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Soham Baksi [1] Pinaki Bose [2] Di Xiang [3]

Abstract

For certain products, consumers' misinformation about quality is more endemic at intermediate levels of the quality spectrum rather than at the top or the bottom levels of quality. Using an oligopoly model of vertical product differentiation with three quality levels – green, natural, and brown – we examine the consequences of consumers' overestimation of the quality of the natural (i.e. intermediate quality) product. There are three firms in the market, with each type of firm producing the corresponding type of the product. The firms choose the quality level of their product before choosing its price (Bertrand case) or quantity (Cournot case). Irrespective of the nature of second stage competition, we find that quality overestimation by consumers increases profit of the natural firm, and motivates it to raise its product's quality. In response, the green firm improves its quality even further, but ends up with lower profit. Overall, average quality of the vertically differentiated product improves, which raises consumer surplus. Social welfare increases when firms compete in prices but falls when they compete in quantities.

JEL classifications: L13; L15; M30

Keywords: credence good, product label, misinformation, quality

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1. Introduction

There are numerous instances where consumers are misinformed about the quality of the products they purchase from markets. This arises especially when quality is unobservable to consumers and producers take recourse to misleading advertising. Credence goods have attributes that consumers care about but do not observe before purchase or even after consumption (Darby and Karni, 1973). The attributes may be unobservable to consumers because they relate to the production phase of the good (e.g. involvement or otherwise of child labour), or to its post-consumption phase (e.g. extent to which the good can be recycled). Eco-labels and claims by producers, affixed to a product's packaging material, can solve the information asymmetry problem inherent in credence goods by conveying relevant information to consumers. However, in many cases, product labels and claims are found to use vague or misleading terms that induce consumers to overestimate the quality of the product (e.g. "greenwashing").[4] Because quality overestimation by consumers is beneficial for the relevant producers, the latter have an incentive to encourage such misinformation.

For certain products, consumers' misinformation about quality is more endemic at the intermediate levels of the quality spectrum rather than at the bottom or top levels of quality. This arises when the standards followed by low quality conventional products sold without labels, and high quality products sold with well-known third party labels, are more transparent and familiar to consumers than the standards followed by intermediate quality products that are sold with misleading self labels. Examples of such 'more misinformation at the middle' can be found with respect to many food products sold in the market. These products come in a range of qualities and carry a variety of labels or claims that highlight their health, safety, environmental or animal-welfare impacts. While some of the labels are well-defined third party labels, whose uses

[4] For specific examples, see CBC Marketplace's program on top ten "lousy labels": http://www.cbc.ca/marketplace/2012/lousylabels (broadcasted on February 3, 2012). The program suggests that both producers and consumers share responsibility for consumers' misjudgement of quality while shopping. When firms sell branded products that are similar in functionality and price in intensely competitive markets (e.g. tissue papers), they have an incentive to play up their product differentiation along dimensions such as greenness or sustainability. Shoppers, who have little time or knowledge, but have to decide which brand to purchase from a multitude of similar alternatives, often end up buying the affordable brand that conveys, even if vaguely, that an effort has been made to make it a better product.

are controlled by reputed organizations (e.g. USDA Organic), others are unregulated and imprecisely-defined claims (e.g. "environmentally responsible" or "cage free").[5]

For example, in the US, studies have noted that there is significant consumer confusion regarding "organic" vs. "natural" meat and poultry products (e.g. Abrams, et al., 2010; Gifford and Bernard, 2011).[6] The United States Department of Agriculture (USDA) regulates the use of the "organic" label for all types of food products, but regulates the use of the "natural" label for only meat and poultry, even though the natural label can be and is used on all types of food products. Meat and poultry products have to fulfill more stringent conditions in ordered to be labeled organic than they have to fulfill in order to be labeled natural. Broadly, the former conditions relate to the production and processing stages, while the latter conditions relate to the post-production procession stage only.[7] Thus, meat from animals that were given antibiotics or genetically modified food can be legally labeled as natural in the US. Consumers, however, tend to associate the natural label with a larger set of desirable attributes than it actually represents. In their survey of 139 individuals, Gifford and Bernard (2011) found that 65.4% of the respondents *overestimated* the requirements of natural chicken while 68.5% of them correctly identified the requirements of organic chicken. Goss, et al. (2002) found that 70% of respondents overestimated the requirements of natural beef.[8] On the other hand, conventional products that appear without labels or claims in the market are typically associated with the lowest quality level by consumers.

What are the consequences of consumer misinformation that makes them overestimate intermediate level qualities? The paper examines this question using a standard oligopoly model of vertical product differentiation involving three firms (e.g. Scarpa, 1998; Pezzino, 2010), with each firm producing a specific quality product. While consumers are correctly informed about

[5] Most conventionally raised egg-laying hens are kept in cages. A USDA report notes that the cage-free label "does not guarantee that the bird had access to the outdoors" (Oberholtzer, et al., 2006, p.6). The cage-free label is unregulated and does not require third party certification.

[6] A New York Times article refers to natural as a "slippery word". See "When it comes to meat, 'natural' is a vague term", *New York Times*, 10 June 2006.

