Competition for Lowering Impurity in Consumer Staples

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***Abstract*—**World economies are growing and offering more people a wider variety of products both in terms of type and quality. The producers of many consumer products compete in terms of the quality they offer, and the economic literature offers models for analyzing the nature of their competition. For many products, most notably staple products like water and basic food items, the quality is better expressed in terms of a lower level of impurity rather than a higher level of quality. We present a model that modifies the standard competition models to show how two firms that offer products with different levels of impurity can exist in a stable equilibrium in terms of price and the different level of impurities. The model demonstrates how changing populations and the costs of reducing impurities determine the levels of impurities in the products offered consumers.

***Keywords*—**Game theory, quality competition, duopoly equilibrium, consumer staples market.

I. Introduction

There is an extensive literature on quality and price competition. To date, the focus in the literature has been on how firms can compete by offering products that offer a higher level of utility by offering a higher level of quality. For many products, however, there is an upper limit to the quality, and the focus should be on how far the product deviates from that upper limit. Such products include water and basic food products. We develop a model that modifies the existing price and quality models to demonstrate the properties of a market where two firms compete by offering products with differing levels of impurity.

Our model is an adaptation of a general model developed by Anderson, de Palma, and Thisse (1992), henceforth ADT. The ADT model is well established in the industrial organization literature, and it describes a duopoly market where the firms avoid direct competition by offering products with different qualities and prices. We build upon the ADT model by modifying the nature of quality to being a negative value based on impurity and introducing a virtually free alternative such water from a natural source or a staple food product sold at a low, fixed marginal cost. Consumers can choose the free variety of the good, or consumers can purchase from one of two established, industrial providers that offer products with different levels of impurities, which are lower than that associated with the lowest cost alternative.

The model shows how exogenous factors determine the percentage of consumers that choose each type of product and the prices charged by the industrial producers. The exogenous parameters are the higher impurity level of the non-industrial product, the number of consumers, and the tastes of the consumers. The solutions allow researchers to analyze how changes in the exogenous parameters affect the decisions of the industrial providers. As the numbers of consumers increase, for example, the impurity levels should decline. The findings can help understand how world trends in population size and tastes will affect the market for consumer staples such as water and basic agricultural products.

The review of the literature in the next section provides the foundation of the theories and assumptions used in this model. After that section, we introduce the parameters assuming there is only a low-impurity producer identified as Firm 1. That Firm 1 competes with the non-industrial sources that have a fixed level of impurity, and the price for that variety is either zero or a low, fixed marginal cost of production. After demonstrating the implications of that model, we expand the model to include Firm 2 that offers a product with a higher level of impurity than Firm 1 but a lower level of impurity than the non-industrial sources. We employ comparative statics to demonstrate the implications of the model with respect to world trends. After that demonstration, we offer a summary and discussion.

II. Models of Quality Competition

A. Review of the Literature

Models analyzing the effects of quality competition are important because economic welfare is generally better when consumers and/or consumers have a wider variety of products and services from which to choose (see Mussa and Rosen, 1978; Anderson et al., 1992). Those offering the products, services and investments can benefit from being able to distinguish themselves and avoid direct competition. New entrants to an industry must usually try to find their own market niche, and that niche may be a quality that is different from the quality of existing products. Existing firms in the industry can benefit by allowing other firms to enter the industry with products that do not directly compete with the products already offered as opposed to entering with a product that directly competes. Previous researchers have verified how it is often too costly for monopolists offering a given quality of goods to prevent entrants with a different quality product from entering the market; see Dixit (1980), Schwartz and Thompson (1986) and

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Schwartz and Baumann (1987). This section summarizes the development of the literature that explores the dynamics and effects of this competitive process.

Over the years, a large literature has built upon early works such as Leland (1977) and Shaked and Sutton (1982) to show how quality differentiation relaxes price competition. The reason for such differentiation is to avoid the Bertrand (1883) outcome associated with firms that compete with the same quality product. Researchers created the moniker "Bertrand death" to describe a competitive situation where prices are falling and production costs are increasing from direct competition. In the resulting equilibrium, the firms have non-positive profits (Anderson et al., 1992). According to Sutton (1997), "loss-making strategies will be avoided" by firms; also, "if a profitable opportunity exists in the market, there is 'one smart agent' who will fill it." Rather than risking a competitive outcome where profits are non-positive, the entering firm can choose a quality that is different enough to allow it to not directly compete with the existing firm.

