HOW DO INFOMEDIARIES AFFECT FIRMS’ INFORMATION STRATEGIES, AND HOW DO THEY IMPACT BUYER AND SOCIAL WELFARE?

Completed Research Paper

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Abstract

Product information websites have become ubiquitous. This article explores their impact on firm profitability, consumer surplus, and social welfare. Using an analytical model, we show that firms take advantage of such infomediaries and cut down on their own information investments, increasing their profitability. Surprisingly, we find that the existence of these websites may be reducing social welfare, even if we ignore their cost of operation. In addition, and contrary to the common belief that product information websites are good for buyers, we show that they may be hurting consumers, even when their goal is to maximize consumer surplus. These findings lead us to recommend that product information websites should focus on roles that complement, rather than substitute, the information disclosure investments that firms freely choose on their own accord.

Keywords: Product information websites, consumer uncertainty, infomediaries, consumer surplus, social welfare, firm information strategy
Introduction

A major activity in markets is the acquisition of product information by consumers. Today, this activity is becoming increasingly important and widespread for three main reasons. First, new technologies facilitate product and service vendors in the dissemination of product information, and reduce the cost of informing consumers even for product attributes that are traditionally considered experiential. Second, consumers increasingly demand that they are better informed about the products that they subsequently purchase. Finally, numerous infomediaries have emerged as an alternative source of product and service information, so that today’s consumers do not necessarily have to rely on product vendors in order to reduce their uncertainty prior to purchase. These infomediaries usually operate websites, but also newsletters, social media groups, and increasingly, mobile apps. In our article we will refer to them as either infomediaries, or product information websites, recognizing the most common form by which infomediaries provide consumers with product information. Before we pose our main research questions we proceed to analyze these three trends.

Technology presents new options to vendors that wish to reduce consumer uncertainty about their products. For example, Apple’s iTunes allows consumers to sample a music album, while many video game developers distribute playable demo versions of their games (Zhu and Zhang 2010). Rich media that incorporate video and sound are also being increasingly employed. The online clothing retailer Asos offers catwalk videos that help consumers visualize the clothing item in real life, and the shirt retailer T.M. Lewin uses hover boxes that allow zooming into the shirt picture to observe the fabric weave pattern.

More advanced technology examples abound. The seller of prescription eye-glasses Warby Parker is among many retailers who offer virtual try-ons. The company superimposes a consumer's photo with the company's products, creating the illusion of standing in front of a mirror and trying on different pairs of glasses (Miller 2011). IKEA now uses augmented reality technology to let prospective customers see how the company's products fit in a room. This is done via a smartphone app that can render furniture in 3D in real time (Truong 2013). BlackBerry uses elaborate online demos that let buyers to deeply explore a wide range of features. Microsoft created an HTML-5 webpage so that users of Android and iOS phones can “sample” Microsoft’s mobile operating system, by making their phone appear as if it is running Windows Mobile. Other innovative technologies used to reduce consumer uncertainty include recommendation technologies (Pathak et al. 2010) such as collaborative filtering (Benlian et al. 2012), and data analytics. For example, Netflix uses collaborative filtering (Feuerverger et al. 2012) to recommend movies that match a customer's taste, and data analytics to customize TV-series trailers according to a customer's demographic information (Carr 2013).

Product vendors have good reasons to employ technology that reduces buyers’ uncertainty about their products. The Wall Street Journal reports that when the Internet shoe retailer Zappos tested showing its products with and without a video description, it observed a 10% increase in sales for the shoes that included video (Nassauer 2011). It is interesting to note that Zappos does not use video in the conventional advertising sense of employing professional models to enhance the attractiveness of the product. Instead, the retailer’s employees provide product information to viewers, and are shown wearing and walking around in the shoes.

With increased availability of product information online, it is not surprising that consumers are becoming more likely to actively search for product information prior to product purchase (McKinsey Global Institute 2011). Accenture reports that of consumers they surveyed, more than two thirds explored product features online, and found that this was a rising trend (Accenture 2007). Similar results have been reported for the UK market (GSI Commerce International 2011). Further, consumers seem to appreciate factual product information more so than traditional advertising techniques. Consider the top three website features that make consumers more likely to purchase clothing and accessories online (GSI Commerce International 2011):

- **Image zoom** – the ability to zoom in and see the item up-close.
- **Search filters** – the presence of search filters that allow consumers to zero-in their desired products based on well-specified search parameters.
- **360 degrees rotation** – the ability to rotate the item, so that it can be seen from an arbitrary point of view.
More than 50% of consumers agree on the importance of these features, and the trend is increasing. For comparison, images of celebrities rank 14th in the list, with only about 10% of consumers agreeing that this feature increases their propensity to purchase an item (GSI Commerce International 2011).

Even as consumers increasingly turn online to acquire product information, they no longer have to rely exclusively on information provided by product vendors. Today, numerous third-party infomediaries (Montgomery et al. 2004) offer a variety of information services to consumers, sometimes complementing, but often substituting for the information that product vendors themselves also provide. Infomediaries set up websites to help consumers to identify their needs, to acquire product information, to assess the risk of transacting with different sellers, and to better use the product after purchase and maximize their utility. Obviously, only few infomediaries offer all of the services mentioned, while most tend to help consumers in a subset of their information needs. In addition, while all of the roles described are important, they are also quite different from each other, having different goals and outcomes, and they would require significantly different analytical approaches for their study. This article focuses on the role of infomediaries as alternative sources of information during the product information acquisition stage of a consumer’s purchasing process.

We also focus on taste-related product information, that is, product information about taste-related, as opposed to quality-related, product attributes. Taste-related attributes are product attributes about which consumers do not generally agree on what is better when they try to compare them. Examples are design elements of a mobile phone, or the rendition of out-of-focus highlights of a high-end camera lens. Taste-related attributes contrast with attributes that are related to product quality and for which consumers generally agree when they compare them. Examples are the battery life of a mobile phone, or the maximum aperture of a camera lens. While the relative importance of taste-related information may be rapidly increasing due to the prevalence of social commerce and recommendation technologies that are especially suited to communicate taste-related attributes (Markopoulos and Clemons 2013), we consider both types of information (quality and taste) as equally important, each meriting its own careful analysis. Indeed, we study the two types separately in different articles, this being the article that analyzes taste-related product information.

