MARKETING INFORMATION: A COMPETITIVE ANALYSIS

by

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Marketing Information: A Competitive Analysis

Abstract

This paper proposes a simple framework to investigate competition when the product sold is information. In information markets consumers have the option to combine products from different sellers to obtain a more accurate view of the world. In order to find the optimal number of products to buy, consumers take into account the relations (perceived correlations) among the different products, as well as their price and perceived reliability (quality). Our paper shows that firms' anticipation of consumer information acquisition strategies leads to interesting forms of competition. In particular, we show that under reasonable conditions an information seller is better off facing competition than being a monopolist, and collusion in price among sellers can increase consumer surplus as well as profits.

(Information sales; Competitive strategy; Complements; Substitutes)
Introduction

Recently, Portugal Telecom has simultaneously hired three independent investment banks to value the firm before its privatization. There are two decision problems underlying this story. From the Telecom's point of view the question is: how many information sources to consult in order to obtain a fair estimate for the value of the firm? On the other hand, the investment banks' problem is: how to price the consulting service given the uncertainty of the Telecom's value and given the presence of competing investment banks providing valuation services? In essence, what is being exchanged in this example is information - in this specific case, information about the value of a firm. This paper seeks to explore similar situations faced by marketing managers who sell information products or services in a competitive setting.

Information products can take on a variety of forms: industry reports, consulting services, database access, and professional opinions given by medical, engineering, accounting/financial, and legal professionals, among others. The term "information product" is used in a broader sense in the literature, including information technology, advertising or the media. In contrast, our definition follows Jensen (1991, p. 424), by referring to information that is (1) paid for, and (2) valuable for making decisions (e.g. expert advice). Our discussion, therefore, excludes advertising since it is not paid for. Likewise, information which is used to entertain (e.g. movies) is also not explored. Jensen (1991) reports detailed statistics on the business-to-business sector of the information industry in the U.S.A. for the period 1982-1988. Table 1 shows that this $17.7 billion industry is especially relevant for marketing where most of the revenues are generated.\(^1\)

\(^1\)In 1988 the U.S. information services industry included some 1,500 - mostly small - companies. Examples of large information services providers include Dun & Bradstreet Business Information Reports, F. W. Dodge Construction Project News, IMS International Sales Territory Reports and Consumer Reports among others.
Despite the dynamic development of the “information sector” (12% average annual growth over the 1980s) there is relatively little academic work devoted to the subject. The objective of this paper is to fill this gap by developing a simple game-theoretic framework to understand competition in information markets. In particular, we are interested in answering the following questions: (1) Is competition fundamentally different when competing firms sell information rather than traditional goods and services, and - if yes - why? (2) What are the implications of such differences for decision makers (marketers and regulators)? (3) Can we explain some of the observed marketing strategies in information markets?

The next section provides an intuitive description of the problem and relates our approach to the relevant literature. The model is formally developed in section 3. In this section, care is taken to relate the analytic findings to observed business strategies. Before concluding, section 4 briefly explores extensions of the model and discusses potential limitations.

2 The Problem

2.1 Intuition

Traditionally, when we talk about “competing” products (brands) we think of differentiated substitutes. Most consumers choose one coffee brand over another or one car from a set of alternatives. When purchasing information, consumers facing important decisions may find it beneficial to buy from several information sellers. This is more likely to happen when the reliability of information is low and the sources of information are independent. Under such conditions, information sellers anticipate the consumers’ problem and tend to charge higher prices. In the opposite case, when information is reliable and/or sellers’ sources are highly correlated, consumers are satisfied after consulting a single source. In this case, sellers tend to decrease prices to induce consumers to choose their brand. In other words, higher correlation between information sources make information products substitutes. Uncertainty and independence among information sources, however,
What makes information different from other goods and services is that the latter are either substitutes or complements in the relevant product-attribute space, whereas information may be one or the other depending on its position within the same product-attribute space. Said differently, the nature of competition changes qualitatively with a (continuous) change in basic product-attribute levels.

To better illustrate this difference consider the following example. Imagine consumers of brass - a metal composed of zinc and copper - who are served by two brass sellers. Irrespective of product characteristics (qualities), their products will always be substitutes because one seller - at least partially - replaces the other. Firms are interested in decreasing prices to capture a larger part of the total demand. With identical firms one will observe marginal cost pricing. Consider now the case of two firms producing copper and zinc respectively for the same consumers. This time, irrespective of their characteristics (qualities), the two products are perfect complements. Purchasing from only one firm is pointless without purchasing from the other. In such a setting, firms do not try to undercut the competitor’s price but rather try to increase prices to extract as much surplus as possible from the total price that consumers are willing to pay for the composite good. The prices set by a monopolist producing both components would be lower than the equilibrium prices under competition.

In competition, traditional goods behave either like brass (they are substitu-

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2In this paper we define substitutability and complementarity from the firms’ point of view by referring to the sign of the cross-price elasticity of demand. If it is positive products are substitutes, in the opposite case they are complements. Had we taken the consumer’s viewpoint our conclusions would not differ from those of standard sampling theory with fixed sampling cost. The innovation in our model is that the “cost of sampling” is endogenous.

3Technically speaking, for traditional goods the value of the cross-price elasticity may change with a change of basic product attributes but its sign does not. In the case of information products, changing the products’ attributes can result in a change of the sign of the cross-price elasticity of demand.

4This example has been inspired by the earliest study on perfect complements by Cournot (1838). Economides and Salop (1992) provide a formal description of this Cournot model and a discussion on complements. Other important papers on complementarity include Matutes and Regibeau (1988), Economides (1989) and Gilbert and Riordan (1995).
tutes) or like copper and zinc (they are complements). What is interesting with information products is that - unlike most other goods - they are substitutes or complements depending on the levels of basic product characteristics, attributes which are inherent to information: reliability (variance) and similarity (correlation). As a result, competitive behavior is very different in different regions of the product-attribute space. When information products are reliable or highly correlated, products are substitutes and competition between information suppliers is intense. When product reliability is low products are complements and competition between sellers is relatively mild (if reliability is a measure of quality, this may also mean that profits are higher when competitors have lower quality products). These findings are consistent with the general theory on substitutes and complements (see the references in footnote 4). In particular, we get the standard result that integration or merger of firms producing perfect complements raises profits as well as consumer welfare (Allen 1938).