[7] For details, see USDA's National Organic Program website: http://www.ams.usda.gov/AMSv1.0/nop

[8] Another example is the label "grass-fed" which, contrary to what many consumers may expect, does not mean that the animal was exclusively fed grass. Although USDA regulated, the grass-fed label does not limit the use of antibiotics, hormones, or pesticides. In Canada, consumers may be similarly conflating the requirements of the labels "Product of Canada" and "Made in Canada", even though the latter (but not the former) can involve the use of imported ingredients. See http://www.inspection.gc.ca/english/fssa/labeti/inform/prodcane.shtml

the qualities of the highest and lowest quality products, they overestimate the intermediate quality. The firms compete in the long run using qualities, and in the short run using either prices or quantities. In such two-stage games, firms differentiate the qualities of their products in the first stage in order to soften the intensity of second stage market competition (Shaked and Sutton, 1982).

In those industries where firms choose their capacities and production before the determination of the market-clearing price, it can be assumed that firms compete in quantities. Conversely, in industries where capacity constraints are less important and production can be quickly adjusted, it is more relevant to assume that firms compete in prices (Kreps and Scheinkman, 1983). Irrespective of the nature of second stage competition, we find that quality overestimation by consumers increases the profit of the firm producing the intermediate quality product, and motivates it to raise its product's quality. In response to this pressure from below, the firm producing the highest quality product improves its quality even further, but ends up with lower profit. Overall, average quality of the vertically differentiated product increases, which makes consumers better off. However, whether social welfare rises or falls as a result of consumers' quality overestimation, is found to depend on the nature of market competition (prices vs. quantities).

Our paper is related to the literature on the welfare impacts of "persuasive" advertising (see the survey by Bagwell, 2007). Glaeser and Ujhelyi (2010) examine the impact of consumer misinformation on welfare, and compare alternative ways of regulating misinformation. In their paper, misinformed consumers underestimate the (health) cost of consuming a homogeneous product. Because such misinformation offsets the under-consumption associated with imperfect competition, the authors find that consumer misinformation can increase social welfare, even though it always reduces consumer surplus. Methodologically, our paper is related to the literature on minimum quality standards (e.g. Ronen, 1991; Crampes and Hollander, 1995; Scarpa, 1998; Valletti, 2000; Pezzino, 2010). Using oligopoly model of vertical product differentiation, this literature examines the impacts of exogenous increases in minimum permissible quality on the qualities supplied by higher quality firms and on social welfare. The results in that literature vary for price vs. quantity competition, as in our paper.

The rest of the paper proceeds as follows. Section 2 introduces the model, and the following section derives the equilibrium for the two alternatives cases of price and quantity competition. The results for these two cases are then compared in section 4, while the last section concludes.

2. The model

Consider a product that is vertically differentiated into three types – "green", "natural", and "brown". These types are denoted by subscripts g, n, and b respectively. The true quality of the product is denoted by s_i, where $i = g, n, b$. The green type is a high quality product that uses well-defined third-party labels (e.g. organic food), while the brown type is a low quality conventional product that is unlabeled (e.g. food produced using antibiotics, hormones or genetically modified organisms). The natural type is an intermediate quality product that carries unregulated and misleading self-labels (e.g. natural food).

All consumers are correctly informed about the qualities of the green and the brown types of the product. However, they are misinformed about the quality of the natural type and perceive its quality to be $\tilde{s}_n$, which is higher than its true quality. The extent of this quality overestimation is represented by the parameter β. Specifically, we assume that

$$s_g > \tilde{s}_n = \frac{s_n}{\beta} > s_n > s_b > 0, \quad \text{where } \beta \in \left(\frac{s_n}{s_g}, 1 \right) \tag{1}$$

Lower values of β denote situations where consumers overestimate the true quality of the natural good by a larger extent. However, overestimation is not so large that consumers perceive the natural good's quality to be higher than the quality of the green good. In this sense, consumers' quality overestimation is moderate rather than extreme. When consumers do not overestimate the natural good's quality, we have $\beta = 1$.

Each consumer either buys one unit of the good or does not buy it at all. If a consumer purchases the type i good, she gets a (perceived) surplus of

$$V = \theta s_i - p_i \qquad \text{if } i = g, b$$
$$= \theta \tilde{s}_n - p_n \qquad \text{if } i = n \tag{2}$$

In (2), p_i denotes price of the type i good, and θ is a taste parameter that represents the consumers' willingness to pay for quality. Consumers are assumed to be heterogeneous in terms of their taste for quality, and $\theta \in [0,1]$ is uniformly distributed with unit density.[9,10] If a consumer does not buy the good, she gets a surplus of zero.

Given the assumptions about consumer preferences, Figure 1 shows the threshold values of the taste parameter that identifies consumers who are indifferent between the various purchase options. Thus, the consumer who is indifferent between not buying the good and buying the brown type is given by

$$\theta_1 = \frac{p_b}{s_b} \tag{3}$$

The consumer who is indifferent between buying the brown and the natural types has the taste parameter

$$\theta_2 = \frac{p_n - p_b}{\tilde{s}_n - s_b} \tag{4}$$

Finally, the consumer who is indifferent between buying the natural and the green types is given by

[9] As noted by Motta (1993), θ can be interpreted as the marginal rate of substitution between income and quality, so that higher values of θ correspond to a lower marginal utility of income and thus a higher income. As such, our model is similar to models where consumers differ by income rather than by taste.