There are numerous infomediaries that provide taste related product information in the form of expert product reviews, detailed product specs, and information on actual use experience, often making use of rich, interactive media to better convey the information (Kohler et al. 2011). For example, a photographer who needs detailed information about a certain Nikon camera lens (e.g., suitability for different uses), may be able to find this information at Nikon’s website where the firm offers detailed information for some, but not all, of its lenses in the form of Modulation Transfer Function charts (MTF curves). Alternatively, the photographer can visit DxO Labs (dxomark.com), which puts cameras and lenses through standardized tests and often provides even more information than Nikon, on Nikon lenses.

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1 Studying taste and quality related product information separately, also allows us to concentrate on the most interesting questions in each case. For example, in the case of quality information, the presence of infomediaries affects product quality in a non-intuitive way, while its impact on social welfare and consumer surplus is less interesting and more predictable that the case of taste-related information.

2 We exclude from our analysis information based on consumer reviews. Consumer reviews (as opposed to product expert reviews, and other forms of factual product information) are an important source of product information (Markopoulos and Clemons 2013). The main difference between expert reviews and other factual forms of product information is that consumer reviews tend to be biased (Nan et al. 2009) (Li and Hitt 2008) (Li and Hitt 2010), and more importantly, highly affected by consumers’ own taste preferences as well as their personal usage situations (Chen and Xie 2008). Consequently, consumer reviews not only provide information to consumers about the product, but also to firms about the distribution of consumer preferences in the market. For this reason, consumer reviews require different treatment and do not satisfy some of the key assumptions made in our analytical model.

3 MTF curves have a strong taste-related information component, related to the aperture at which the lens displays peak performance: larger apertures are best for portraiture; smaller apertures are best for landscapes. MTF curves also provide information on the rendition of out-of-focus highlights, a pure taste-related attribute.
Similarly, a consumer who wants to see exactly how a certain Samsung mobile phone looks like, can visit Samsung’s own website which includes detailed photos from 5-6 different angles. Alternatively, the consumer can visit phonearena.com, which includes true 3D product views, and in addition a size comparison with standard objects, such as an AA battery, so that the consumer can better visualize the phone’s true size. When Apple introduced iOS7, a mobile operating system, the company put considerable effort into sharing the OS’s new design elements with prospective customers, in its website. However, it was a third party product information website, Recombu.com, that created the first interactive demo, following the aforementioned example of Microsoft. In these and uncountable other examples, we find sellers and product information websites offering information on the same taste-related product attributes to consumers.

The key questions that we address in this paper are tied to product information disclosure in the presence of third-party infomediaries that focus on being an alternative source of product information to consumers. First, we ask how much firms should invest in informing consumers and how they should price their products in the presence of third-party infomediaries. Finally, we ask whether the infomediaries, increase or decrease social welfare and consumer surplus.

In brief, in this paper we find that a firm can take advantage of product information websites and reduce its own information investments, increasing profitability. In other words, the firm is able to free ride on the information that infomediaries provide. We show that a firm maximizes profits under moderate levels of information availability, that is, when market parameters are such that the firm and the third-party websites do not provide neither too much, nor too little product information. Surprisingly, we find that infomediaries, even when their operation is considered costless, may reduce social welfare. More specifically, infomediaries increase social welfare when information disclosure is relatively cheap, they reduce social welfare when information disclosure has moderate costs, and do not affect social welfare when information is expensive to provide. Even more surprising is our finding that product information websites can even reduce consumer surplus, even if they actively try to improve it.

The intuition behind this surprising result is that, when the majority of the benefits from improved information accrue to the firm, the firm, if alone, would prefer to disclose more information than the infomediary. However, in the presence of the infomediary, the firm is quite happy to let the infomediary disclose less information in order to save the firm the information disclosure investment. In this case, the infomediary’s presence causes overall information availability to decrease, hurting consumers. In other cases, the majority of the benefits from improved information accrues to the buyers, in which case it is the infomediary who prefers to disclose more information than the firm, and its operation is beneficial to consumers. This is discussed in more detail below.

We have also found our results to be robust to alternative modeling assumptions, including different ways of modeling buyer uncertainty. To the best of the authors’ knowledge, these results are novel, they have clear and actionable managerial implications, and enable us to be the first to analytically evaluate the social impact of product information websites that act as an alternative source of product information to consumers.

The rest of the paper is organized as follows. We first review the relevant literature, and then present our analytical model of a monopolistic market with infomediaries. We then proceed to solve the model and present our analytical results, before we turn to discussing the social role of infomediaries. Finally, we conclude by summarizing our main findings and laying out our plans for future work.

Literature Review

Despite the emerging importance of taste-related product attributes, previous literature has mostly focused on quality attributes. Jovanovic (1982) was among the first of many researchers to study how firms undertake costly investments that reduce consumer uncertainty about their products’ quality. This was an extension of the work of Grossman, Shapiro, Milgrom, and others (Grossman and Hart 1980; Grossman and Shapiro 1984; Milgrom 1981), who showed that rational buyers should discount the quality

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4 With the exception of the finding that a firm may be able to free ride on infomediaries’ information, which was first shown in (Chen and Xie 2005).
of firms that do not make credible investments to try to demonstrate their quality. More recent work that analyzes consumer uncertainty about quality-related attributes, includes the work of Levin et al. (2009) who also allow the products to be horizontally differentiated (buyers are only uncertain about quality), Board’s analysis of the impact of competition to the disclosure of quality attributes (Board 2009), and Hotz and Xiao (2010) who looked at the interplay between quality disclosures and price competition in a competitive market. More closely related to our analysis is the work of Chen and Xie (2005; 2008) who have directly looked at how third-party information sources affect firms’ marketing strategy. For example in (Chen and Xie 2005) they study the possibility of infomediaries both substituting and complementing vendor information, depending on the type of information given by infomediaries (recommendation versus description) and find that the effects depend on product quality.

This article is also closely related to the literature that considers consumer uncertainty for taste-related attributes, that is, uncertainty under horizontal product differentiation. An early model that includes horizontal differentiation and uncertainty is due to Wolinsky (1984). A seminal paper by Grossman & Shapiro (1984) shows that vendors will overinvest, from a social perspective, to provide basic product information, such as their existence and price. These models were followed up by Bakos (1997) who synthesized prior work with the dynamics of the then emerging phenomenon of Internet markets. The next steps were taken by Meurer & Stahl (1994) and by Anderson & Renault (2009) with studies of duopolies in horizontally differentiated markets. Specifically, in the latter model, it is shown that comparative advertising (related to consumer taste) asymmetrically favors a smaller firm against a larger competitor.