2.2 Related Literature

Our work is related to three important streams of literature: normative decision theory, industrial organization and information economics. The focus of normative decision theory is the problem of a decision maker who has to acquire information before making decision(s). The goal is to assess the value of information in order to trade it off against its cost. In this context, the “cost” of information is exogenous or it is under the control of the decision maker. In modern economies, however, the price of information is endogenously determined in competitive markets. In this paper we focus on the supply-side of information markets and allow competing information sellers to set the price of information. In this respect our work is closer in spirit to the second stream, the literature on oligopolistic competition. In particular, our model is related to the literature on complementarity (see references in footnote 4) and the literature on vertical differentiation (Mussa and Rosen 1978, Gabszewicz and Thisse 1979, Shaked and Sutton 1982, Moorthy 1988) which assumes that consumers differ in their willingness to pay for higher levels of product quality.

We depart from the third stream of literature, the information economics tradition, in a number of ways. Economic theory considers information to
be a "public good", that is, a good available for free. The argument is either that information does not perish when used, and therefore it can be resold after "consumption", or that it gets revealed in the actions of the information users, so there is no incentive to purchase information. We depart from this tradition by realizing that, in modern economies, legal constraints (e.g. copyright laws) prevent the resale of information. We also assume that information is not revealed in the actions of the information users, this being an issue only when consumers can observe a large number of simple transactions (e.g. stock markets).\footnote{Important papers on this problem include Grossman and Stiglitz (1980), Admati and Pfleiderer (1986, 1988, 1990) and Saunder (1992).} Second, we do not consider the effects of information asymmetry due to opportunistic behavior of the firms (e.g. signalling or screening). In our discussion, information asymmetry exists to the extent that sellers hold tradable information of value to consumers.

3 The model

To illustrate the model we will use the example of competing consulting companies (firms) selling reports on the status of an industry and its future prospects to their clients (the consumers) who buy these report(s) to use them when planning their business strategies. A good example of this scenario is EMCI Inc., a U.S. based company specialized in selling reports on the mobile telecommunications industry. There are, of course, many other types of consulting services. Often consultants provide diagnosis for clients or recommendations on how to implement a given marketing strategy. For the sake of illustration, we have picked one type of consulting firm that nicely captures the essence of information selling. Later we show that a very similar formulation would apply to other types of consulting services that involve diagnoses or recommendations.\footnote{Our discussion excludes situations where the consultant is also contracted to implement the recommended strategy. We restrict our attention to cases where only information is delivered to the consumer. A recent paper by Wolinsky (1993) looks at competition in a market for services offered by informed experts who also diagnose how serious the consumer's problem is. His paper focuses on opportunistic behavior when the expert has an incentive to overstate the seriousness of the problem.} Besides consulting, this illustration is also analogous to a variety of other situations such as the competition between cardiologists providing medical diagnosis, lawyers giving legal advice, or stock
brokers giving buy/sell recommendations.

It is not rare in practice that a firm buys and compares several reports, each from different consultants, to get a better picture of the industry. The number of reports that the client buys depends on the perceived reliability of each report (e.g. its perceived quality), on their perceived similarity (e.g. their perceived substitutability) and their prices. Knowing these perceptions, consultants simultaneously set their prices while forming expectations about consumers' information acquisition strategies. We will require these expectations to be rational, i.e. they must be fulfilled in equilibrium. In this setting, product perceptions are exogenous and fixed. Later, we will discuss the case of a two-stage game where firms first choose their positions in the perceptual space and then, in the second stage, set prices given these product positions.

3.1 The players and the product space

3.1.1 Firms

Assume a duopoly that consists of two consultants selling reports. They have similar cost structures and for simplicity we assume that the marginal, as well as fixed cost of producing a report are 0. In section 4 we will explore the implications of relaxing this assumption. We also assume that entry in the industry is not possible.

Suppose further that the information content of consultant i’s report consists of a number, $x_i$, that can be thought of as the predicted dollar value of total business opportunities in the industry. We assume that $x_i$ is a random draw from a normal distribution with mean $m$, the true value of business opportunities and variance $\sigma_i^2$, which represents the inverse of the “reliability” of firm i’s report. Had we used another scenario, $x_i$ and $m$ would mean different things. In the case of EMCI Inc., for instance, $m$ is the true demand for cellular services and $x_i$ is a demand forecast. Alternatively, if the report would be about the implementation of a marketing strategy (say the recommended size of the salesforce), $m$ would be the “best” implemented solution (the optimal size).\footnote{We would like to thank the Editor for this insight.} The reports issued by different firms do not have to be
independent and we suppose that the $x_i$-s are correlated with correlation coefficient $\rho$.\(^8\) At the time of the purchase decision, the value of $m$ is unknown to all players but the $\sigma_i^2$-s and $\rho$ are common knowledge.\(^9\) Thus, the product space can be described with a bivariate normal distribution with mean vector $(m, m)$ and covariance matrix

$$
\Sigma = \begin{pmatrix}
\sigma_1^2 & \sigma_1 \sigma_2 \rho \\
\sigma_2 \sigma_1 \rho & \sigma_2^2
\end{pmatrix},
$$

where all parameters are exogenous. In marketing terms, the parameter space $(\sigma_1, \sigma_2, \rho)$ can be thought of as the perceptual space for information products.

### 3.1.2 Consumers

Consumers can choose to buy the report of firm 1, the report of firm 2 or both reports. For simplicity we will refer to these alternatives as product configurations, indexed $1, 2$, and $\Sigma$ for the composite good. If the consumer buys one report, say from firm $i$, her estimate for $m$ will be $x_i$ with variance $\sigma_i^2$. Upon buying two reports the consumer weights their contents with their corresponding reliabilities\(^10\), thus her estimate of $m$ will be the composite product, $\bar{x}$ with variance $\Sigma^2$, where

$$
\bar{x} = \frac{x_1/\sigma_1^2 + x_2/\sigma_2^2}{1/\sigma_1^2 + 1/\sigma_2^2}
$$

\(^8\)Positive correlation of expert opinion is supported by empirical evidence. It can result from the fact that experts share some information sources or that they have similar priors due to common education, for instance. Negative correlation is unlikely but theoretically possible.