There is a lengthy literature on the entry of firms into industries where profit opportunities exist. Prescott and Visscher (1977) and Hay (1976) pioneered the modern sequential-entry models. Lane (1980) extended the model to allow for endogenous prices, and this development has characterized later models including the one in this paper. Subsequent works in this area include Shaked and Sutton (1982), Bernheim (1984), Harris (1985), Eaton and Ware (1987), Dewatripont (1987), Benoit and Krishna (1987), Vives (1988), Mclean and Riordan (1989), Donnenfeld and Weber (1992), and Anderson et al. (1992).

The model in our paper builds upon the model established in Anderson et al. (1992), or ADT. The ADT model is a vertical differentiation model with a stable equilibrium where the quality levels could theoretically increase to infinity. In our model, we measure the quality with a non-positive number which represents the impurity of the product, and the upper limit on quality is zero. In our model, the second-order conditions are satisfied, and the model yields a unique and stable equilibrium.

The next section summarizes the assumptions of the ADT model and modifies that model so that its inputs correspond to products with impurities. That section lays the groundwork for the sections that describe an economy where Firm 1 and Firm 2 coexist and differentiate themselves by their respective impurity levels. Those subsequent sections also demonstrate the impact of changes in exogenous parameters on the choice variables of Firm 1 and Firm.

B. Single Firm Model

This section serves two purposes. First, it introduces the assumptions of the model as well as the parameters that describe the characteristics of Firm 1 and the consumers in the model. Second, this section derives the equilibrium where Firm 1 only competes with an exogenous product that has a higher level of impurity. The equilibrium is a standard result, but it sets the stage for examining the equilibrium when there are is Firm 1 and Firm 2.

To describe how the consumers make their choices, we adapt the indirect utility function of consumers used by ADT. In the ADT model, indirect utility is a function of income, price, taste and quality, which are represented by y, P_i, θ, and q_i, respectively:

$$V_i(\theta) = y - P_i + \theta q_i \quad (i = 1 \ldots n) \tag{1}$$

Each period, consumers purchase and consume a single unit of the product indexed i. The price and quality of the product are P_i and q_i, respectively. The increase in utility from consuming the product depends on each agent's unique preference factor denoted θ. Preferences follow a uniform distribution over an interval bounded by a lower and upper value of θ. The symbol q_H represents the quality level offered by the high-quality producer or the monopolist in the single-seller case. In the duopoly market, the low-quality producer offers q_L; therefore, $q_L<q_H$. The net benefit of consuming product variety i is given by the quantity θq_i-P_i.

Using the same basic concept, we propose the following profit function for the consumer of a staple good characterized by its level of impurity:

$$V_i(\kappa) = U - P_i - \kappa\varepsilon_i \quad (i = 1, \ldots n) \tag{2}$$

Where,

- U: the utility from consuming the staple;
- P_i: the price charged by Firm "i";
- κ: the factor that determines the disutility from a given level of impurity;
- ε_i: a level of impurity in the product offered by firm "i".

Each consumer gets the same basic utility from consuming a pure variety of the product, e.g., water to quench a thirst. There is a continuum of such consumers, and each has a unique value for κ, which identifies each consumer. Firm 1 charges P_1 to maximize net revenue and lowers ε_1 to a target level. That target level will be below ε_L, which is the exogenous impurity level offered by non-industrial sources.[1]

Effectively, each consumer has the choice between an expected utility equal to U - $\kappa\varepsilon_L$ or paying P_1 for an expected utility equal to $U-P_1-\kappa\varepsilon_1$, where $\varepsilon_L>\varepsilon_1$. Consumers characterized by $\kappa>P_1/(\varepsilon_L-\varepsilon_1)=\kappa^*$ will choose to pay P_1 for only suffering with a ε_1 level of impurity. In other words, consumers with a higher value of κ, which means a higher sensitivity to impurity, are willing to pay the price for a less impure product.[2]

As assumed in the ADT model and many other models of this type, κ is uniformly distributed. The lower bound on κ is zero, and there is an upper bound, which we denote K. The value of the density function over zero to K is the number of consumers divided by K. Letting N represent the number of potential consumers and $\phi'(\kappa)$ represent the density function, we can write $\phi'(\kappa)=N/K$ when $0<\kappa<K$, else $\phi'(\kappa)=0$. At this point we assume that U is sufficiently high so as to exceed both the price and the disutility from the less-than-perfect product. Future research will

[1] We can interpret ε_L as the level of impurity in water drawn from a stream. Or, it is the unrefined properties of an agricultural product sold by farmers in a perfectly competitive market where the price is a fixed, low price equal to the marginal cost of production.