The impact of increased information availability to horizontally differentiated products in the presence of idiosyncratic consumer preferences, is increasingly drawing the attention of researchers in the IS and Marketing communities. Clemons et al. (2005) have claimed that highly differentiated products are likely to asymmetrically benefit from increased information availability over their mass-market counterparts. In (Clemons et al. 2006) they furnished evidence for this finding from the craft beer industry. Brynjolfsson et al. (2011) confirmed that long-tail clothing items asymmetrically benefit by the introduction of technologies that facilitate the consumers’ information acquisition process. Sun (2012) found the same to be true for books, but only if the average product review is sufficiently low.

Finally, evidence that available product information in the market still leaves consumers uncertain about many product attributes is provided by the literature that documents persistent on-line price dispersion in different markets (Baye et al., 2006) (Venkatesan et al. 2007) with imperfect information being one of the potential sources of the price dispersion. While not directly related to the work we present here, the literature on price persistent price dispersion in online markets underlines (among other things) the magnitude of the gap between the amount of information that is available in the market, versus an ideal perfect information regime. For example, Brynjolfsson and Smith (2000) studied price dispersion in the online book industry. Clemons, Hann and Hitt (2002) have documented significant price dispersion among different online travel agents, even after accounting for differences in airfare qualities. More recently, Chellapa et al (2010), while focusing on the impact of price-format, note that consumer uncertainty is unlikely to ever disappear from the airline market. Ghose & Yao (2010) showed that some of the dispersion can be explained away by focusing on actual transaction prices. The authors also provide a comprehensive list of potential explanations, including the violation of a basic assumption of the Bertrand model, that consumers are perfectly informed about product attributes (Salop and Stiglitz 1977).

A Model of Information Disclosure in the Presence of Infomediaries

**Model Definition**

We model a monopolistic market where a single firm offers a single-purchase good, for which consumers are imperfectly informed before purchase. The product is composed of one quality parameter and one taste-related parameter that we call the product type. The market is modeled as a Salop circle of unit size,

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5 The terms firm and vendor will be used interchangeably throughout the article

6 Economists often use the term variety to describe what we refer in this article as type.
where all possible product types lie (Salop 1979). The exact product type, i.e., its actual location on the circle, is denoted by \(d\). The firm supplies the good with constant marginal cost, normalized to zero. The product price is denoted by \(p\), and the product quality by \(v\). In Figure 1 we depict a schematic representation of our market.

![Figure 1: Our model of a monopoly vendor with consumer uncertainty about product type](image)

The utility that a buyer with ideal product type \(z\) receives from consuming the product is given by:

\[
V(p, d, z) = v - p - t|d - z|
\]  

where \(t\) is the fit cost parameter (identical for all buyers) which denotes the intensity of consumers’ preferences for their ideal product type, and the product \(t|d - z|\) is the consumer’s fit cost. All buyers are assumed to be risk neutral and demand one unit of the good, subject to their reservation utility \(V\) being positive. Buyer preferences are uniformly distributed around the circular market’s circumference.

Consumers do not know the exact product type. Their knowledge depends on the information that the firm or an independent infomediary has released about the product. The true product type offered by the firm is \(d\), but the consumers cannot observe it. On the basis of available information, consumers form beliefs about the true product type being uniformly distributed in the interval \([d_a, d_b]\) which includes the product’s true type, i.e., \(d \in [d_a, d_b]\). The interval \([d_a, d_b]\), of size \(a = d_A - d_B\) is termed the firm’s “uncertainty interval”. The variable \(a\) is the measure of uncertainty that exists in the market about the product’s taste-related parameter and is the minimum of \(a_x\) and \(a_i\), which respectively denote the information that has been provided by the vendor and the infomediary about the vendor’s product: \(a = \min(a_x, a_i).\)

A consumer with preferred product type \(z\) will purchase the vendor’s product if and only if \(E(V) = v - p - F(a, x) > 0\), where \(F(a, x)\) is the consumer’s expected fit cost, given \(a\) and \(x\), where \(x\) is the distance between the buyer’s ideal product type \(z\) and the center of the vendor’s uncertainty interval (See the left

\[7\] We do not require that \(d\) coincides with the center of the firm’s uncertainty interval; in our model this would enable buyers to know exactly what the product type is. Thus, in general, the buyers can be biased in their estimate about the true product type.

\[8\] There is an equivalent way to define \(a\). As, we discuss below, the firm first reduces uncertainty to \(a_x\) and the infomediary follows by further reducing uncertainty to \(a_i\). The action of the infomediary is additive, as it incurs only the additional disclosure cost required to reduce uncertainty from \(a_x\) to \(a_i\). The infomediary may choose to augment the information that the firm provides, choosing \(a_i < a_x\), or it may choose to simply repeat the information that the firm provided (at no cost) with \(a_i = a_x\). Thus, we may equivalently define \(a = a_i\) by assuming that consumers will always get their information from the infomediary, who can always offer at least as much information as the firm. Our results would be identical. Instead, we prefer to define \(a = \min(a_x, a_i)\), to allow consumers to also acquire their information directly from the firm, if the infomediary does not offer any more information than the firm does.
hand graph of Figure 2). $F(a, x)$ is calculated as follows: if $x > a/2$, $F(a, x) = \int_{x-a/2}^{x+a/2} \frac{y}{a} \, dy = x \cdot t$ and if $x < a/2$, $F(a, x) = \int_{0}^{a/2-x} \frac{y}{a} \, dy + \int_{a/2-x}^{a/2} \frac{y}{a} \, dy = \frac{(a/2)^2 + x^2}{a} \cdot t$. In summary:

$$
F(a, x) = \begin{cases} 
  x \cdot t, & x \geq a/2 \\
  \frac{(a/2)^2 + x^2}{a} \cdot t, & x < a/2 
\end{cases} 
$$

(2)

![Figure 2: Left: A buyer whose ideal location, $z$, is $x$ units from the center of a vendor's uncertainty interval. Point $z$ can be outside (upper diagram) or inside (lower diagram) the vendor's uncertainty interval. Right: the resulting fit cost as a function of distance $x$.](image)