[10] In the model, we assume misinformation affects all consumers equally. Alternatively, misinformation could affect a fraction x of the consumers (the "uninformed") and make them overestimate the quality of the natural good, while fraction $(1-x)$ could be correctly informed about quality (the "informed"). As long as the uninformed consumers have the same distribution of taste parameter θ as the informed, the two alternative ways of modeling misinformation will be equivalent. That is, a decrease in β in our model will yield qualitatively similar results as an increase in x in the alternative way of modeling misinformation.

$$\theta_3 = \frac{p_g - p_n}{s_g - \tilde{s}_n} \tag{5}$$

The demands for the different types of the good then emerge as follows:

$$q_b = \frac{p_n - p_b}{\tilde{s}_n - s_b} - \frac{p_b}{s_b} \tag{6}$$

$$q_n = \frac{p_g - p_n}{s_g - \tilde{s}_n} - \frac{p_n - p_b}{\tilde{s}_n - s_b} \tag{7}$$

$$q_g = 1 - \frac{p_g - p_n}{s_g - \tilde{s}_n} \tag{8}$$

where q_i denotes the quantity demanded of the type i good. Notice that, as $\theta_1 > \theta_{\min} = 0$, some consumers do not buy the good and the market is not fully covered. Consequently, we can solve (6)-(8) simultaneously and obtain the inverse demand functions:

$$p_b = s_b \left(1 - q_g - q_n - q_b\right) \tag{6a}$$

$$p_n = \tilde{s}_n \left(1 - q_g - q_n\right) - q_b s_b \tag{7a}$$

$$p_g = s_g \left(1 - q_g\right) - q_n \tilde{s}_n - q_b s_b \tag{8a}$$

Note that, if prices and true quality levels were exogenously given,[11] an increase in consumers' overestimation of the natural good's quality would lead to increased demand for the natural good and reduced demands for both the brown and green goods. This is because an increase in $\tilde{s}_n$, *ceteris paribus*, leaves θ_1 unchanged but decreases θ_2 and increases θ_3.[12]

[11] This may happen if prices are determined by costs in a perfectly competitive market, and quality levels are dependent on currently existing technology.

[12] If production or consumption of the different types of good involved different external costs (e.g. if higher quality goods cause lower pollution damage), these demand changes imply that an increase in consumer misinformation can increase social welfare under appropriate conditions on these costs. However, to focus on the effects of misinformation on consumer and producer surpluses, we abstract away from externalities in this paper.

To endogenize prices and qualities, we consider the following supply side. Production is undertaken by three firms, with the type i firm producing the corresponding type of the good. Each firm has to incur a fixed cost of production, $C_i = \frac{1}{2} s_i^2$, which increases convexly with the quality of the good it produces. Moreover, the marginal cost of production is assumed to be constant and is set equal to zero for simplicity.[13] Thus, profit of firm i is given by

$$\pi_i = R_i - C_i = p_i q_i - \tfrac{1}{2} s_i^2, \tag{9}$$

where $i = g, n, b$.

We consider the following two-stage game. In the first stage, each firm non-cooperatively chooses its quality s_i, taking as given the quality of the other two firms. In stage two, taking their quality choices as given, the three firms compete in the market where demands are given by (6)-(8). We consider two alternative forms of market competition – one involving prices (the Bertrand case) and another involving quantities (the Cournot case). To obtain the subgame perfect Nash equilibrium, the game is solved by backward induction. Throughout, we assume that the extent to which consumers overestimate the natural good's quality, β, is exogenously given and known to the firms.[14]

When misinformation affects consumers' preferences, perceived consumer surplus is different from true consumer surplus, and the correct measure of consumer surplus is not obvious (Dixit and Norman, 1978). From a planner's normative perspective, however, true consumer surplus seems a more relevant measure of their welfare (Glaeser and Ujhelyi, 2010). Hence, for the purposes of this paper, we define consumer surplus, *CS*, as the welfare gained by consumers from the true qualities of the products they consume

[13] Our supply side assumptions are similar to those in Ronen (1991), Scarpa, (1998), Valletti (2000), and Pezzino (2010). Like them we assume that quality improvements involve higher fixed costs (e.g. expenditure on R&D, machinery or advertising activities) rather than higher variable costs (e.g. more expensive raw materials).

[14] In the model, $\tilde{s}_n$ and s_n are multiplicatively related through β. When the natural firm increases the true quality of its product, it is able to raise consumers' perceived quality as well through misleading self labels or claims. Even if $\tilde{s}_n$ and s_n were related in an alternative manner (e.g. additively), our results relating to quality, consumer surplus and profits of the green and natural firms (that are robust to Bertrand and Cournot competition) would remain qualitatively unchanged.

$$CS = \int_{\theta_1}^{\theta_2} \left(\theta s_b - p_b\right) d\theta + \int_{\theta_2}^{\theta_3} \left(\theta s_n - p_n\right) d\theta + \int_{\theta_3}^{1} \left(\theta s_g - p_g\right) d\theta \tag{10}$$

Social welfare is then defined as $W = CS + \pi_b + \pi_n + \pi_g$, which represents its actual (rather than perceived) value. Furthermore, average quality of the quality differentiated good, denoted by $\overline{s}$, is defined as

$$\overline{s} = \frac{q_b s_b + q_n s_n + q_g s_g}{q_b + q_n + q_g} \tag{11}$$

3. Equilibrium

In this section, we derive equilibrium solutions for the two-stage game. Depending on the nature of product market competition at the second stage, we have the following mutually-exclusive cases.