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examine the implications of the possibility of $U<P_i + \kappa\varepsilon_i$.

Firm 1 incurs costs in lowering ε_i:

$$C(cost|\varepsilon_1)= \xi(\varepsilon_L-\varepsilon_1)^2 \quad (3)$$

The cost function embodies the assumptions that costs are a function of how much Firm 1 lowers impurities below that associated with non-industrial sources, $(\varepsilon_L-\varepsilon_1)$, and that the principle of increasing costs applies. There is a scale factor, ξ, which could vary based on technology and the inputs to the product. The profit function is:

$$\pi_1=(N/K)(K-\kappa^*)P_1 - \xi(\varepsilon_L-\varepsilon_1)^2 \quad (4)$$

Firm 1 chooses the lower level of level to offer, ε_1, and the price to charge consumers to maximize net revenue. Substituting κ^* into the profit function and optimizing with respect to the price gives this expression for optimal price: $P_1^*=K(\varepsilon_L-\varepsilon_1)/2$. Using the assumed distribution of κ gives the following expression:

$$\kappa^* = [K(\varepsilon_L-\varepsilon_1)/2]/(\varepsilon_L - \varepsilon_1) = K/2 \quad (5)$$

This is a standard result where there is only one seller or service provider.

The first-order conditions[3] provide the solution for the optimal ε_1 for Firm 1 to choose. The solution for the level of improvement is: x

$$\varepsilon_L-\varepsilon_1=0.125\varepsilon_L NK/\xi \quad (6)$$

The optimal ε_1 is

$$\varepsilon_1 = \varepsilon_L - 0.125\varepsilon_L NK/\xi \quad (7)$$

Other things equal, a unit increase/decrease in the impurity of the non-industrial product, given by ε_L, will increase/decrease ε_1 by an equal amount. Other relationships are clear: $d\varepsilon_1/dK<0$, $d\varepsilon_1/dN<0$, $d\varepsilon_1/d\xi>0$. Firm 1 chooses to differentiate its product more from ε_L when either there are more consumers, i.e., N increases, or there is a higher sensitivity to impurities as measured by an increase in K. An increase in N increases the marginal revenue from a given increase in P_1, and the Firm will lower ε_1. Firm 1 finds it profitable to accommodate an increase in the aversion of consumers to impurities by distinguishing its product more from ε_L. Naturally, Firm 1 will increase (decrease) ε_1, when the cost of lowering it increases (decreases).

The optimal price is $P_1 = 0.0625\varepsilon_L NK^2/\xi$, and $dP_1/dK >0$, $dP_1/dN >0$, $dP_1/d\xi<0$. Increases (decreases) in the number of consumers and/or their aversion to the impurity will allow Firm 1 to increase the price. Interestingly enough, an increase in the scale factor ξ for lowering ε_1 will decrease the price, but this is because Firm 1 will have to allow ε_1 to increase, and consumers will want a decrease in the price for the increase in ε_1.

The profit to Firm 1 is $\pi_1 = 0.015625\varepsilon_L(NK)^2/\xi$, and $d\pi_1/dK >0$, $d\pi_1/dN >0$, $d\pi_1/d\xi<0$. As we would expect, net revenue increases when the number of consumers increase or the scale parameter in the cost function decreases. Interestingly enough, net revenue increases when consumers have a higher level of aversion to impurity.

These results hold when κ follows a distribution other than the uniform distribution. A cumulative distribution function, denoted $\phi(\kappa)$, can help create a more general expression for net revenue:

$$\pi_1 = NP_1\{1- \phi[P_1/(\varepsilon_L-\varepsilon_1)]\}- \xi (\varepsilon_L-\varepsilon_1)^2 \quad (8)$$

The optimal price is $P_1^* = [1- \phi(\kappa^*)]/[(\varepsilon_L-\varepsilon_1) - \phi'(\kappa^*)]$, which then gives the expression:
$\kappa^* = [1- \phi(\kappa^*)]/\phi'(\kappa^*)$. The value of κ^* is a constant nominal value for many distributions. Unique solutions exist for κ^* and the second-order conditions are satisfied when $\phi(\kappa)$ represents a uniform, normal or exponential distribution[4].