We plot Equation (2) on the right hand graph of Figure 2, where we see that as long as there is some uncertainty in the market ($a > 0$), the expected fit cost can never be zero. Note that for $x \geq a/2$, that is, if the buyer's ideal location $z$ is outside the vendor's uncertainty interval (upper diagram on the left in Figure 2), then uncertainty (the size of $a$) has no impact in the buyer's fit cost. Intuitively, as we increase uncertainty, we worsen the worst-case scenario for the buyer, that is, the product may actually be even further away from the buyer's ideal. However, at the same time, we improve the best-case scenario, which is that the product is even closer to the buyer's ideal. On average, Equation (2) says that a risk neutral buyer would be indifferent in this case. This contrasts with a buyer for which the ideal location $z$ is inside the vendor's uncertainty interval, with $x < a/2$ (lower diagram on the left in Figure 2). In this case, increasing $a$ would worsen the worst-case scenario for the buyer (as before) but would not improve the best-case scenario, which remains that the vendor's product is exactly located at $z$. This explains the shape of $F(a, x)$: if we set $a$ to zero the curve meets the axis origin, that is, the fit costs decreases for all $x$ less than $a/2$.

Also note that, whereas a buyer’s utility after consumption, given by Equation (1), depends on the product’s actual variety $d$, the buyer’s decision on whether or not to purchase the product depends on the positioning of the vendor’s uncertainty interval, in relation to the buyer’s own ideal variety $z$. This is because, prior to purchase, the product’s true variety $d$ is unobservable and the best possible information that the buyer has about the product prior to purchase, is summarized in the position and size of the vendor’s uncertainty interval. Once the product is purchased, the utility that the buyer eventually gains from the product, presumably after a long period of product use, depends on the product’s true variety.

Both the vendor and the infomediary incur a cost when they reduce consumer uncertainty. We assume that attributes which make up the product’s type have both a search and an experience component (Nelson 1974).

- The search component of the product’s information represents the part of the information that can be easily communicated prior to product purchases, e.g., through easy to understand product specs, such as size, color, weight etc. We will assume that there is a fixed cost to communicating the search component of the product’s information, normalized for convenience to zero.
The experience component of the product's information represents the part of the information that cannot be easily communicated prior to product purchase, and it usually requires actual experience of using the product, perhaps over a period of time, before the experience component can be safely ascertained. The experience component is therefore difficult and thus expensive to communicate. Relevant costs represent the investments that the vendor or the infomediary must make in order to, among others, put the product through thorough testing, better organize and present available information by use of interactive technology and rich media, provide real or virtual product samples, etc. The magnitude of the experience component of the product's information is denoted by $\alpha_x$.

A vendor can reduce consumer uncertainty all the way down to $\alpha_x$ at zero cost by communicating the search component of the product's information. Perfect information prior to product purchase is unattainable as it would require actual and prolonged product use on the part of the buyer in order to achieve it. Therefore, below $\alpha_x$, it becomes increasingly expensive to reduce consumer uncertainty.

The relevant cost functions that are consistent with the above discussion are as follows. For the product vendor, the cost $c_v$ to reduce consumer uncertainty to $\alpha_x \leq \alpha_v$ is given by (see Figure 3):

$$c_v(\alpha_v) = m \left( \frac{1}{\alpha_v} - \frac{1}{\alpha_x} \right)$$

where $m$ is a parameter that determines the information disclosure investment cost, for any given level of disclosure $\alpha_v$. In simple terms, markets with higher $m$ include products whose information is more difficult to be communicated than markets with lower $m$, for any required level of specificity.

For the infomediary, who, as we explain in the next section, will always invest in information disclosure after the vendor, the cost $c_i$ to reduce uncertainty to $\alpha_i \leq \alpha_v$ is given by (see Figure 3):

$$c_i(\alpha_i) = \begin{cases} m \left( \frac{1}{\alpha_i} - \frac{1}{\alpha_x} \right), & \alpha_i < \alpha_v \\ 0, & \alpha_i \geq \alpha_v \end{cases}$$

Note that the cost functions of the infomediary and the vendor are identical (neither party has a cost advantage when conveying product information to consumers), but once a vendor reduces uncertainty to $\alpha_v$, the infomediary can costlessly achieve the same amount of information simply by referring consumers.
to the information that has been made available by the vendor. However, the cost to providing additional information, beyond $a_v$, does not change by a vendor’s disclosure, and is still given by $m(1/a_t - 1/a_x)$.

The vendor’s objective is to maximize profit. The infomediary’s incentives are closely aligned with the buyers: the infomediary will release more product information, as long as the consumer surplus generated exceeds his own information disclosure cost. Thus, the infomediary’s objective is to maximize total consumer utility minus its information disclosure cost. The rationale for choosing this particular objective function for the infomediary is to stress our finding that product information websites may actually reduce buyer utility, even when it is their explicit goal to increase it, and even without being at an information disadvantage vis-à-vis the vendor. Our results remain qualitatively the same for a wide range of infomediary objective functions, including product information websites that charge the firm a commission, or others that profit mainly through advertising. Our results remain qualitatively the same, even when multiple infomediaries compete for seller referral fees, as we discuss below.

Given price $p$, the distance $x$ from the center of the uncertainty interval of the last buyer who expects to receive positive utility from buying the product is given by the equation:

$$D(a, p) = \begin{cases} \frac{2v - p}{t}, & \frac{v - p}{t} \geq \frac{\alpha}{2} \\ \frac{2}{\sqrt{a}} \left( \frac{v - p - a^2}{4} \right), & \frac{v - p}{t} \leq \frac{\alpha}{2} \end{cases}$$

The firm’s profit function is given by:

$$\Pi(a, p) = p \cdot D(a, p) - c_v(a_s)$$

Note that the demand facing the firm depends on the level of information available to consumers $a$, but the information disclosure cost $c_v(a_s)$ depends on the amount of information that the vendor releases. The two may not be the same if the infomediary invests in releasing information $a_i < a_v$, in which case the vendor would have incurred cost $c_v(a_s)$, but the consumers will make their purchase decisions based on $a = \min(a_i, a_v) = a_i$.