3.1 Bertrand case

In the second stage of the game, the firms compete in prices taking their quality choices as given. Using (1), (6)-(8) and (9), the first order conditions (FOCs) for profit maximization, $\partial \pi_i / \partial p_i = 0$, yield the following reaction functions in prices:

$$p_b = \frac{\beta s_b p_n}{2 s_n} \tag{12}$$

$$p_n = \frac{p_g \left(s_n - \beta s_b\right) + p_b \left(\beta s_g - s_n\right)}{2\beta \left(s_g - s_b\right)} \tag{13}$$

$$p_g = \frac{\beta s_g - s_n + \beta p_n}{2\beta} \tag{14}$$

The second order conditions (SOCs) are satisfied, as we have $\partial^2\pi_i / \partial p_i^2 < 0$. The second stage reactions functions (12)-(14) show that price of firm *i* is non-decreasing in its rivals' prices and its own quality. Moreover, an increase in consumer's quality overestimation, i.e. a decrease in β, shifts the reaction function of the natural firm outward ($\partial^2\pi_n / \partial p_n \partial\beta < 0$) but shifts those of the green and brown firms inward ($\partial^2\pi_i / \partial p_i \partial\beta > 0$ for $i = b, g$). Thus, a larger overestimation of the natural good's quality by consumers benefits the natural firm, as it enables that firm to charge a higher price for given quality levels. In contrast, it adversely affects the brown and green firms that have to lower their prices for given quality levels.

Simultaneously solving (12)-(14), we obtain the equilibrium prices as functions of true qualities s_i and overestimation parameter β:

$$p_b^* = \frac{s_n\left(\beta s_g - s_n\right)\left(s_n - \beta s_b\right)}{2\left(\beta s_g\left(s_n - \beta s_b\right) + s_n\left(\beta s_g - s_n\right) + 2\beta s_n\left(s_g - s_b\right)\right)} \tag{15}$$

$$p_n^* = \frac{s_n\left(\beta s_g - s_n\right)\left(s_n - \beta s_b\right)}{\beta\left(\beta s_g\left(s_n - \beta s_b\right) + s_n\left(\beta s_g - s_n\right) + 2\beta s_n\left(s_g - s_b\right)\right)} \tag{16}$$

$$p_g^* = \frac{\left(\beta s_g - s_n\right)\left(s_g\left(s_n - \beta s_b\right) + 3s_n\left(s_g - s_b\right)\right)}{2\left(\beta s_g\left(s_n - \beta s_b\right) + s_n\left(\beta s_g - s_n\right) + 2\beta s_n\left(s_g - s_b\right)\right)} \tag{17}$$

By substituting (6)-(8) and (15)-(17) into (9), we can express profit of each firm as a function of all three qualities and β. In the first stage of the game, each firm chooses the quality level that maximizes its own profit. To obtain the Nash equilibrium quality levels s_i^*, we solve the three FOCs $\partial\pi_i(s_g, s_n, s_b, \beta) / \partial s_i = 0$ simultaneously for different values of β starting from 1 and decreasing in increments of 0.01.[15] Additionally, we check that the following conditions hold in equilibrium: (i) $s_n^* / s_g^* < \beta$ as required by (1), (ii) all SOCs are met locally, and (iii) given the

[15] The solutions are computed numerically using the software Mathematica.

other firms' quality choices, firm *i*'s profit reaches a global maximum at s_i^*. The last condition implies that "leapfrogging" is not a profit-improving strategy for the firms (see Motta, 1993).

We find that equilibrium, where the above conditions are satisfied, exists for $\beta \in [0.82,1]$ in the Bertrand case. Table 1 presents equilibrium values of the relevant variables for selected values of β.[16] By increasing its marginal revenue of quality ($\partial^2 R_n(s_g, s_n, s_b, \beta) / \partial s_n \partial \beta < 0$), consumers' quality overestimation motivates the natural firm to supply higher levels of quality. Hence, decreases in β lead to higher values of s_n^* in Table 1. To relax the intensity of price competition that takes place at the second stage, the green firm responds by increasing s_g^* at the first stage of the game. Moreover, the brown firm, which is adversely affected by the decreases in β, lowers its quality s_b^*. As a result of these changes, both the quality spectrum $(s_g^* - s_b^*)$ as well as average quality $\bar{s}$ of the vertically differentiated good, increases.

Further, by reducing $\theta_1^* = p_b^* / s_b^*$, consumers' overestimation of the natural good's quality increases the total number of consumers served in the market. The additional market coverage and the improvement in average quality benefit consumers by increasing their (true) surplus. The natural firm also gains. The advantage afforded to it by consumers' quality overestimation allows the natural firm to raise its nominal and quality-adjusted (or hedonic) prices, p_n^* and p_n^* / s_n^* respectively, which increases its profit. In contrast, decreases in β lower the nominal and quality-adjusted prices of the green and the brown goods, and adversely affect those firms' profits. Overall, social welfare is found to improve as consumers' quality overestimation increases.

Proposition 1 summarizes the above results.

Proposition 1. *When the firms compete in prices, an increase in consumers' overestimation of the natural good's quality:*

[16] The numbers in the Tables are rounded off. Note that when $\beta = 1$, and consumers do not overestimate quality, our Bertrand case is identical to Scarpa (1998). The equilibrium we obtain for $\beta = 1$ is consequently identical to that in Scarpa (1998).

(i) Increases equilibrium average quality. Quality of the green and the natural good increases, but that of the brown good decreases.

(ii) Increases consumer surplus as well as profit of the natural firm, but decreases profit of the green and the brown firms. Social welfare increases as a result.

