1$ into lemma 2 and equation (4) shows that a low quality seller sets necessarily $\alpha_L = 0$ and $p_L = q_L/2$, hence it obtains $\pi_L = \hat{\pi}_L = q_L/4$. The high quality seller plays $s_H = (\alpha_H, p_H)$ and obtains a profit of $\pi_H = p_H D(q_H, 0, \alpha_H, p_H)$.

Separation occurs in equilibrium only if the low (resp., high) quality seller does not find it profitable to imitate the high (resp., low) quality seller.

First, consider that a low quality seller imitates the strategy of a high quality seller. In this case, in the best case, consumers infer that the quality of content is high, and the seller obtains a profit of $\Pi(q_L, 0, \alpha_H, p_H)$. The low quality seller has incentives to imitate the strategy of a high quality seller if he obtains a higher profit under the most favorable beliefs (consumers believe that he is a high quality seller) than under the worst belief (consumers believe that he is a low quality seller), that is if $\Pi(q_L, 0, \alpha_H, p_H) \geq \pi_L$. Therefore, if a high quality seller plays strategy $s = (\alpha, p)$ such that $\Pi(q_L, 0, \alpha, p) < \pi_L$, a low quality seller has no incentive to imitate this strategy. We can then define S_L as the set of strategies of a high quality seller that a low quality has no incentive to imitate. We have

$$S_L = \{s = (\alpha, p) \mid \Pi(q_L, 0, \alpha, p) \leq \pi_L\}.$$

Now, consider the incentives for the high quality seller to imitate a low quality seller. If a high quality seller plays a strategy $(\alpha, p) \neq (\alpha_H, p_H)$, consumers infer (at worst) that he is a low quality content seller and he obtains a profit of $\Pi(q_H, 1, \alpha, p)$. Let S_H denote the set of strategies that give a high quality seller a higher profit under the most favorable beliefs than the maximum profit

he can earn under the worst beliefs. We have

$$S_H = \left\{ s = (\alpha, p) \mid \Pi(q_H, 0, \alpha, p) \geq \max_{\alpha', p'} \Pi(q_H, 1, \alpha', p') \right\}.$$

The interaction of S_L and S_H gives the set of strategies of a high quality seller such that he has no incentive to deviate and that a low quality seller has no incentive to imitate. We can then characterize a separating equilibrium.

Lemma 4 *A pair of strategies $\{(\alpha_L, p_L), (\alpha_H, p_H)\}$ is a separating equilibrium if $(\alpha_L, p_L) = (\hat{\alpha}_L, \hat{p}_L)$, (α_H, p_H) belongs to $S_L \cap S_H$, and the beliefs are $\mu^*(\hat{\alpha}_L, \hat{p}_L) = 1$, $\mu^*(\alpha_H, p_H) = 0$, and for any other (α, p) , $\mu^*(\alpha, p)$ is sufficiently small such that neither type finds it profitable to play (α, p) .*

In a separating equilibrium, quality is perfectly inferred by consumers. A low quality seller acts as in perfect information. A high quality seller distorts its choice of price and proportion of free content, compared to perfect information. Indeed, suppose that the high quality seller plays the perfect information strategy $(\hat{\alpha}_H, \hat{p}_H)$. A low quality seller would gain from imitating a high quality seller, because if consumers believe that it is a high quality seller it obtains a profit of $q_H/4$, which is higher than $\pi_L = q_L/4$. Therefore, the equilibrium in perfect information is not a separating equilibrium of the game of imperfect information.

A more general question is whether a high quality seller can its price only to separate from a low quality seller. In the following, we show that it is not the case.