Total consumer surplus is given by (see Appendix):

$$U_B(a, p) = \begin{cases} \frac{p^2 + v^2}{t} - \frac{t \cdot a^2}{12} - \frac{2 \cdot p \cdot v}{t}, & \frac{v - p}{t} \geq \frac{\alpha}{2} \\ \frac{4v - 4p - a \cdot t}{6} \sqrt{a \cdot (4v - 4p - a \cdot t)}, & \frac{v - p}{t} \leq \frac{\alpha}{2} \end{cases}$$

As discussed, the infomediary tries to maximize total consumer surplus minus disclosure cost. Its utility $U_i$ is:

$$U_i(a_i) = U_B - c_i(a_i)$$

Finally, social welfare is given by:

$$S_M = U_B(a, p) + \Pi(a, p) - c_i(a_i)$$

We can now define the game as follows:

- **Stage 1**: The firm chooses the amount of information to release $a_v$
- **Stage 2**: The infomediary observes $a_v$ and chooses its own information disclosure $a_i$
- **Stage 3**: The firm chooses product price
- Each consumer buys either one (if utility is positive) or zero units of the good.
The firm is able to disclose first, since it has access to its product’s information even before the product is released. It also has the incentive to do so: disclosing first allows it to act strategically and free ride on the infomediary’s information. It is thus natural to allow the firm to commit first to a level of disclosure. We shall return to this issue in the Concluding Remarks section.

Pricing is decided last, as it is the most flexible of the decision variables, and can be adjusted at will after product information has been disclosed. Indeed, it is often the case that the firm can simply increase or reduce its price after the infomediary disclosure. It would thus not seem natural to forbid the firm from doing so. In contrast to this, the firm (and the infomediary) cannot take back information already released, as a response to a price change. For example a video game developer can adjust his price multiple times, but he cannot undo the release of a playable demo version online.\(^9\)

**Results and Implications**

**Firm Price and Profit**

At the game’s last stage, the vendor and the infomediary have already chosen the level of information to release, \(a_v\) and \(a_i\), respectively. The remaining uncertainty about the vendor’s product, \(\alpha = \min(a_v, a_i)\), defines an uncertainty interval of size \(\alpha\) within which the vendor’s true variety lies, with every position inside the uncertainty interval being equally likely as being the product’s true location. By taking F.O.C. on Equation (6), we can show:

**Proposition 1:** At the final game stage, the vendor sets his price
\[
p^*(\alpha) = \begin{cases} 
\frac{v}{2}, & a \leq \frac{v}{t} \\
\frac{4v - a \cdot t}{6}, & a > \frac{v}{t}
\end{cases}
\]

where \(a = \min(a_v, a_i)\).

Proposition 1 shows that if consumer uncertainty is below a certain threshold \((a \leq \frac{v}{t})\) the vendor’s optimal price is not affected by uncertainty. It is easy to verify that this is threshold that places the marginal buyer (the buyer that is indifferent between purchasing and not purchasing the product) just outside the vendor’s uncertainty interval, so that, as we discussed for Equation (2), the marginal buyer is no longer affected by uncertainty. If, however, the information released in the previous game stages by the infomediary and the vendor is not enough to place the marginal buyer outside the uncertainty interval, then, as the second branch in Proposition 1 shows, the vendor must also consider the amount of buyer uncertainty, when setting product price.

The vendor’s profit \(\Pi(a_v, a_i)\) is given by using equilibrium price with Equation (6). Similarly, the infomediary’s equilibrium utility \(U_i(a_i)\) and the social welfare \(S_{\Pi}(a_i, a_v)\) are also derived by using equilibrium price with Equations (8) and (9). For example, the infomediary’s utility are given by:

\[
U_i(a_i) = \begin{cases} 
\frac{v^2}{4t} - \frac{a^2t}{12} - c_i(a_i), & a \leq \frac{v}{t} \\
\frac{4v - a \cdot t}{18\sqrt{3}} - c_i(a_i), & a > \frac{v}{t}
\end{cases}
\]

and as expected, it has two branches for low and high uncertainty, due to the change in the shape of the buyer’s fit cost function at distance \(x = a/2\) from the center of the vendor’s uncertainty interval.

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\(^9\) The pricing stage being last does not affect our main results, which remain qualitatively the same, even if the firm commits to a price up-front. It is interesting to note that, in general, most firms do not re-price their products as a response to third-party disclosures, even if they have the ability to do so (Chen and Xie 2005).
In Figure 4, we depict the corresponding equilibrium firm profit, as given by using equilibrium price in Equation (6). Note that, even though equilibrium price branches at $a = v/t$, equilibrium profit is not discontinuous at that point, which we can easily verify by computing the left and right derivative of Equation (6) at $a = v/t$, and checking that they are equal. The reason is that equilibrium price is smooth at $a = v/t$, and so is the fit cost function (Figure 2) at $x = a/2$. Profit is low when the vendor provides too little information (very high $a_v$ - assuming the infomediary does not provide more) as buyers' expected fit costs increase and demand falls, and it is also low when the vendor provides too much information (very low $a_v$) as the high disclosure costs damage profitability. Optimal profit is achieved at a moderate level of information disclosure. It is important to note that optimal profit always occurs at $a_v > v/t$. This is because, as we discussed for Proposition 1, $a = v/t$ is the point where the marginal buyer is no longer affected by uncertainty (size of market becomes larger than the uncertainty interval), so that further information disclosure investments do not benefit the vendor as they only increase the expected utility of buyers who would have purchased the product anyway.

In Figure 4, we also depict the infomediary's utility, which is discontinuous at point $a = v/t$. This means that the infomediary may be happy with both a high information regime ($a_i > v/t$, in which case optimal $a_i$ is $a_{ih}$) and with a low information regime ($a_i < v/t$, in which case optimal $a_i$ is $a_{il}$). Whether utility is maximized at $a_{il}$ or $a_{ih}$ depends on the disclosure cost parameter $m$. With $m > m_{min}$ ($m_{min}$ to be defined below) the peak at $a_{ih}$ is higher, and the infomediary maximizes utility by providing relatively little information. The opposite is true, when $m < m_{min}$. We discuss this further below.