\(^9\)Later, the value of $m$ may be revealed but this is irrelevant for the firms’ current decision making. As it will become clear later, 1 is a natural limit for $\sigma_i^2$, above which no consumer would purchase product $i$ alone. Thus we will assume that $\sigma_i^2 < 1$ ($i = 1, 2$).

\(^10\)The literature on expert resolution suggests several possible weighting schemes to combine overlapping expert opinion (see, for example Winkler 1981, Makridakis and Winkler 1983, Ashton 1986, Clemen 1987, Gupta and Wilton 1987, Morrison and Schmittlein 1989, Schmittlein et. al. 1990, Batchelor and Dua 1995). A good review can be found in Clemen (1989). In addition to the above weights we have also tried several other weighting schemes, including simple average, weighting by the inverse of the standard deviations and the weights suggested by Winkler (1981) which take into account the dependence of the reports. The results are virtually equivalent to the ones presented below.
and

$$
\Sigma^2 = \frac{\sigma_1^2 \sigma_2^2}{(\sigma_1^2 + \sigma_2^2)^2} (\sigma_1^2 + \sigma_2^2 + 2 \sigma_1 \sigma_2 \rho).
$$

The estimation error \((y = x_i - m, \text{ if one report is bought and } y = \bar{x} - m, \text{ if two reports are bought})\) is also normally distributed with mean 0 and the variance of the estimators. We assume that consumers have a quadratic loss function, \(L(y) = y^2\). The expected loss of a consumer buying \(n\) reports \((n = 1, 2)\) is, therefore:

$$
\mathbb{E}L = \int_{-\infty}^{\infty} y^2 f_n(y) \, dy
$$

where \(f_n(y)\) is the density function of \(y\) \((n\) refers to the number of reports bought\) and \(\mathbb{E}\) stands for expectation. It follows that the expected loss of a consumer is equal to the value of the variance of the estimator.

Adopting the framework of the vertical differentiation literature, we assume that consumers are heterogenous in their willingness to pay for the “quality” of the reports. The advantage of this approach is that we do not need to have specific assumptions on the way consumers use the purchased information. We need to define, however, what we mean by the “quality” of information. We will define the quality of the purchased product configuration as \(s = 1 - \Sigma^2\); i.e. quality is linearly decreasing in the value of the consumer’s expected loss.\(^{11}\) Thus,

\[
s_i = 1 - \sigma_i^2 \quad \text{if only firm } i’s \text{ report is bought},
\]

\[
s = 1 - \Sigma^2 \quad \text{if both firms’ reports are bought}.
\]

Given the constraints on the \(\sigma_i\)-s, quality is allowed to vary between 0 and 1. Following the literature on vertical differentiation we will assume that the expected surplus of a consumer with type \(\theta\), for buying a configuration, given that firms charge prices \(p_i\) for their reports is:

\[
U = \begin{cases} 
\theta(1 - \Sigma^2) - p_1 - p_2 & \text{if both reports are bought}, \\
\theta(1 - \sigma_i^2) - p_i & \text{if only firm } i’s \text{ report is bought}, \\
0 & \text{otherwise}. 
\end{cases}
\]  

\(^{11}\)We could have defined quality as \(s = 1/(\mathbb{E}L)\), but this would have lead to huge values of \(s\) in the case of reliable reports. Another advantage of our definition is that, in this way, the parameter space is finite and allows graphical illustration of the results (see later the argument on the uniqueness of the equilibria, for instance).
Here, $\theta$ is a positive taste parameter (see Tirole 1990, Chapter 2, pp 96) with a higher $\theta$ meaning that the consumer values the quality of information more or, equivalently, that she is more sensitive to potential losses. Another interpretation of $\theta$ is that it is the inverse of the marginal rate of substitution between income and quality (Tirole 1990), i.e. wealthier consumers have a higher $\theta$. We assume that $\theta$ is known to be distributed across consumers between 0 and 1 according to the cumulative density function $F$. Thus, there is a continuum of consumers and without loss of generality we normalize their total number to 1. Finally, note that utility does not depend on the content of the reports. As mentioned before, consumers do not know this value before making the purchase decision, so their ex ante utility for information should not depend on it.

As we will see later, the above preference structure implies that the demand function is piece-wise continuous (Tirole 1990). Thus, we derive the solutions to the game as follows. Suppose that firms expect the demand for each product configuration to be $D_k(p_1, p_2)$, where $k (k = 1, 2, \Sigma)$ refers to the configuration in question. For these expectations to be rational the equilibrium prices have to fulfill certain conditions. Given the demand, we solve for the equilibrium prices, $p^*$. Finally, we feed back these prices in our ex ante condition to make sure that firms’ expectations are rational, i.e. that given the prices, consumers choose the optimal number of reports. In this way we delimit the parameter region where the $(D_k, p^*)$ pair forms a rational expectations equilibrium in pure strategies.

### 3.2 Solutions of the game

In what follows, we will analyze three cases. First, to set a benchmark we explore the model with a monopolist. Next, we take the case of two competing consulting firms. Finally, we examine the case when the monopolist can internalize competition by creating two marketing subsidiaries that consumers perceive as being independent (i.e. producing the reports independently).\(^{12}\)

\(^{12}\)Note that even in this case the reports may be correlated but not “more” correlated than the reports of two competing consultants. The monopolist could also pool the content of the separate reports and sell a single report for a higher price. This may not be always possible if consumer perceptions are linked to the reputation of “brands” (see the discussion later on the formation of consumer perceptions). In such cases the monopolist may not
We compare the monopoly outcome to the equilibria under different forms of competition. For the remaining discussion we will assume that $\mathcal{F}$ is the c.d.f. of the uniform distribution between 0 and 1. We also assume that $\sigma_i^2 < 1 \forall i$.