Corollary 1 *A high quality seller always proposes free content.*

Proof. Suppose that there is a separating equilibrium such that $\alpha_H = 0$. The profit of the high quality seller if it plays (α_H, p_H) is

$$\pi(p_H) = p_H \times D(q_H, 0, 0, p_H) = p_H \times \left[1 - \frac{p_H}{q_H} \right].$$

Assume that $\pi(p_H) > \pi_L$. In this case, the high quality seller has no incentive to mimic the low quality seller. If the low quality seller imitates the high quality seller, he obtains $\pi(p_H)$, since there is no free content and hence everything is as if it were a high quality seller. As $\pi(p_H) > \pi_L$, the low quality seller has incentive to imitate the other type, which implies that there is no separating equilibrium such that $\alpha_H = 0$. ■

This corollary shows that at any separating equilibrium, free content is used to signal high quality of content. This is in contrast with the result of Moraga-Gonzales [2000] who shows that informative advertising never occurs at any separating equilibrium. In his paper, consumers receive informative advertisements, but do not observe the advertising effort. Hence, price signals quality, and advertising is redundant. In our paper, free content is an informative signal

in itself for some consumers because it can reveal the true quality of content. But as it is observed by consumers, it can also serve as a signal of high quality.

Though lemma 4 characterizes an infinity of separating equilibria, all of them are not equally convincing. Indeed, in a separating equilibrium, a high quality seller signals its quality by offering free content such that a low quality seller has no incentive to imitate his strategy. But since the profit of the high quality seller decreases with the proportion of free content, a high quality seller obtains maximum profit when it offers the smallest proportion of free content such that there is separation at the equilibrium.

The intuitive criterion of Cho and Kreps [1987] helps us to formalize this intuition. This criterion states that consumers believe that a seller who plays an off the equilibrium strategy s has type $\chi = L, H$ with probability 0 if this strategy is dominated for a seller of type χ . Therefore, the only separating equilibrium that survives this criterion is such that the high quality seller sets α_H and p_H so as to maximize its profit, given that a low quality seller has no incentive to imitate this strategy.

Consider that the high quality seller chooses a proportion $\alpha_H > 0$ of free content and sets the optimum price given that separation occurs at the equilibrium, i.e., we have $p_H = (1 - \alpha_H) q_H/2$. The profit of the high quality seller, denoted $\Pi_H(\alpha_H) = (1 - \alpha_H) q_H/4$, obviously decreases with α_H . The high quality seller solves

$$\max_{\alpha_H} \Pi_H(\alpha_H),$$

subject to

$$\Pi(q_L, 0, \alpha_H, (1 - \alpha_H) q_H/2) \leq \pi_L. \quad (6)$$

Since we have

$$\begin{aligned} \Pi(q_L, 0, \alpha_H, p_H) &= p_H \times D(q_L, 0, \alpha_H, p_H) \\ &= (1 - \alpha_H) \frac{q_H}{2} \times \frac{1}{2} \left[1 - \gamma \left(\frac{q_H}{q_L} - 1 \right) \right], \end{aligned}$$

equation (6) is equivalent to

$$(1 - \alpha_H) \frac{q_H}{2} \times \frac{1}{2} \left[1 - \gamma \left(\frac{q_H}{q_L} - 1 \right) \right] \leq q_L/4.$$

As $\Pi_H(\alpha_H)$ decreases with α_H , the solution α_H of the optimization problem is given by the following equation,

$$\alpha_H = 1 - \frac{q_L}{q_H \left(1 - \gamma(\alpha_H) \left(\frac{q_H}{q_L} - 1 \right) \right)}.$$

Finally, we check that this equilibrium exists. By construction, α_H is such that the low quality seller has no incentive to imitate the high quality seller. The high quality seller has no incentive to adopt the same strategy than the low quality seller if and only if

$$\frac{(1 - \alpha_H) q_H}{4} > \frac{q_L}{4} \quad (7)$$

or

$$\alpha_H > 1 - \frac{q_L}{q_H}.$$

Inserting the expression of α_H yields the following condition,

$$\left(1 - \gamma(\alpha_H) \left(\frac{q_H}{q_L} - 1\right)\right) < 1,$$

which is always satisfied. Therefore, the unique separating equilibrium is characterized by the following proposition.