**Information Availability**

In the Appendix, we show how the vendor and the infomediary provide information to the buyers:

**Proposition 2:** The vendor and the infomediary will invest in information disclosure as follows:

- At Stage 1 the firm reduces buyer uncertainty to $a_{ih}^* = \begin{cases} 
  a_{ih} & , m > m_{max} \\
  a_x & , m < m_{max} 
\end{cases}$

- At Stage 2 the firm reduces consumer uncertainty as follows:
  1. For $m < m_{min}$, the infomediary will disclose $a_i^* = a_{ii} = \sqrt[3]{6m/t}$
  2. For $m > m_{max}$, the infomediary will disclose $a_i^* = a_v^*$ (its operation is redundant).
  3. For $m_{min} < m < m_{max}$ the infomediary will disclose $a_{ih}$

where $m_{min}$ and $m_{max}$ are given in the Appendix.
We plot Proposition 2 in Figure 5 as a function of the disclosure cost parameter \( m \). Consistent to Proposition 2 and to our previous discussion, the vendor will either only disclose \( a_{v} \), the search component of product information, at zero cost, and rely on the infomediary to provide more information to buyers, or he will disclose \( a_{\text{ph}} > v/t \). On the other hand, the infomediary discloses \( a_{i} = a_{ih} \) for \( m < m_{\text{min}} \) (changing the shape of the graph for equilibrium \( a \) at \( m = m_{\text{min}} \)), and \( a_{i} = a_{x} \) or \( a_{i} = a_{x} ' \) for \( m > m_{\text{min}} \).

Figure 5: Provision of information (higher \( \alpha \) means less information) in monopoly, as a function of the cost parameter \( m \). For comparison, also included is the amount of information the vendor would disclose in the absence of the infomediary and the amount of information that would maximize total social welfare. The values of the parameters used are \( [v = 1, t = 20, a_{x} = 0.2] \).

As in (Grossman and Shapiro 1984), in our model, for \( m > m_{\text{min}} \) the vendor captures a higher percentage of the gains that result from reducing consumer uncertainty. This means that the vendor is willing to disclose product information even for values of the cost parameter \( m \) for which it is not profitable for the infomediary to do so. For example, in Figure 5, the vendor who commits to a level of disclosure before the infomediary, knows that for \( m \) greater than \( m_{\text{max}} \), the infomediary would not disclose below \( a_{x} \) and so the vendor chooses to reduce consumer uncertainty from \( \alpha = 0.2 \) to about \( \alpha = 0.07 \). For \( m_{\text{min}} < m < m_{\text{max}} \) the vendor would, if alone, prefer a lower level of consumer uncertainty than what the market ends up with. However, the vendor takes advantage of being able to commit to a disclosure level before the infomediary, and chooses not to disclose any information, setting \( a_{v} = a_{x} = 0.2 \). The infomediary then reduces consumer uncertainty to levels that range from \( a_{i} \geq 0.07 \) to \( a_{i} \geq 0.10 \), which, while it represents less information than what the vendor would have chosen in the absence of the infomediary, saves the vendor the information disclosure cost and increases profit.

It appears that many firms do behave this way. For example, in 2003 Google stopped providing information to its customers about its AdWords product, and instead created a community (Google Forums) where its customers can answer each other’s questions about product features and about how to best use the product (Levy 2011). The company appears satisfied to forgo the costly investment that would be required to better inform its customers on its own. Even though Google Forums is not an independent product information website, Google’s actions show that a firm can indeed take advantage of alternative sources of product information in order to reduce its own investments to reduce customer uncertainty. Chen and Xie (2005) have studied in more detail the phenomenon of product vendors reducing their information investments in response to improved information availability, due to third parties.

Finally, for \( m < m_{\text{min}} \), the optimal disclosure lever for the infomediary switches from \( a_{i} = a_{ih} > v/t \) to \( a_{i} = a_{i} < v/t \) (see Figure 4), as the peak at \( a_{ih} \) becomes higher than the peak at \( a_{ih} \), and we see a discontinuous increase in the amount of information that becomes available to buyers. What happens is that, for \( m < m_{\text{min}} \), information is cheap enough to disclose that the infomediary chooses a level of uncertainty that is low enough for the marginal buyers to be outside uncertainty intervals (as we discussed for Proposition 1, this occurs when \( a_{i} < v/t \)). We explained that the vendor would never disclose more information than \( v/t \), since he would only be improving the expected utility of buyers who have already
decided to purchase his product, leaving the marginal buyers indifferent about the disclosure. Thus, for $m < m_{\min}$ information availability continues to be determined by the infomediary.

**Infomediary’s Impact to Buyer and Social Welfare**

Using Propositions 1 and 2 with Equations (7) and (9), we can calculate consumer and social welfare, which we depict in Figure 6.

As we discussed, for high enough $m$, that is when disclosure is costly, only the vendor discloses and thus the infomediary does not contribute to consumer information, and consequently has no affect to buyer and social welfare. As Figure 5 also shows, this occurs for $m > m_{\max}$, where $m_{\max}$ is defined in Proposition 2.

For $m_{\min} < m < m_{\max}$, that is, when disclosure costs are moderate, the vendor prefers to forgo disclosure investments, and lets the infomediary disclose instead. As we have explained, in the absence of the infomediary the vendor would have disclosed even more information, so that the presence of the infomediary causes overall information availability to decline (see also Figure 5). The vendor’s effort to extract additional profit by free riding on the infomediary disclosure, is causing an even greater reduction in consumer surplus (left side of Figure 6), which also leads to the deterioration of social welfare (right side of Figure 6).

Finally, when $m < m_{\min}$, that is, when disclosure is cheap, the infomediary increases the amount of information that he makes available to consumers, by setting $a_i = a_{\max} < v/t$. As we discussed before, the firm would never provide more information than $v/t$ on its own, as he can no longer improve his profit by doing so (the marginal buyer no longer benefits from reduced uncertainty). Since the buyer population always benefits from increased information availability (Equation (7) is decreasing in $a$), the infomediary’s presence improves consumer surplus for $m < m_{\min}$. In addition, since information disclosure beyond $v/t$ does not impact the firm, the socially optimal amount of information is simply the amount that maximizes consumer surplus, minus disclosure cost, that is, exactly the target information availability for the infomediary. This can be seen in Figure 5 where we can see that the infomediary discloses exactly the socially optimal amount for $m < m_{\min}$, and as can be seen in Figure 6, causes social welfare to increase.

Looking at the impact of product information websites to consumer surplus and social welfare, across a wide range of information disclosure costs, we see that product information websites are beneficial only...
when information about the products is cheap to disseminate. These infomediaries cannot help buyers with products with a strong experiential information component that is difficult to communicate online, and they may actually make buyers worse off. Unfortunately, these are precisely the types of products for which consumers would need the most help when collecting information online.