### 3.2.1 Monopoly

The monopolist sells a maximum of one report to each client. Expression (1) becomes $U = \theta s - p = \theta (1 - \sigma^2) - p$ and, given our assumption on $\mathcal{F}$, the demand faced by the monopolist is

$$D(p) = \Pr(U > 0) = 1 - \mathcal{F}(p/s) = 1 - p/(1 - \sigma^2).$$

The optimal price charged by the monopolist is $p^M = (1 - \sigma^2)/2$. Output is $q^M = 1/2$ and the monopolist's profit is $\pi^M = (1 - \sigma^2)/4$. Given $p^M$ and the uniform distribution of $\theta$, total consumer surplus is:

$$S^M = \int_{1/2}^1 [\theta(1 - \sigma^2) - p^M]d\theta = (1 - \sigma^2)/8.$$

### 3.2.2 Duopoly

Here consumers can decide to buy zero, one or two reports depending on the $\sigma_i^2$'s, $\rho$ and the prices. The demand conditions are defined by the relative values of the "quality per dollar," $(s/p)$, of the different product configurations. One can show (see Tirole, 1990, pp 97. for a formal proof) that in the above vertical differentiation model, if $s_2 > s_1$ and $s_2/p_2 \geq s_1/p_1$ then product 1 gets no demand, since all consumers who decide to purchase will end-up buying product 2. When $s_2/p_2 < s_1/p_1$, however, some consumers purchase the lower quality product. In our case, there are three alternative product configurations: buying the higher quality report, the lower quality report or both reports. In the last case the price is the sum of the prices of the individual reports and the quality is always higher than any of the individual report's. When setting prices firms have to develop expectations about the relations between the quality/price of each product configuration.

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be able to convince consumers - at least in the short run - that the "master report" is of higher quality than one of its components.
In what follows we will show that in a duopoly there are two types of equilibria: one in which products act as substitutes (Proposition 1) and another in which products are complements (Proposition 2). The propositions tell us under what conditions the proposed equilibria exist. We will analyze these conditions and relate them to some observed market outcomes. Finally, we compare each equilibrium to the monopoly case. We begin by exploring an equilibrium where all three alternatives are chosen by some consumers and argue that in this case, products act as substitutes leading to “intense” competition among information sellers.

**Proposition 1 (Substitutes)** Suppose that \( \sigma_j < \sigma_i \) (i.e. \( s_j > s_i \)). There exists a unique Nash equilibrium in pure strategies in which each of the three product configurations are bought by some consumers if

\[
p > \frac{(\sigma_1^2 + \sigma_j^2)^2}{2(\sigma_1 \sigma_2)^3} \left( \frac{1 - \sigma_j^2}{3 - 2\sigma_1^2 - \sigma_j^2} \right) - \frac{\sigma_1^2 + \sigma_j^2}{2\sigma_1 \sigma_2}. \tag{2}
\]

Under (2) competing products are substitutes.

**Proof of existence:**
Without loss of generality, suppose that \( j = 2 \) and \( i = 1 \), i.e. \( s_\Sigma > s_2 > s_1 \).

For the proposed equilibrium to exist the following condition has to hold:

\[
\frac{s_\Sigma}{p_1 + p_2} < \frac{s_2}{p_2} < \frac{s_1}{p_1}, \tag{3}
\]

in other words, no product configuration dominates others for all consumers. Essentially, (3) represents firms' expectation about the demand. Given prices \( p_1 \) and \( p_2 \), we have for the marginal consumer who is indifferent between purchasing both reports and the higher quality report alone: \( \overline{\theta} s_\Sigma - p_1 - p_2 = \overline{\theta} s_2 - p_2 \). Thus, \( \overline{\theta} = p_1/(\sigma_1^2 - \Sigma^2) \). Similarly, for the consumer who is indifferent between buying the higher quality report and the lower quality one we have: \( \overline{\theta} = (p_2 - p_1)/(\sigma_2^2 - \sigma_j^2) \). Finally, the consumer who is indifferent between buying the lower quality report and not buying at all has taste parameter \( \overline{\theta} = p_1/(1 - \sigma_j^2) \). Thus, the demand for the three configurations respectively can be written as:

\[
D_\Sigma = 1 - \mathcal{F} \left( \frac{p_1}{\sigma_1^2 - \Sigma^2} \right)
\]
\[ D_2 = \mathcal{F}\left( \frac{p_1}{\sigma_2^2 - \Sigma^2} \right) - \mathcal{F}\left( \frac{p_2 - p_1}{\sigma_2^2} \right) \]

\[ D_1 = \mathcal{F}\left( \frac{p_2 - p_1}{\sigma_1^2 - \sigma_2^2} \right) - \mathcal{F}\left( \frac{p_1}{1 - \sigma_1^2} \right). \]

Therefore, the demand of firm 2 is \( D_{II} = D_{\Sigma} + D_2 \) and that of firm 1 is \( D_I = D_{\Sigma} + D_1 \). Note that \( \partial D_{II}/\partial p_1 \geq 0 \) and \( \partial D_I/\partial p_2 \geq 0 \), i.e. the two products are substitutes. Using these demand functions and given our assumptions on \( \mathcal{F} \), it is easy to calculate the equilibrium prices. After some algebra we get:

\[ p_1^* = \frac{3\delta d\Delta}{4\delta(\Delta + d) + 3d\Delta} \]

and

\[ p_2^* = \frac{3\delta d\Delta + 2\delta^2(\Delta + d)}{4\delta(\Delta + d) + 3d\Delta}, \]

where \( \delta = \sigma_1^2 - \sigma_2^2 \), \( d = 1 - \sigma_1^2 \) and \( \Delta = \sigma_2^2 - \Sigma^2 \). To ensure that firms' expectation about the demand is indeed rational we need to put these prices back into the conditions under (3). It turns out that only the first inequality is binding. After substitution and using the definitions of \( d, \delta, \Delta \) and \( \Sigma \), this inequality is equivalent to (2). \( \square \)