3.2 Cournot case

We now examine the case where firms compete in quantities rather than prices. In the second stage of the game, the firms choose quantities taking their quality choices as given. Using (1), (6a)-(8a) and (9), the FOCs $\partial \pi_i / \partial q_i = 0$ lead to the following best-response functions in quantities:

$$q_b = \frac{1 - q_g - q_n}{2} \tag{18}$$

$$q_n = \frac{s_n - q_g s_n - \beta q_b s_b}{2 s_n} \tag{19}$$

$$q_g = \frac{\beta s_g - q_n s_n - \beta q_b s_b}{2 \beta s_g} \tag{20}$$

The SOCs for profit maximization are satisfied, as we have $\partial^2 \pi_i / \partial q_i^2 < 0$. The second stage reactions functions (18)-(20) show that output of firm *i* is decreasing in its rivals' outputs and non-decreasing in its own quality. Moreover, an increase in consumer's quality overestimation, i.e. a decrease in β, shifts the reaction function of the natural firm outward ($\partial^2 \pi_n / \partial q_n \partial \beta < 0$), shifts that of the green firm inward ($\partial^2 \pi_g / \partial q_g \partial \beta > 0$), but leaves the reaction function of the brown firm unchanged ($\partial^2 \pi_b / \partial q_b \partial \beta = 0$). Thus, when consumers overestimate quality to a larger extent, the natural firm expands it output while the green firm reduces its output, for given quality levels. The change in β, however, does not affect the quantity schedule of the brown firm.

Simultaneously solving (18)-(20), we obtain the equilibrium quantities as functions of s_i and β:

$$q_b^* = \frac{\beta s_g s_n}{2\left(\beta s_g\left(2s_n - \beta s_b\right) + s_n\left(2\beta s_g - s_n\right)\right)} \tag{21}$$

$$q_n^* = \frac{\beta s_g\left(2s_n - \beta s_b\right)}{2\left(\beta s_g\left(2s_n - \beta s_b\right) + s_n\left(2\beta s_g - s_n\right)\right)} \tag{22}$$

$$q_g^* = \frac{\beta s_g\left(2s_n - \beta s_b\right) + 2s_n\left(\beta s_g - s_n\right)}{2\left(\beta s_g\left(2s_n - \beta s_b\right) + s_n\left(2\beta s_g - s_n\right)\right)} \tag{23}$$

By substituting (6a)-(8a) and (21)-(23) into (9), we can express profit of each firm as a function of the three qualities and β. In the first stage of the game, each firm chooses the quality level that maximizes its own profit. The Nash equilibrium quality levels, s_i^*, are obtained as earlier. Thus, we solve the three FOCs $\partial\pi_i(s_g, s_n, s_b, \beta)/\partial s_i = 0$ simultaneously for different values of β starting from 1 and decreasing in increments of 0.01. Additionally, we check that the following conditions hold in equilibrium: (i) $s_n^*/s_g^* < \beta$, (ii) all SOCs are locally met, and (iii) given the other firms' quality choices, firm *i*'s profit is a global maximum at s_i^*, so that "leapfrogging" is not a profit-improving strategy.

In the Cournot case, we find that equilibrium where the above conditions are satisfied exists for $\beta \in [0.87, 1]$. Table 2 presents equilibrium values of the relevant variables for selected values of β.[17] By increasing its marginal revenue of quality, quality overestimation by consumers provides an incentive to the natural firm to supply higher quality s_n^* (see Table 2). To relax second stage quantity competition, the green firm responds by increasing its quality s_g^*. Further, the quality response of the brown firm to decreases in β is found to be non-monotonic,

[17] When $\beta = 1$, and consumers do not overestimate quality, our Cournot case is identical to Pezzino (2010). Hence, the equilibrium we obtain for $\beta = 1$ is identical to the unregulated equilibrium in Pezzino (2010).

with s_b^* initially decreasing but finally increasing. Both quality spectrum $(s_g^* - s_b^*)$ and average quality $\bar{s}$ increases, as a result of these changes.

By increasing $\theta_1^* = p_b^* / s_b^*$, lower values of β decreases the total number of consumers served in the market. Despite the decline in market coverage, the improvement in average quality increases consumer surplus. Further, consumers' quality overestimation enables the natural firm to raise its quality-adjusted price, p_n^* / s_n^*, which improves its profit. Quality-adjusted price and profit of the brown firm are also found to increase, with decreases in β. In contrast, the green firm is worse off as its quality-adjusted price and profit decline. These changes are observed to adversely affect overall social welfare, which falls as consumers' quality overestimation increases.

Proposition 2 summarizes the above results.

Proposition 2. *When the firms compete in quantities, an increase in consumers' overestimation of the natural good's quality:*

(i) Increases equilibrium average quality. Quality of the green and the natural good increases, but that of the brown good initially decreases and then increases.

(ii) Increases consumer surplus as well as profit of the natural and brown firms, but decreases profit of the green firm. Social welfare decreases as a result.

4. Comparison

By increasing its marginal revenue of quality, consumers' quality overestimation motivates the natural firm to supply higher quality in both the Bertrand and Cournot cases. Figure 2 shows the equilibrium quality levels, under Bertrand and Cournot competition, for different values of β. Because second stage market competition is harsher under Bertrand than under Cournot (given same qualities), firms differentiate their products more in the former case in an effort to reduce the intensity of that competition (Motta, 1993). As a result, the quality spectrum is wider when the firms compete in prices. Another consequence of the fiercer competition under Bertrand is

that both nominal and quality-adjusted prices, p_i^* and p_i^* / s_i^*, are lower in that case than under Cournot. Moreover, average quality is found to be lower in the Bertrand case.[18]

Further, the difference in intensity of competition implies that consumers' overestimation of quality increases the natural firm's marginal revenue of quality by a smaller extent in the Bertrand case. Consequently, improvements in the natural good's quality are also smaller in that case. For example, as β falls from 1 to 0.87, s_n^* increases by 5.6% (from 0.04972 to 0.05249) in the Bertrand case but by 50.9% (from 0.08946 to 0.13502) in the Cournot case. Consequently, as β decreases, the gap between average qualities in the Bertrand and Cournot cases expands.