**Alternative Modeling Assumptions: Infomediary Competition**

Our results remain qualitatively the same when we change key assumptions in our model, including the way we model consumer uncertainty, the number of sellers in the market, and the incentives of the infomediary. Here we briefly present the case where, instead of a single infomediary aligning his incentives with buyers, there are multiple infomediaries that compete for referral fees.

A model of competing infomediaries may be defined as follows. Let buyers purchase the product through referrals from an infomediary’s website. In that case, the infomediary earns $r\%$ commission fee. The buyers visit the infomediary who provides the most information. Here, infomediaries compete away their profit and provide more and more product information until they simply break-even. This is logically equivalent to a model with a single infomediary who releases product information $a_c$ so that he sets to zero his profit $U_c(a_c) = r \cdot p \cdot D(a_c, p) - c_i(a_c)$, where $D(a_c, p)$ is the demand function given by Equation (5), and $c_i(a_c)$ is the infomediary’s cost, given by Equation (4). There are three possible cases for $a_c$. First, if information disclosure is so costly that the infomediary profit $U_c(a_c)$ is always negative $\forall a_c < a_v$, the infomediary simply repeats the information that the vendor is disclosing $a_c = a_v$, so as to avoid incurring a loss. Second, a solution $a_c = a_{cl}$ of the equation $U_c(a_c) = 0$ may be derived by the first branch of Equation (5), in which case it will be of the form $a_{cl} = \frac{2a_c m t}{2m t + a_c r v^2}$. And third, a solution $a_c = a_{ch}$ of the equation $U_c(a_c) = 0$ may be derived by the second branch of Equation (5), in which case it does not have an analytic formula. The infomediary will reduce buyer uncertainty to:

$$a_c(a_v) = \begin{cases} a_{cl} = \frac{2a_c m t}{2m t + a_c r v^2}, & \text{if } U_c(a_{cl}) \geq U_c(a_{ch}), 0 \\ a_{ch}, & \text{if } U_c(a_{ch}) \geq U_c(a_c), 0 \\ a_v, & \text{otherwise} \end{cases}$$

Compared to our base model, infomediary competition produces a larger variety of potential outcomes as we vary the referral fee parameter $r$. However, our main finding, that infomediaries may actually be reducing consumer surplus and social welfare, remains valid.

In Figure 7 we depict infomediary competition for two different cases. In the left column the infomediaries charge a referral fee of $r = 10\%$, while in the right column $r = 30\%$.

The first case ($r = 10\%$) is very similar to our main model. For a region of intermediate values for the cost parameter $m$, the vendor free rides on the infomediary information, even though the infomediary discloses less information than the vendor would disclose, in the absence of the infomediary. In this region, the infomediary’s presence reduces both consumer surplus and social welfare. However, for low enough disclosure cost, that is, below a threshold for $m$, the infomediary discloses more information than the vendor would, resulting in improved consumer surplus and social welfare.

The case of $r = 30\%$ is different. The infomediary referral fee is high enough to justify considerable investment in information disclosure, so that the infomediary-provided information is always more than what the firm would disclose by itself. Since consumer surplus always increases with more information, the infomediary increases consumer surplus regardless of the value of the disclosure cost parameter $m$. However, even in this case the infomediary may be reducing social welfare (not shown in the Figure).
Discussion and Concluding Remarks

In this article, we studied the impact of product information websites to firm profitability, consumer surplus, and social welfare. We first listed the different roles many such websites fulfill, and chose to focus on their role as alternative sources of information during the product information acquisition stage of a consumer's purchasing process, a role in which they often substitute for the information that product vendors themselves also provide. We then proceeded to study a game theoretic model where consumers acquire information about taste-related product attributes from a product vendor, and from an independent product information website.

We first showed that the infomediary allows the vendor to free ride and reduce information disclosure investments. This is somewhat expected as the infomediary becomes a substitute for the information that the vendor would provide in its own accord. The surprising consequence is that the presence of the infomediary can actually reduce consumer surplus and social welfare, even when the infomediary explicitly sets as its goal to make the buyers better off. Moreover this occurs for products and attributes that are not easy (cheap) to communicate, that is, exactly in those instances for which one hopes that independent product information websites could help consumers the most.

Our findings are robust to alternative modeling assumptions, including different infomediary business models, different ways of modeling buyer uncertainty, and even different market structures (oligopoly). Combined with the increasing importance of product information in modern markets, and the proliferation of third-party information sources – two trends that we reviewed in detail in the Introduction – our results seriously question the uncritical acceptance of infomediaries as beneficial to markets in general, and consumers in particular.

Even though we only studied a subset of the roles that product information websites fulfill during the purchasing process, we conjecture that their impact is similar in other cases in which they substitute for the information that vendors provide on their own accord. For example, such websites may actually be hurting consumers when they offer after-purchase information on product use, including tips by previous buyers, care and safety best practices, and in general advise to maximize product benefits (e.g., product lifetime). Instead, product information websites may be much more socially valuable and beneficial to consumers when they fulfill roles that complement, rather than substitute, product vendors. For example in fact-checking buyer claims, in helping consumers to objectively identify their needs, in educating them about the product category in general, and helping buyers assess the risk of transacting with different sellers.
There is also an important policy implication for infomediaries who act as alternative sources of information during buyers’ product information acquisition: they must try to commit to a level of disclosure up-front. If a product information website believes that firms free ride on the information that it provides on a certain product attribute (which is not cheap to inform consumers about), then it would do consumers a service by announcing that it will cease to provide this information, and will instead only double-check the information that the firms disclose on this attribute themselves. For example, consider DxO Lab, the provider of information on cameras and lenses, which we mentioned in the Introduction. If the company believes that lens manufacturers free ride on the information that it provides on a certain product attribute (which is not cheap to inform consumers about), then it would do consumers a service by announcing that it will cease to provide this information, and will instead only verify or correct the MTF curves that lens manufacturers themselves provide. If this commitment is enforced without exceptions, lens manufacturers will be compelled to cease free riding, provide more information themselves, and consumers will benefit from increased information availability.

Naturally, there are limitations to our study, which we would like to overcome in future work. We have already begun a stream of work that studies the impact of infomediaries to product quality information, rather than taste-related information, which is the focus of the present article. Further, we would like to move beyond our conjectures and understand the impact of infomediaries in each of the roles that we describe in Figure 1. It could very well be the case that we are mistaken in conjecturing that third-party infomediaries may be hurting consumers when they offer after-purchase advice, because such information has a social value component (Hirshleifer 1971), which was absent in the roles that we studied in the present article.