Proposition 1 *The unique separating equilibrium, consistent with the intuitive criterion of Cho and Kreps (1987), is characterized by the following strategies:*

$$s_H = \left(\alpha_H, \frac{(1 - \alpha_H)q_H}{2}\right),$$

$$s_L = \left(0, \frac{q_L}{2}\right),$$

where α_H is the solution of

$$\alpha_H = 1 - \frac{q_L}{q_H \left(1 - \gamma(\alpha_H) \left(\frac{q_H}{q_L} - 1\right)\right)}.$$

In the unique separating equilibrium, beliefs are given by $\mu^*(s_L) = 1$ and $\mu^*(s_H) = 0$ and for any other strategy $s \neq s_L, s_H$, $\mu^*(s)$ is sufficiently small such that neither type of seller gains from deviating to s .

In this equilibrium, the high quality seller provides free content to signal its quality. The price of a high quality seller is lower than under perfect information. This implies that consumers surplus is higher in the separating equilibrium of proposition 1 than under perfect information.

Illustration Assume that $\gamma(\alpha) = \alpha$, and let $\lambda = q_H/q_L$. We find that

$$\alpha_H = \frac{\lambda^2 - \sqrt{\lambda^4 - 4\lambda^3 + 8\lambda^2 - 4\lambda}}{2(\lambda^2 - \lambda)}.$$

We observe that α_H increases with λ , and that α_H goes to 0 when λ goes to 1, whereas α_H goes to 0.29 when λ goes to 2. Otherwise stated, the higher q_H relative to q_L , the higher the proportion of free content provided by the high quality seller. This is because the incentives of a low quality seller to mimic a high quality seller become stronger, hence a high quality seller has to provide more free content to separate.

5.3 Pooling equilibria

Now, we characterize the pooling equilibria of the game. In a pooling equilibrium, a low and a high quality supplier choose the same strategy $s^* = (\alpha^*, p^*)$,

hence consumers do not revise their beliefs. A low quality supplier obtains $\Pi(q_L, \rho, \alpha^*, p^*)$, whereas a high quality supplier obtains $\Pi(q_H, \rho, \alpha^*, p^*)$. We assume that off the equilibrium, for any strategy s such that $s \neq s^*$, beliefs are given by $\mu(s) = 1$.

This equilibrium is valid only if the low quality supplier has no incentive to deviate to its perfect information strategy, $(\hat{\alpha}_L, \hat{p}_L)$, i.e., only if¹⁰

$$\Pi(q_L, \rho, \alpha^*, p^*) > \hat{\pi}_L = q_L/4.$$

The intuitive criterion eliminates all pooling equilibria. The (standard) argument is as follows. For a low quality seller, any strategy $s = (\alpha, p)$, such that $s \neq s^*$, is dominated by strategy s^* . This is because consumers believe that a seller who plays a strategy off the equilibrium is a low quality seller and a low quality seller has no incentive to deviate from the equilibrium strategy. Therefore, for any $s \neq s^*$, we have

$$\Pi(q_L, \rho, \alpha^*, p^*) > \Pi(q_L, 0, \alpha, p).$$

as the intuitive criterion implies that $\mu(s) = 0$. But in this case, there exists a strategy s that a high quality has incentives to adopt.

To summarize, if we apply the intuitive criterion, the separating equilibrium of proposition 1 is the unique equilibrium of the game. A low quality seller proposes no free content and sets the perfect information optimum price, whereas a high quality seller proposes free content to signal its (high) quality. The greater high quality relative to low quality, the larger the proportion of free content, if we assume that the probability to discover quality equals the proportion of content offered for free.