The section has introduced the model and developed results when only Firm 1 exists and competes against an exogenous, more impure product. For the most part, the results are straightforward and conform to intuition. The process has allowed for the introduction of parameters and assumptions of the model in a relatively simple case. The next section investigates the results when Firm 2 attempts to attract consumers by offering a product with a lower price but also a higher level of impurity.

B. Competition Between Firm 1 and Firm 2

To describe the interaction of the Firm 1 and Firm 2, we use the widely-used assumption that the managers engage in a quality-then-price two-stage game. In this case the quality is the levels of impurity associated with the products of the firms. Representative works using this assumption include Tirole (1988), Jehiel (1992) and Xavier (1996). The model developed here has a stable equilibrium that defines the proportional number of consumers in for each product, the respective prices, the values ε_1 and ε_2, and net revenues to the in terms of the external parameters defined in the previous section.

In the first stage of the game, the firms recognize how their choices of ε_i determine the relative number of consumers who will purchase their respective products. They also recognize the benefits of distinguishing themselves so that $\varepsilon_2 >\varepsilon_1$ and $P_2 <P_1$. Recalling Equation (2), the condition that leads a consumer to choose Firm 1's product over that of Firm 2 is $-P_1-\kappa\varepsilon_1>-P_2-\kappa\varepsilon_2$. The preference factors for the marginal consumers are:

$$\kappa_1^* = (P_1-P_2)/(\varepsilon_2-\varepsilon_1) \quad (9)$$

$$\kappa_2^* = P_2/(\varepsilon_L-\varepsilon_2) \quad (10)$$

The term $(N/K)(K-\kappa_1^*)$ indicates the number of consumers who choose to Firm 1's product. The corresponding measure for Firm 2 is $(N/K)(\kappa_1^*-\kappa_2^*)$. Solving for each P_i^* as before yields,

$$P_1^* = 2K(\varepsilon_2-\varepsilon_1)(\varepsilon_L-\varepsilon_1)/(3\varepsilon_L+\varepsilon_2-4\varepsilon_1) \quad (11)$$

$$P_2^* = K(\varepsilon_2-\varepsilon_1)(\varepsilon_L-\varepsilon_2)/(3\varepsilon_L+\varepsilon_2-4\varepsilon_1) \quad (12)$$

For ease of notation we write $P_1^*=2K\delta_{2,1}\delta_{L,1}/\omega$ and $P_2^*=K\delta_{2,1}\delta_{L,2}/\omega$. The implied transformations are $\delta_{L,1} = \varepsilon_L-\varepsilon_1$,

[2] We assume that U is the basic utility from consuming the product, e.g., quenching a thirst.

[3] The first derivative is $d\pi_1/d\varepsilon_1 = -(R^2/4) + 2\xi(\varepsilon_L-\varepsilon_1)/\varepsilon_L$. The second-order condition is satisfied: $d^2\pi_1/d(\varepsilon_1)^2 = -2\xi/\varepsilon_L$.

[4] There are distributions for which κ^* is not unique. One example is $\phi(\kappa) = 1-K/\kappa$; κ:[K+∞), where K is a positive constant.

$\delta_{L,2} = \varepsilon_L - \varepsilon_2$, $\delta_{2,1} = \varepsilon_2 - \varepsilon_1$, $\omega = 3\varepsilon_L + \varepsilon_2 - 4\varepsilon_1$.