In Proposition 1 we have assumed that the quality of the two reports are strictly different. If the qualities were exactly equal, then Bertrand competition would drive prices down to marginal cost. Indeed, the equilibrium prices above become 0 as the difference between the quality of the reports goes to 0 (i.e. \( \delta \) becomes 0). Under this condition we expect all consumers to purchase both reports. One can check that this is the case: \( D_1 \) and \( D_2 \) are 0 and \( D_{\Sigma} = 1 \). To see this, note that

\[ \lim_{\sigma_1 \rightarrow \sigma_2} \frac{p_2 - p_1}{\sigma_1^2 - \sigma_2^2} = \lim_{\delta \rightarrow 0} \frac{2\delta(\Delta + d)}{3d\Delta + 4\delta(\Delta + d)} = 0. \]

It is also easy to show that \( D_{\Sigma} \) decreases in \( \rho \), i.e. higher correlation results in less consumers purchasing both reports in equilibrium. Said differently,
higher correlation makes the products substitutes. Finally, in the parameter region defined by (2) profits are smaller and consumer surplus is higher under competition than for a monopolist. This is natural when products are substitutes and it is easy to check for symmetric competitors. As we have seen profits are 0 in symmetric competition, whereas under monopoly, $\pi^M = (1 - \sigma^2)/4$. In a symmetric duopoly consumer surplus is:

$$S^D = \int_0^1 \theta(1 - \Sigma^2)d\theta = (1 - \Sigma^2)/2,$$

which is always higher than $S^M = (1 - \sigma^2)/8$, the surplus under monopoly.

What is the meaning of Proposition 1? Proposition 1 identifies the condition under which products clearly act as substitutes. The firms have an incentive to undercut each other’s prices in a Bertrand-type competition. With symmetric competitors this leads to 0 profits. Condition (2) says that for this to happen information products need to be reasonably reliable and/or have to be correlated enough. In other words, in information markets with such product characteristics we can expect intense competition among sellers.

Now let us consider an equilibrium in which all consumers who decide to purchase at all buy both reports. We will argue that, in this equilibrium, products act as complements. Proposition 2 states the condition for such an equilibrium to exist.

**Proposition 2 (Complements)** Suppose that $\sigma_j \leq \sigma_i$ (i.e. $s_i \geq s_j$). There exists a unique, symmetric Nash equilibrium in pure strategies in which consumers buy zero or two reports if

$$\rho \leq \frac{(\sigma_1^2 + \sigma_2^2)^2}{2(\sigma_1 \sigma_2)^3} (2\sigma_2^2 - 1) - \frac{\sigma_1^2 + \sigma_2^2}{2\sigma_1 \sigma_2}.$$  

(4)

Under (4) competing products are complements.

**Proof of existence:** Suppose again that $j = 2$ and $i = 1$. In equilibrium, buying two reports is optimal for all consumers who decide to purchase, if and only if,

$$\frac{s_1}{p_1 + p_2} \geq \frac{s_2}{p_2} \quad \text{and} \quad \frac{s_1}{p_1}.$$  

(5)
In other words, firms’ expectation is that the product configuration including both reports dominates all other product configurations. Given this assumption, by finding the consumer who is indifferent between purchasing both reports or nothing, we obtain the demand for each of the configurations:

\[ D_\Sigma = 1 - \mathcal{F}(\frac{p_1 + p_2}{1 - \Sigma^2}) \]

and

\[ D_2 = D_1 = 0. \]

Note that now \( D_{II} = D_I = D_\Sigma \) and \( \partial D_\Sigma / \partial p_i \leq 0 \) \( \forall i \), i.e. the two products are complements. Solving for equilibrium we obtain \( p_1^* = p_2^* = (1 - \Sigma^2)/3 \). Note that the equilibrium prices are symmetric even if the qualities of the reports are different, so the seller with the lower quality report “free rides” on the other. Feeding the equilibrium prices back in condition (5) and taking into account that only the first inequality is binding we get condition (4) of the Proposition which completes the proof. □.

Under condition (4), in equilibrium, the demand for the configuration that includes both products (that is the sales of both firms) is \( D_C = 1/3 \), firms’ profits are \( \pi_C = (1 - \Sigma^2)/9 \) and consumer surplus is:

\[ S^C = \int_{2/3}^{1} [\theta(1 - \Sigma^2) - \frac{2}{3}(1 - \Sigma^2)]d\theta = (1 - \Sigma^2)/18. \]

In this equilibrium, consumers perceive information as complementary. Anticipating this, firms price their reports in such a way that, in equilibrium, buying a single report makes no sense to anyone. Said differently, the products are perfect complements. In this case, each firm tries to extract as much as possible from the total price that the consumers are willing to pay for the composite product, i.e. firms tend to increase their prices rather than undercut competition. This results in relatively mild competition where even symmetric firms make positive profits. Complementarity also drives the free-riding effect in this equilibrium. If the products are perfect complements one is worthless without the other irrespective of product qualities. In other words, there is no reason for consumers to pay a higher price for any of
them.\textsuperscript{13} Proposition 2 says that for such an equilibrium to exist the reports have to be unreliable enough and not too correlated.

Summarizing, if condition (2) holds then there exists an equilibrium under which each configuration is purchased by some consumers and products are substitutes. If condition (4) is fulfilled, there exists an equilibrium in which consumers buy zero or two reports and the products are complements. Figure 1 illustrates these conditions in the parameter space \((\sigma_1^2, \sigma_2^2, \rho)\). The two surfaces delimit the regions defined by (2) (over surface 1a) and (4) (under surface 1b). The two regions do not intersect, which ensures uniqueness of the two Nash equilibria in the corresponding parameter regions.\textsuperscript{14} Figure 2 shows cross sections of the parameter space when \(\sigma_i = \sigma_j\), i.e. the competitors are symmetric (Figure 2a) and when \(\rho = 0\), i.e. their reports are independent (Figure 2b). Observing these figures helps to understand the main message of the paper, namely that, unlike other goods, information products face very different competitive structures in different regions of the same product attribute space. This is best seen on Figure 2a, i.e. when competitors are symmetric. In this case there always exists an equilibrium in pure strategies and each consumer buying any report purchases two of them. The equilibrium outcomes are very different in the two regions divided by the curve on the Figure. On the left side of the curve the price of both reports is 0 and every consumer buys. On the right side, however, the price jumps to a positive amount and some consumers are excluded from the market. It is this discontinuity that makes information products interesting.