Figure 3 shows components of social welfare, in the Bertrand and Cournot cases, for different values of β. The more intense competition under Bertrand makes consumers even better off in that case relative to the Cournot case. While consumer surplus increases in both cases with decreases in β, the gap between the two consumer surpluses shrinks, reflecting the fact that average quality rises faster under Cournot.

Further, as β decreases, profit of the natural firm increases in both cases, making consumers' quality overestimation beneficial for that firm. It however reduces the green firm's profit, which falls more drastically under Cournot than under Bertrand. For example, a lowering of β from 1 to 0.87, leads to a 49.4% reduction of π_g^* in the Cournot case (from 0.01861 to 0.00941) but to a 7.1% reduction of π_g^* in the Bertrand case (from 0.02348 to 0.02182). This large reduction in profit of the green firm dominates the other welfare changes under Cournot, leading to a worsening of welfare in that case. In contrast, welfare increases in the Bertrand case for lower values of β.

5. Conclusion

The paper has examined the consequences of consumers' overestimation of the quality of intermediate-quality products. For certain products, consumer misinformation about quality is more pervasive at the intermediate levels of the quality spectrum, rather than at the extremes.

[18] In a model without quality overestimation, Pezzino (2010) also finds average quality under Cournot exceeds that under Bertrand.

Given the incentives of the producers of these intermediate quality products, this misinformation is likely to be manifested as an overestimation of actual quality rather than its underestimation.

Our results indicate that consumers' quality overestimation is not necessarily bad, at least for certain sections of society. Expectedly, it leads to gains for producers of the intermediate quality products. Less obvious are the benefits that accrue to consumers due to improvements in average quality of the vertically differentiated product. However, consumers' erroneous belief about intermediate quality adversely affects the high quality producer, especially when the firms compete in quantities. In that case, the reduction in profit suffered by the high quality producer can be so large as to worsen overall social welfare. As well, we find that the impact on the low quality producer depends on the nature of market competition. Our findings suggest that consumer protection bodies may not wish to counter misleading claims by producers of intermediate quality goods. However, competition authorities may take a different view on this matter, especially when it leads to reductions in social welfare.

The paper has assumed that quality improvements raise fixed rather than variable cost of production. Nevertheless, even when the latter is considered, our results will remain qualitatively unchanged as long as variable cost of production rises sufficiently slowly with quality.[19] Further, the paper has examined the consequences, rather than the causes, of consumers' misinformation about quality by treating β as a model parameter. In future work, it would be interesting to endogenize β and incorporate government regulation of misinformation in this context.■

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[19] In a duopoly model of vertical product differentiation, Motta (1993) compares two alternative specification of costs – one where quality-dependent costs are fixed, and another where they affect variable cost of production. For both specifications of cost, Motta finds that (i) firms differentiate qualities more under price competition than under quantity competition, and (ii) welfare is higher under price competition than under quantity competition.

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Figure 1: Consumers

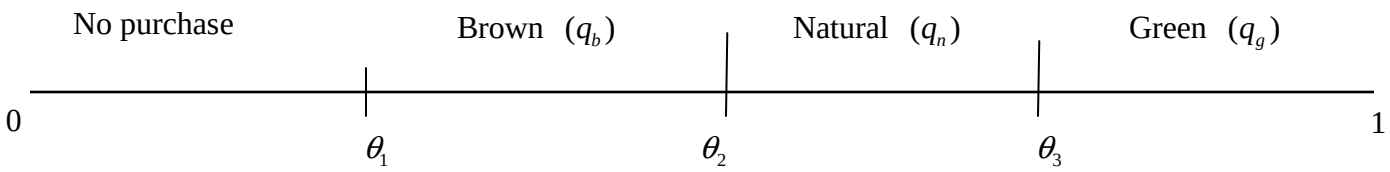

Table 1: Bertrand Equilibrium

β	s_g^*	s_n^*	s_b^*	p_g^*	p_n^*	p_b^*	q_g^*	q_n^*	q_b^*
0.82	0.25518	0.05341	0.00914	0.10092	0.01181	0.000828	0.53107	0.27291	0.10540
0.84	0.25482	0.05306	0.00921	0.10156	0.01148	0.000838	0.52998	0.27271	0.10642
0.86	0.25446	0.05268	0.00928	0.10218	0.01116	0.000846	0.52891	0.27257	0.10739
0.87	0.25430	0.05249	0.00931	0.10249	0.01101	0.000850	0.52837	0.27252	0.10788
0.88	0.25414	0.05229	0.00934	0.10279	0.01085	0.000853	0.52785	0.27247	0.10836
0.9	0.25386	0.05189	0.00939	0.10337	0.01055	0.000859	0.52688	0.27234	0.10929
0.92	0.25358	0.05147	0.00944	0.10394	0.01025	0.000864	0.52593	0.27226	0.11020
0.94	0.25332	0.05104	0.00947	0.10449	0.00996	0.000868	0.52502	0.27220	0.11108
0.96	0.25308	0.05061	0.00950	0.10502	0.00967	0.000872	0.52414	0.27215	0.11193
0.98	0.25288	0.05016	0.00952	0.10554	0.00940	0.000874	0.52330	0.27213	0.11277
1	0.25266	0.04972	0.00953	0.10604	0.00913	0.000875	0.52247	0.27213	0.11358