Appendix

Derivation of Equation (7):

We will use Figure 2 to walk through the proof. The case of \((v - p)/t \geq a/2\), corresponds to the case where the marginal buyer is outside the vendor’s uncertainty interval (upper diagram of left graph of Figure 2). Let the true location of the vendor is at distance \(h\) from buyer \(z\). Then the utility of the buyers to the left of the vendor is \(\int_0^h (v - p - t \cdot y) dy\) and the utility of the buyers to the right of the vendor is \(\int_0^{D(a,p)-h} (v - p - t \cdot y) dy\), where \(D(a,p)\) is given by the first branch of Equation (5). Thus, given \(h\), the buyers’ total utility is \(h \cdot (2v - 2p - t \cdot h)\). Now, \(h\) can range from \(D(a,p)/2 - a/2\) to \(D(a,p)/2 + a/2\), with equal probability, as we have assumed that the vendor’s true location is uniformly distributed inside the uncertainty interval. Thus, in the case of \((v - p)/t \geq a/2\), total buyer utility is \(\int_{D(a,p)/2-a/2}^{D(a,p)/2+a/2} h \cdot (2v - 2p - t \cdot h)dh = \frac{p^2 + v^2}{t} - \frac{v^2}{12} - \frac{2p}{t} \cdot \frac{v^2}{2} \cdot \frac{v}{2}\). Counting all buyers, \(h\) ranges from \(-D(a,p)/2\) to \(D(a,p)/2\), where \(D(a,p)\) is given by the second branch of Equation (5). Thus, when \((v - p)/t < a/2\), total buyer utility is \(\int_{-D(a,p)/2}^{D(a,p)/2} (v - p - \frac{a \cdot t}{4} - \frac{h^2 \cdot t}{a}) dh = \frac{4v^2 - 4p - a \cdot t}{6} \sqrt{\frac{a (4v - 4p - a \cdot t)}{t}} \).

Analytical Solution

Stage 3: Pricing

The pricing stage has already been analyzed.
Stage 2: Information Disclosure by Infomediaries

At the game’s second stage, the monopolistic firm has already chosen the level of information to release $\alpha_i$. Anticipating equilibrium pricing in the game’s last stage, the infomediary seeks to maximize $U_i(\alpha_i)$, given by Equation (10), which is also affected by the vendor’s choice of $\alpha_v$.

There are three possible solutions for $\alpha_i$ that maximize the infomediary’s utility $U_i(\alpha_i)$, $a_{ii}$ and $a_{ih}$, the last two of which are depicted in Figure 4. Assuming that $a_{ii} > v/t$ (we will see shortly that the assumption is always satisfied), the first branch of $U_i(\alpha_i)$, given by Equation (10), is maximized for $a_{ii} = 3\sqrt{6m}/t$. The solution is interior in $[0, v/t]$, as long as $m < v^3/(6t^2)$. The second possible solution is $a_{ih}$ which maximizes the second branch of $U_i(\alpha_i)$ and does not have an analytic formula. Finally, the third possible solution is $\alpha_i = \alpha_v$. Note that $a_{ii} = v/t$ cannot occur, as for $m \geq v^3/(6t^2)$, $U_i(a_i = v/t, m \geq v^3/(6t^2)) \leq 0$. In summary, in Stage 2, the infomediary will reduce consumer uncertainty to:

$$a_i^* = \begin{cases} 
    a_{ii} = 3\sqrt{6m}/t, & \text{if } U_i(a_{ii}) \geq U_i(a_{ih}), \ U_B(a = a_v p^*) \\
    a_{ih}, & \text{if } U_i(a_{ih}) > U_i(a_{ii}), \ U_B(a = a_v p^*) \\
    a_v, & \text{if } U_B(a = a_v p^*) > U_i(a_{ii}), \ U_i(a_{ih}) 
\end{cases} \tag{11}$$

$m_{\text{min}}$ from Proposition 2 corresponds to the first inequality, which can be used for its analytic derivation, by setting $U_i(a_{ii}) = U_i(a_{ih})$.

Stage 1: Information Disclosure by the Vendor

At the game’s first stage, the vendor knows that the infomediary will, in the next stage, choose to disclose information according to Equation (11) and that, subsequently, the vendor will price according to Proposition 1.

We first note that the vendor will never choose $a_v < v/t$, since, from our previous discussion, the vendor’s profit for $a_v < v/t$ will always be lower than profit for $a_v = v/t$. There are two possible choices for $\alpha_v$. The first is $a_v$, which maximizes the second branch of $\Pi(\alpha_v, a_i = a_v)$, with $a_i = a_v$, and does not have an analytic formula. The second possible equilibrium solution is $\alpha_v = \alpha_{v_1}$, where the vendor will only release the search component of the product information and incur zero information disclosure costs. Any other choice of $a_v$ will be dominated either by $a_{v_2}$ or by $a_v$. For example, consider the vendor choosing some $a_v < v/t$. Then if in the next stage $a_i^* < a_v$, then the vendor would have been better off having chosen $a_v = a_{v_1}$, in order to forgo the information disclosure cost. If on the other hand in the next stage $a_i^* = a_v$, then the vendor would have been better off having chosen $a_v = a_{v_1}$, since, by definition, it maximizes the profit function when $a = a_v$. Consequently:

$$a_v^* = \begin{cases} 
    a_{v_1}, & \Pi(\alpha_{v_1}, a_i^*(\alpha_{v_1})) > \Pi(\alpha_v, a_i^*(\alpha_v)) \\
    a_v, & \Pi(\alpha_{v_1}, a_i^*(\alpha_{v_1})) \leq \Pi(\alpha_v, a_i^*(\alpha_v)) 
\end{cases} \tag{12}$$

$m_{\text{max}}$ from Proposition 2 corresponds to the equality $\Pi(\alpha_{v_1}, a_i^*(\alpha_{v_1})) = \Pi(\alpha_v, a_i^*(\alpha_v))$, which can be used for its analytic derivation. The intuition for the existence of $m_{\text{max}}$ is that, because the vendor captures most of the social welfare, there exists an $m'$ beyond which the infomediary cannot achieve positive utility by disclosing information, while the vendor can.

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