\textbf{INSERT FIGURES 1 AND 2 ABOUT HERE}

How can we relate this finding to observed market outcomes? The model

\textsuperscript{13} The free-riding effect holds when firms are not too different. If the quality differences are very large then the firm with the higher quality simply drives the other firm out of the market (see the graphical analysis of the conditions of the equilibria below). Assuming the existence of marginal costs leads to different equilibrium prices but the free-riding effect persists in the sense that firms' profits are equal.

\textsuperscript{14} To be precise, in order to prove uniqueness, one also needs to show that the above mentioned two equilibria are the only possible rational expectations equilibria. In a technical appendix (available from the authors) we show that other possible scenarios can not constitute an equilibrium.
predicts that the more information products are correlated and the more reliable they are the more they become substitutes and the more competitors have incentive to decrease prices. In the opposite case, products become complements and equilibrium prices tend to increase. This may explain the differences in competitive structures for different types of consulting services. Contrast valuation services (the case of Portugal Telecom) with market research for instance (IRI or AC Nielsen). Techniques for company valuation involve a fair amount of subjective assessment especially when intangible assets need to be taken into account. They also differ substantially in their approach. These methodologies are typically perceived to be unreliable - not because of a lack of expert competence but rather because of the nature of the problem. As a result, in most IPO-s (Initial Private Offerings), or take-overs, multiple consultants are hired to assess the value of the target firm. In contrast, market research techniques used by IRI or AC Nielsen tend to provide similar and quite accurate results. It is rare that a firm would hire both companies simultaneously\textsuperscript{15} and, as a result, competition is fierce in this business. The model also helps to understand the contrast between competition of consultants in Eastern Europe and western countries. It is not rare to observe multiple consultations in East European countries where the economy undergoes fundamental changes. Despite the fact that import costs are lower (firms hire locals) and consulting advice is less reliable due to the general lack of experience in economic environments under transformation, consultants are able to maintain relatively high fee structures. The reason is that in risky environments the combination of different opinions may lead to a better decision, i.e. information products are complements.

Based on these examples, one might naturally ask: are there conditions under which a monopolist is better off facing a competitor? We can address this question by comparing profits and consumer surplus under competition and monopoly. We have already seen that when each configuration is bought by some consumers (reports are substitutes), consumer surplus is higher and profits are lower under competition than under a monopoly regime. When no consumer buys a single report (reports are complements) this is not always

\textsuperscript{15}According to a recent survey by Mercer Management Consulting, only about 17% of consumer packaged goods manufacturers simultaneously purchase information from both IRI and AC Nielsen. We would like to thank Alan Montgomery for this example.
the case. The following Proposition establishes the conditions under which a monopolist is better off encouraging the entry of a competitor.

**Proposition 3** Suppose that the condition of Proposition 2 holds and that the monopolist is player $k$ ($k = 1, 2$). Then profits and consumer surplus are higher under competition if

$$
\rho \leq \frac{(\sigma_1^2 + \sigma_2^2)^2}{8(\sigma_1 \sigma_2)^2} (9\sigma_k^2 - 5) - \frac{\sigma_1^2 + \sigma_2^2}{2\sigma_1 \sigma_2}.
$$

Figure 3 illustrates Proposition 3 when the entering competitor has the same product quality as the monopolist (Figure 3a) and when the competitor’s product is statistically independent from the monopolist’s (Figure 3b). In the first case, the left curve is condition (4) of Proposition 2: below the curve, in equilibrium, the reports are complements. Under the right curve, firms’ profits are higher in competition than the monopolist’s. To interpret the case of asymmetric competitors, note that condition (6) is different depending on the product quality of the new entrant. On Figure 3b we have assumed that $k = 2$, i.e. the monopolist has a higher product quality in the lower right corner of the parameter space (where $\sigma_1 > \sigma_2$). When the entering competitor has lower product quality, condition (6) of Proposition 3 is more restrictive than in the opposite situation. Said differently, the higher the product quality of the monopolist the less inclined she is to invite competition. This is due to the free-riding effect mentioned earlier. Inviting a higher quality competitor provides relatively more benefits for the incumbent because the quality of the composite good will be better.

The intuition behind Proposition 3 is the following. When products are complements the quality and the price of the composite good alone determine the demand. When the individual reports’ reliability and correlation is very low, the increase in quality is very high after the combination of the reports. In other words, the base demand increases significantly. At the same time prices do not fall as we have shown in Proposition 2.

This finding may explain an apparently irrational behavior of EMCI Inc. (the publisher of industry reports, discussed earlier). EMCI seems to encourage
the entry of competition by regularly swapping its client mailing lists with competitors.\textsuperscript{16} It is important to note that industry forecasts show very high variance (are typically unreliable) in the cellular phone industry. Realizing that their products are complements, the firm does not expect that clients will purchase from competitors instead of EMCI. It expects them to purchase from both.

3.2.3 Monopolist with two independent marketing subsidiaries

If under some conditions the monopolist and consumers are better off in a duopoly where firms charge higher prices, clearly the monopolist may be interested in creating two marketing subsidiaries which are perceived by consumers as being independent. In this case the monopolist has to decide alone about the prices of the two reports given their characteristics, thus internalizing the price competition. As mentioned earlier, this situation is equivalent to pooling the content of the two reports and selling the resulting single report for a higher price (a merger). Furthermore, one can also think of this situation as two firms producing their reports independently but colluding in price. The monopolist has to decide which strategy is feasible under the existing marketing and legal constraints.\textsuperscript{17}

The following Proposition establishes (for a specific pricing rule) the condition under which the monopolist can induce all consumers, who end-up purchasing at all, to buy the reports of both subsidiaries.

**Proposition 4** If a monopolist can credibly commit to have two independent subsidiaries and if she sets the quality-price ratio of the products to be equal \((s_1/p_1 = s_2/p_2)\) then the monopolist can sell two reports to the consumers who end-up buying at all, if

\[
\rho \leq \frac{(\sigma_1^2 + \sigma_2^2)^2}{2(\sigma_1 \sigma_2)^3} \left(\frac{\sigma_1^2 + \sigma_2^2}{\sigma_1 \sigma_2} - 1\right) - \frac{\sigma_1^2 + \sigma_2^2}{2\sigma_1 \sigma_2}.
\]

\textsuperscript{16}Based on a personal interview with the company chairman, September 20, 1993.