β	$\bar{s}$	p_g^* / s_g^*	p_n^* / s_n^*	p_b^* / s_b^*	CS	π_g^*	π_n^*	π_b^*	W
0.82	0.16611	0.39549	0.22101	0.09062	0.04761	0.02104	0.00180	0.000046	0.07049
0.84	0.16555	0.39856	0.21640	0.09089	0.04718	0.02136	0.00172	0.000047	0.07031
0.86	0.16498	0.40156	0.21191	0.09112	0.04677	0.02167	0.00166	0.000048	0.07014
0.87	0.16470	0.40303	0.20972	0.09123	0.04657	0.02182	0.00162	0.000048	0.07005
0.88	0.16442	0.40446	0.20755	0.09132	0.04637	0.02196	0.00159	0.000049	0.06997
0.9	0.16391	0.40719	0.20329	0.09148	0.04599	0.02225	0.00153	0.000050	0.06981
0.92	0.16339	0.40989	0.19915	0.09161	0.04563	0.02252	0.00147	0.000051	0.06966
0.94	0.16288	0.41248	0.19512	0.09171	0.04528	0.02277	0.00141	0.000052	0.06951
0.96	0.16239	0.41497	0.19118	0.09177	0.04495	0.02302	0.00135	0.000052	0.06937
0.98	0.16192	0.41735	0.18735	0.09180	0.04463	0.02326	0.00130	0.000053	0.06924
1	0.16144	0.41969	0.18361	0.09180	0.04432	0.02348	0.00125	0.000054	0.06910

Table 2: Cournot Equilibrium

β	s_g^*	s_n^*	s_b^*	p_g^*	p_n^*	p_b^*	q_g^*	q_n^*	q_b^*
0.87	0.25553	0.13502	0.02667	0.10367	0.04405	0.00414	0.40571	0.28380	0.15524
0.88	0.25502	0.12839	0.02634	0.10505	0.04087	0.00406	0.41192	0.28014	0.15397
0.9	0.25424	0.11806	0.02593	0.10716	0.03597	0.00395	0.42150	0.27421	0.15215
0.92	0.25364	0.11012	0.02573	0.10875	0.03224	0.00388	0.42878	0.26939	0.15092
0.94	0.25316	0.10366	0.02567	0.11003	0.02925	0.00385	0.43463	0.26521	0.15008
0.96	0.25278	0.09822	0.02572	0.11109	0.02675	0.00385	0.43948	0.26147	0.14953
0.98	0.25248	0.09356	0.02587	0.11199	0.02463	0.00386	0.44358	0.25799	0.14921
1	0.25220	0.08946	0.02610	0.11276	0.02279	0.00389	0.44711	0.25470	0.14909

β	$\bar{s}$	p_g^* / s_g^*	p_n^* / s_n^*	p_b^* / s_b^*	CS	π_g^*	π_n^*	π_b^*	W
0.87	0.17299	0.40571	0.32622	0.15525	0.04574	0.00941	0.00339	0.000287	0.05882
0.88	0.17147	0.41193	0.31833	0.15396	0.04512	0.01076	0.00321	0.000278	0.05936
0.9	0.16923	0.42149	0.30468	0.15214	0.04413	0.01285	0.00289	0.000264	0.06014
0.92	0.16760	0.42876	0.29281	0.15091	0.04336	0.01447	0.00262	0.000255	0.06070
0.94	0.16634	0.43463	0.28214	0.15007	0.04273	0.01578	0.00238	0.000249	0.06114
0.96	0.16534	0.43947	0.27235	0.14952	0.04219	0.01688	0.00217	0.000244	0.06148
0.98	0.16454	0.44356	0.26325	0.14922	0.04173	0.01781	0.00198	0.000241	0.06175
1	0.16387	0.44711	0.25470	0.14910	0.04132	0.01861	0.00180	0.000240	0.06197