6 Conclusion

In this paper we have studied the incentives of an online content provider to offer some of its content for free when there is uncertainty about the quality of content. We have shown that there is no pooling equilibrium of this game that survives the intuitive criterion of Cho and Kreps (1987). A unique separating equilibrium survives the intuitive criterion. In this equilibrium, a low quality content provider offers no free content and sets the perfect information optimal price, whereas a high quality content provider offers free content, in order to signal that it offer high quality content, and sets a price which lower than the optimal price in perfect information. We also show that price cannot signal the quality of content alone; offering free content is the only way for a high quality seller to separate from a low quality seller. As free content acts as a partially informative signal, the low quality seller has no incentive to imitate the high

¹⁰If this condition holds, a high quality seller has no incentive to deviate either. Indeed, if it deviates, it obtains the same profit, $\hat{\pi}_L$, whereas if it does not deviate it obtains $\Pi(q_H, \rho, \alpha^*, p^*) > \Pi(q_L, \rho, \alpha^*, p^*)$.

quality seller, because some consumers would discover that he provides a low quality of content.

Our result seem to be consistent with what we observed in the online financial information market. On one hand, Serial-Traders proposed low quality content and no free content at a reasonable price. On the other hand, Boursorama offered high quality content and a part of its content for free, which allowed consumers to discover the quality of content and maybe to decide to switch to the expensive "premium" services.

The strategy of the supplier could be impacted by different factors. In this paper, we ignored advertising revenues. A supplier would have a higher incentive to provide free content if he could derive advertising revenues. Another important aspect of our model is that providing free content diminishes the willingness to pay for paid content. If the supplier could differentiate free content and paid content, this effect would be reduced; however, the quality of the signal about the quality of paid content would also decrease. This might be an interesting idea for future research.

References

- [1] Barros P., Kind H. J., Nilssen T., Sorgard L., 2002, Media competition when the audience dislikes advertising: a theory of vertical alliances on the Internet, working paper.
- [2] Baye M. R., Morgan J., 2000, A simple model of advertising and subscription fees, *Economics Letters*, 69, 345-351.
- [3] Bester H., Ritzberger K., 2001, Strategic pricing, signalling, and costly information acquisition, *International Journal of Industrial Organization*, 19, 1347-1361.
- [4] Che Y., 1996, Customer return policies for experience goods, *The Journal of Industrial Economics*, 44, 17-24.
- [5] Cho I-K., Kreps, D., 1987, Signaling Games and Stable Equilibria, *Quarterly Journal of Economics*, 102, 179-221.
- [6] Crémer, J., 1984, On the economics of repeat buying, *Rand Journal of Economics*, 15, 396-403.
- [7] Ferrando J., Gabszewicz J., Laussel D., Sonnac N., 2004, Two-sided network effects and competition: an application to media industries, working paper.
- [8] Gabszewicz J., Laussel D., Sonnac N., 2004, Network effect in the press and advertising industries, working paper.
- [9] Gaudeul A., 2003, Shareware competition: selling and experience, Working paper.
- [10] Lethiais V., 2001, La tarification des services sur Internet: intégration verticale et gratuité, *Revue Economique*, 52, 39-56.
- [11] Lewis T., Sappington D., 1994, Supplying information to facilitate price discrimination, *International Economic Review*, 35, 309-327.
- [12] Linnemer L., 2002, Price and advertising as signals of quality when some consumers are informed, *International Journal of Industrial Organization*, 20, 931-947.
- [13] Milgrom P., 1981, Good news and bad news: representation theorems and applications, *The Bell Journal of Economics*, 12, 380-391.
- [14] Milgrom P., Roberts J., 1986, Price and advertising signals of product quality, *Journal of Political Economy*, 94, 796-821.
- [15] Moraga-Gonzalez J.L., 2000, Quality uncertainty and informative advertising, *International Journal of Industrial Organization*, 18, 615-640.