\textsuperscript{17}Note that internalizing competition through collusion is always possible and we expect firms to be always better off this way. The point here is that when the products are complements collusion may be better not only for the firms but also for consumers (see Proposition 5). This is why we are interested in situations where the reports are complements, i.e. when both of them are purchased by all consumers.
The proof (and graphical illustration) of Proposition 4 is similar in spirit to the previous proofs and can be found in the technical appendix. When two reports are sold to all consumers (one by each subsidiary) output of each is \( q^s = 1/2 \), total profit of the monopolist is \( \pi^s = (1 - \Sigma^2)/4 \) and consumer surplus is \( S^s = (1 - \Sigma^2)/8 \). Comparing profits and consumer surplus under the two-subsidiary situation and the competitive case, we obtain Allen's (1938) result for the case of perfect complements:

**Proposition 5** If the monopolist with two marketing subsidiaries can sell two reports to all the consumers who eventually buy, then consumer surplus as well as aggregate profits will be higher than under competition.

The intuition behind Proposition 5 comes from the fact that under complementarity firms try to extract as much as possible from the total price that the consumers are willing to pay for the combined product. This results in higher prices than the ones chosen by a monopolist who wants to simultaneously maximize the revenues from both products. Proposition 5 may be relevant to regulators of information markets. It points to the fact that whether cooperation among information providers - in the form of explicit mergers or pricing agreements - is socially beneficial depends on the basic properties of the information products available in the market. The analysis above suggests that when information is unreliable and the sellers' sources are independent, competition may not necessarily lead to the increase of social welfare. Said differently, mergers or price fixing agreements may be socially beneficial under these circumstances.

The trade press has recently discussed a number of interesting cases related to the regulation of the information industry. In 1987, for instance, the Federal Court opposed to the acquisition of IRI by Dun & Bradstreet - the owner of AC Nielsen (Business Week, Dec. 7, 1987). Despite this decision, some years later, IRI was successful in buying Arbitron's SAMI service from Control Data Corporation, thus reducing the marketing research business to two major players (Advertising Age, Oct. 8., 1990, p.82). Besides these specific examples there is a general discussion in the trade press on the regulation of referral firms and independent medical practice associations. In a recent issue of Fortune magazine, for example, Olson (1989) analyzes the development of large referral firms that have several hundred experts on call to testify in lawsuits. The article asks whether such services should be ordered
by the court or by the opposing sides. It would seem reasonable, for example, that in legal proceedings the court system be responsible for the hiring (and, therefore, pricing) of consultations of expert witnesses, as is common practice in many European countries (rather than both parties hiring several experts representing the opposing sides). Similar arguments might be made for providers of certain health services. Planners are divided over the issue of how "free" a medical services market should be? While this is a complex discussion, our findings concern one subset of medical services, the provision of expert diagnoses. According to our results, when products are unreliable, the planner can increase welfare by internalizing the effect of the price competition among experts. Such policies can be observed in France, for example, where there is an upper limit to the price a doctor can charge for various routine diagnostic visits. Similar price controls have been set in France for certain consultations with lawyers.

An interesting question in the two-subsidiary case is: when will a monopolist (or a cartel) sell the information products under the name of two independent subsidiaries, versus pooling the content of the reports and sell this for a higher price? The answer depends largely on how consumer perceptions are formed. If these perceptions are linked to the reputations of brands, i.e. if they take a substantial time to develop, then the joint firm may be better off selling the individual reports separately under the original brand names. The reason is that consumers may not perceive the pooled report to have better quality when sold under the brand name of any of the original firms. A recent example is the merger of Dialog and Data-Star, two competing firms providing access to various databases (Online, July, 1993; Information World Review, March, 1993; Information Today, April, 1993). An interesting feature of this merger is that the two companies "will stay competitors", as announced by Data-Star. The same outcome occurred after the merger of two other information providers, Dow Jones News/Retrieval and Data Times: the two companies will maintain their original compet-

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18 See also recent issues of Modern Healthcare, Barron's, Business Insurance, Journal of Healthcare Marketing, Trustee and Medical Economics on this topic.

19 The French government has recently been forced to introduce the "Carnet the Santé", a medical record booklet which exists to discourage individuals from visiting multiple doctors for the same illness since the government traditionally reimbursed all diagnostic visits.
ing brands (Information Today, Sept. 1990; Link-Up, May/April, 1992). In other situations perceptions of product quality may be linked to observable features such as a specific technology (e.g. the diagnosticity of different types of medical equipment). In this case firms may be able to convince consumers in the short term that by combining different technologies the resulting information product (diagnosis, forecast, etc.) is of better quality and the firms can, therefore charge a higher price for it.

Finally, regulators are generally more interested in making sure that in an a priori profitable cartel, the subsidiaries produce independently from each other ex post. In some cases this is in the interest of the monopolist. An example would be the situation when the monopolist wants to preserve in the long run the favorable consumer perceptions of the composite good. Under other situations the regulator has to face the moral hazard of the information sellers.

4 Extensions and Limitations

4.1 Two-stage game with costs

Fixed costs:
In the previous model the parameters, \(\sigma_1, \sigma_2\) and \(\rho\) cannot be influenced by firms. One could think of an extension in which, in the first period, producers choose their positions in the perceptual space at some fixed costs, \(K_i(\sigma_i)\) (see Hauser and Shugan 1983), and compete according to our previous analysis in the second stage (\(\rho\) can stay exogenous but may also be influenced by firms at some cost). This case would be analogous to situations where the experts first need to establish reputations and then compete accordingly. The cost of establishing a reputation can come from the costs of a “good” education, the purchase of expensive equipment or from a costly marketing campaign.

With fixed costs in the first period, producer \(i\) needs to maximize:

\[
\pi_i(\sigma_i, \sigma_j) - K_i(\sigma_i)
\]

with respect to \(\sigma_i\). In expression (8), \(\pi_i(\sigma_i, \sigma_j)\) is the second period equilibrium profit given \(\sigma_i\) and \(\sigma_j\). Note, that this profit function is not continuous.
in \( \sigma \), and we can expect the equilibrium positions in the parameter space to be very sensitive to the cost function, possibly leading to corner solutions.