Figure 2: Equilibrium qualities under Bertrand (^B) and Cournot (^C) competition

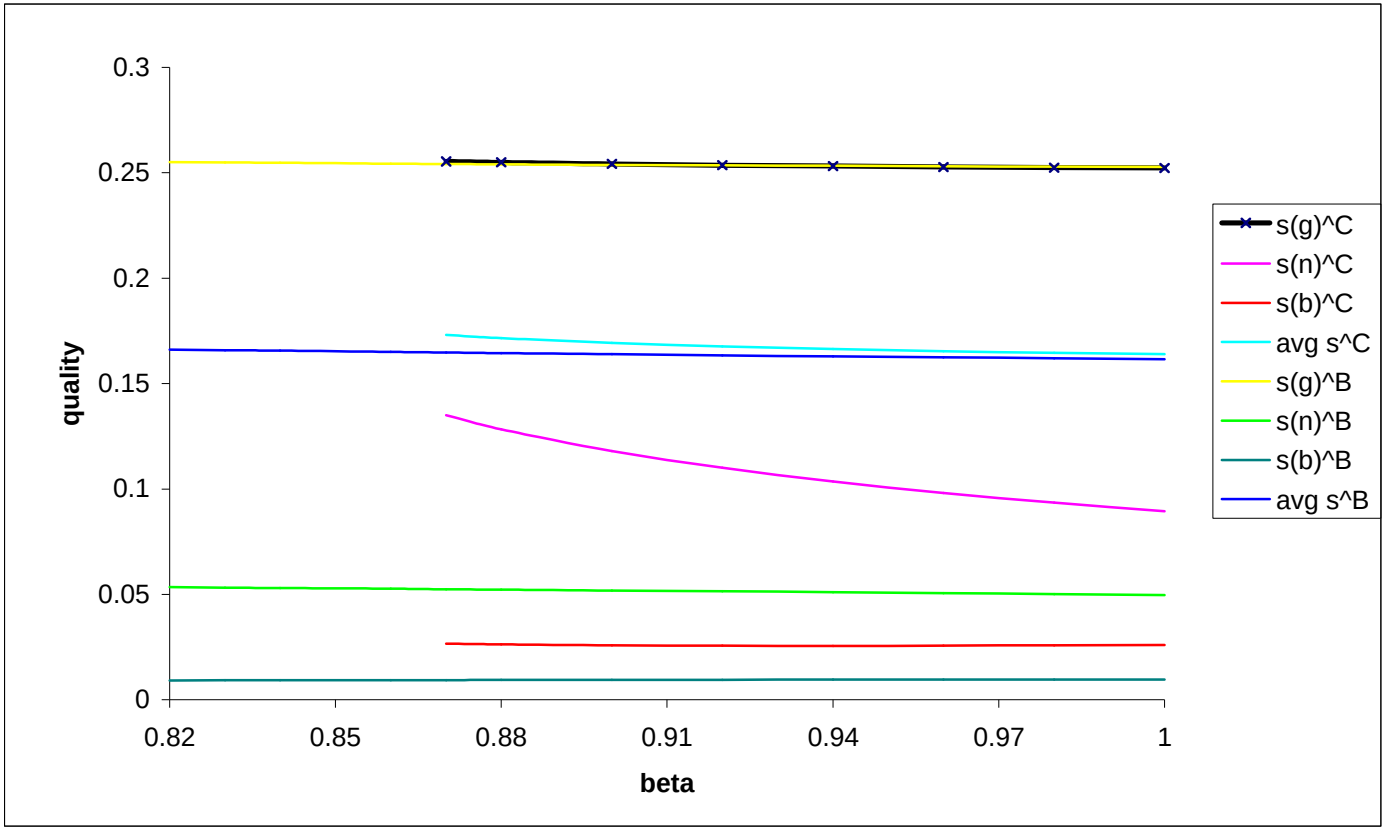
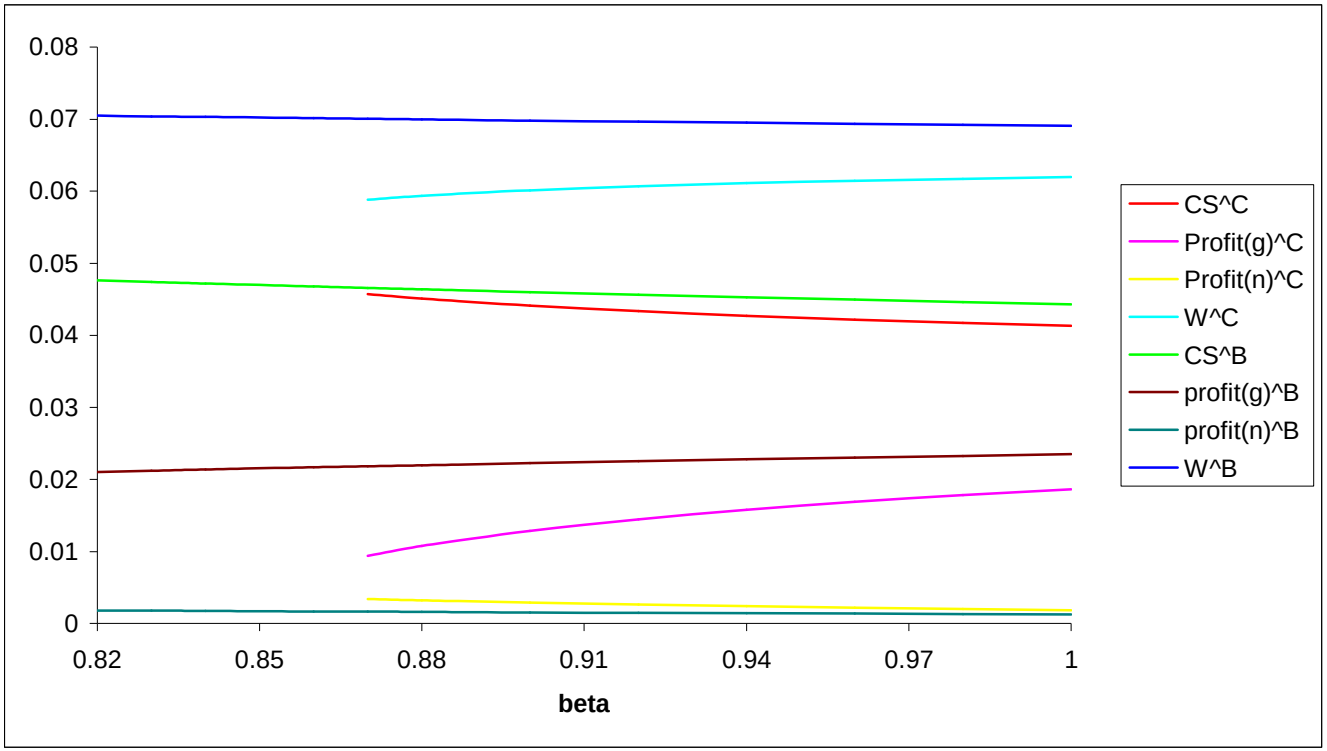
Figure 3: Consumer Surplus, Profit, and Welfare under Bertrand (^B) and Cournot (^C) competition