- [16] Nelson P., 1970, Information and consumer behaviour, *Journal of Political Economy*, 78, 311-329.
- [17] Nelson P., 1974, Advertising as information, *Journal of Political Economy*, 81, 729-754.
- [18] Okuno-Fujiwara M., Postlewaite A., Suzumara K., 1990, Strategic information revelation, *Review of Economic Studies*, 57, 25-47.
- [19] Online publishers association, 2003, Online paid content: Demographic and Usage Report, <http://www.online-publishers.org/>.
- [20] Online publishers association, 2004, Online paid content: U.S. Market Spending Report, <http://www.online-publishers.org/>.

7 Appendix

7.1 Proof of lemma 2

The demand, given by equation (1), is composed of two parts. We begin by optimizing the supplier profit on each demand segment. Then, we will show that only one local optimum is attained, hence it is the global optimum.

First, assume that $\theta_L^* < 1$. The first-order condition for profit maximization gives the following local optimum,

$$p_{L1}^* = \frac{(1 - \alpha) q_L E_\mu(q)}{2 [q_L + \gamma (E_\mu(q) - q_L)]}.$$

The second-order condition is always satisfied. This local maximum exists if and only if $\theta_L^* < 1$. We show that this condition holds always. Inserting p_{L1}^* into θ_L^* shows that $\theta_L^* < 1$ if and only if

$$(1 - 2\gamma) E_\mu(q) < 2(1 - \gamma) q_L. \quad (8)$$

If $\gamma \geq 1/2$, this condition is always satisfied as the left-hand side is negative. When $\gamma < 1/2$, condition (8) can be rewritten as

$$E_\mu(q) < \frac{2(1 - \gamma)}{1 - 2\gamma} q_L,$$

which holds always, as $2(1 - \gamma) / (1 - 2\gamma) \geq 2$ when $\gamma \in [0, 1/2)$, $E_\mu(q) \leq q_H$ and $q_H \leq 2q_L$.

Second, assume that $\theta_L^* > 1 > \theta^*$. The first-order condition for profit maximization gives the following local optimum,

$$p_{L2}^* = \frac{(1 - \alpha) E_\mu(q)}{2}.$$

The second-order condition is always satisfied. This local maximum exists if and only if $\theta^* < 1$ and $\theta_L^* > 1$. We show that this local optimum is not attained. By inserting p_{L2}^* into θ^* , we find that $\theta^* = 1/2$, hence $\theta^* < 1$ holds always. But we have $\theta_L^* > 1$ if and only if

$$E_\mu(q) > 2q_L,$$

which is never satisfied as $E_\mu(q) \leq q_H$ and $q_H \leq 2q_L$. Therefore, p_{L1}^* is the global maximum of the profit function.

7.2 Proof of lemma 3

The demand, given by equation (2), is composed of two parts. We begin by optimizing the supplier profit on each demand segment. First, assume that $\theta^* \leq 1$. The first-order condition for profit maximization gives

$$p_{H1}^* = \frac{(1 - \alpha) E_\mu(q) q_H}{2 [q_H - \gamma (q_H - E_\mu(q))]}.$$

The second-order condition is always satisfied. This local maximum exists if and only if $\theta^* \leq 1$. Inserting p_{H1}^* into θ^* shows that $\theta^* \leq 1$ if and only if

$$E_\mu(q) > \left(1 - \frac{1}{2\gamma}\right) q_H, \quad (9)$$

which is always satisfied as $E_\mu(q) \geq q_L \geq q_H/2$ and $1 - 1/2\gamma < 1/2$.

Second, assume that $\theta^* > 1 > \theta_H^*$. The first-order condition for profit maximization gives

$$p_{H2}^* = \frac{(1 - \alpha) q_H}{2}.$$

The second-order condition is always satisfied. This local maximum exists if and only if $\theta_H^* < 1$ and $\theta^* > 1$. But we have $\theta^* > 1$ if and only if

$$E_\mu(q) < \frac{q_H}{2},$$

which never holds as $E_\mu(q) \geq q_L \geq q_H/2$. Therefore, p_{H1}^* is the global optimum of the profit function.