**Variable costs:**
It is possible that higher perceived reliability is acquired with higher fixed costs as well as higher variable costs. The firm may use higher quality paper in producing its reports, for instance. In this section we would like to examine how the results of the previous sections change when, in the second stage, the marginal cost of producing a report with higher perceived reliability is also higher. With positive marginal costs, the condition for an equilibrium where all product configurations are purchased by some consumers (i.e. the products are substitutes) is the following (see technical appendix):

\[
\Delta^2 [3d\delta + 2\delta^2 + (\delta + d)(c_1 + 2c_2)] - \Delta [3d\delta^2 + d\delta^2 - c_1(d\delta - 2(d + \delta)^2) - dc_2(\delta - d)] - 2d\delta c_1(\delta + d) < 0. 
\]  

(9)

When in equilibrium only the composite good is sold (i.e. products are complements) the condition is:

\[
(\Sigma^2)^2 - \Sigma^2(2\sigma_2^3 - c_1 + 2c_2) + \sigma_2^3(2 + c_1 + c_2) + c_2 - 2c_1 - 1 > 0. 
\]  

(10)

In both expressions \( d, \delta, \Delta \) and \( \Sigma \) are the same as above and \( c_i \) is used as a short hand for \( c(\sigma_i) \). We assume the marginal cost function to be decreasing in \( \sigma \). Although expressions (9) and (10) differ significantly from the simple conditions (2) and (4), it is easy to show that they are equivalent when costs are assumed away. It is particularly interesting that (10) is identical to (4) when the two competitors are symmetric irrespective of the cost function assumed. In other words, the existence of an equilibrium under which information products act as complements does not hinge on any specific marginal cost function in the model. To further evaluate the robustness of the model we also tested the effect of marginal costs with simulations. Using two simple marginal cost functions, \( c(\sigma) = C(1 - \sigma^4) \) and \( c(\sigma) = C(1 - \sigma) \), we found that, qualitatively, the features of the equilibria are equivalent to the ones reported in the paper for different levels of \( C \). This is especially true when the products do not differ too much in their qualities.

\[ ^{20}\text{These cost functions follow better our model, in which everything is bounded between 0 and 1, than } c(\sigma) = C/\sigma, \text{ for instance.} \]
4.2 Potential limitations

The proposed model has made several simplifications. First, the present paper studies competition in a duopoly. Assuming more firms may be interesting because it is possible that competition of three firms providing complementary information may be socially more efficient than a duopoly (i.e. it pareto dominates a duopoly). In the present model this is not the case. More precisely, an equilibrium where each consumer buys from all three information sellers does not exist. The intuition behind this finding is that combining expert information has decreasing returns in terms of the accuracy of the final forecast (Morrison and Schmittlein, 1989), especially if expert opinions are correlated. Second, our model uses a specific definition of information. In the technical appendix, we examine the case where information has a somewhat different meaning. In this extension, information suppliers have different information structures (in the sense that their partitions of the state space are different) and consumers are interested in having the finest possible partition of the state space (see Milgrom, 1981 and Sebenius and Geanakoplos, 1983 for details). The informal analysis indicates that the results are similar to the ones found here.

Finally, our model considers a simultaneous one-shot game. This is justified in many situations. It is not uncommon that managers need to make one-shot decisions to buy from one, two or no information sources due to the lead time required to collect the data and the lack of time post delivery to order additional opinions before decision making. In reality, the purchased information is rarely a simple value as modeled here. Thus, the evaluation of the reports may be lengthy, and consumers have to gather information before full evaluation is possible. Often, purchasing information means subscription to an on-line database. This decision may be independent from a specific application of the database.

\[21\text{In our model the quality of information is linearly decreasing in variance. It is possible that under a different specification a market with more than two competitors can dominate a duopoly. Even in this case the size of the market would be limited to a few competitors due to decreasing returns to combining information.}\]

\[22\text{When evaluating marketing effectiveness using scanner data, for example, clients of market research companies, such as AC Nielsen or IRI Inc., have to order all marketing research well in advance, before seeing the result(s) of any reports.}\]
From a modelling point of view we have chosen a static model for two reasons: First, our utility function depends only on the reliability and dependence of the reports and this is assumed to be common knowledge. A dynamic model, therefore, would provide the same results. One could consider the case where the utility for additional information depends on the value of previously purchased information (i.e. the purchase of the second report is contingent on the content of the first). In this case firms would make their prices contingent on the value of their own reports. This would allow rational consumers to extract the information in the reports from the observed prices without buying the reports, i.e. the market would break down. Our model preserves the rationality of consumers and the existence of the market by assuming a simultaneous game. Providing a dynamic model of information markets is a challenging task left for future research.

5 Concluding remarks

This paper proposes a model to explain competitive structures in markets for information. Such markets become more and more common with the development of the services industry. Our approach concentrates on modeling competition, given the interdependencies among information products. These externalities lead to counter-intuitive results regarding competitive structures which imply various policy options. Some examples in the information services, medical and legal professions are provided to illustrate these conclusions. Information is often only one aspect of the total product/service sold which suggests that the results reported here may have wider applicability than "information-only" products. It is important to realize that in these cases our results can not explain alone the observed market outcomes but only provide insight with respect to information-related aspects. In the previous section, we have also highlighted a number of interesting - mostly theoretical - research directions. Finally, there is potential for empirical research to test the suggested theory.
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Note: Adopted from Jensen (1991)
Figure 1a: Equilibrium with all three configurations

Figure 1b: Equilibrium with no consumers buying 1 report

Note: Reliability scale is reversed. Reliability is high when $\sigma$ is low.
Figure 2a: Conditions with symmetric competitors

Figure 2b: Conditions with independent competitors

Note: Reliability scale is reversed. Reliability is high when $\sigma$ is low.
Figure 3a: Higher competitive profits with symmetric competitors

Figure 3b: Higher competitive profits with independent competitors

Note: Reliability scale is reversed. Reliability is high when \( \sigma \) is low.
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