The net revenue functions in the first stage of the game are:

$$\pi_1 = 4NK\delta_{2,1}\delta_{L,1}^2/\omega^2 - \xi(\delta_{L,1})^2 \quad (13)$$

$$\pi_2 = NK\delta_{L,2}\delta_{2,1}\delta_{L,1}/\omega^2 - \xi(\delta_{L,2})^2 \quad (14)$$

The first-order conditions for the Firm 1 and Firm 2 respectively are[5],

$$\xi = 2NK\varepsilon_L(2\delta_{L,2}^2 - 3\delta_{L,1}\delta_{L,2} - 4\delta_{L,1}^2)/(\delta_{L,1}\omega^3) \quad (15)$$

$$\xi = NK\varepsilon_L\delta_{L,1}(4\delta_{L,1} - 7\delta_{L,2})/(2\delta_{L,2}\omega^3) \quad (16)$$

Equating the two expressions for ξ gives a third degree polynomial in a variable defined as $\delta_{L,1}/\delta_{L,2}$. Only a single real-root exists: $\delta_{L,1}/\delta_{L,2} = 5.25123$. Entering this value into the equations above yields solutions for the degree to which each lowers the impurities below that offered from a non-industrial source.

$$\delta_{L,1} = \varepsilon_L - \varepsilon_1 = 0.12665NK\varepsilon_L/\xi \quad (17)$$

$$\delta_{L,2} = \varepsilon_L - \varepsilon_2 = 0.02412NK\varepsilon_L/\xi \quad (18)$$

These expressions define several interesting relationships. Using the term $\varepsilon_L NK/\xi$ as a unit of measure, for example, Firm 2 improves ε_L to ε_2, but that distance is less than one fifth the distance of $\varepsilon_L - \varepsilon_1$.

The prices are $P_1 = 0.05383NK^2\varepsilon_L/\xi$ and $P_2 = 0.00513NK^2\varepsilon_L/\xi$. Net revenues per period are $\pi_1 = 0.0122193(NK)^2\varepsilon_L/\xi$ and $\pi_2 = 0.0005075(NK)^2\varepsilon_L/\xi$. Firm 1's revenue is higher, which is consistent with findings of previous models; see Lehmann-Grube (1997).[6]

The competition between the Firm 1 and Firm 2 forces prices to decline. The Firm 1 price, P_1, in the two-firm model is about 14% lower than P_1 in the one-firm model. The corresponding ε_1 declines by about one percent, which means the existence of the Firm 2 choice for consumers leads to the Firm 1 increasing the level of impurity in its product slightly, but they lower the price by much more in percentage terms. These adjustments increase the proportion of consumers who choose the Firm 1 from 50% in the one-firm case to 52.5%. Firm 2 attracts 26.25% of all potential consumers. The remaining 21.25% of the consumers choose to purchase the non-industrial variety. These market shares are immutable as long as both Firm 1 and Firm 2 remain in the market and they both have the same value for ξ.

This section has demonstrated how an equilibrium can exist in the competition for consumers between the Firm 1 and Firm 2. The model builds upon that proposed by ADT by offering the consumers a third, exogenous choice. In our model, that third choice is to consume a non-industrial variety of the product. Under these conditions, a unique set of prices, net revenues, number of consumers and impurities results. The next section examines how changes in exogenous parameters affect the resulting values in that equilibrium.

III. Changes in Impurity Levels from Changes in Exogenous Factors

This section examines how changes in exogenous parameters affect the equilibrium derived in the previous section. Comparative statics yield interesting results with respect to the impact on the equilibrium qualities of impurities, prices and net revenues in response to changes in ε_L, ξ, N and K. Respectively, these parameters relate to an exogenous level of impurity, a scale parameter for the cost to lower impurity, the number of potential consumers, and the aversion consumers have to impurity.

The results in the previous sections yield the following expressions: $\varepsilon_1 = \varepsilon_L - 0.12665NK\varepsilon_L/\xi$ and $\varepsilon_2 = \varepsilon_L - 0.02412NK\varepsilon_L/\xi$. The distance between the two levels is $\varepsilon_1 - \varepsilon_2 = 0.10253NK\varepsilon_L/\xi$. Thus, when ε_L changes, both of the industrial quality levels change in the same direction, but the distance between them changes. An increase (decrease) in the general level of impurity in the non-industrial product, as represented by ε_L, would increase (decrease) the impurity of the products offered by both Firm 1 and Firm 2, and ε_1 and ε_2 would diverge (converge). Exogenous levels of pollution would be one factor that would determine ε_L.

An increase in K implies that the consumers are more averse to the impurity levels. Firm 1's impurity level is more sensitive to changes in K:

$$|d\varepsilon_1/dK| = |-0.12665N\varepsilon_L/\xi| > |d\varepsilon_2^2/dK| = |-0.02414N\varepsilon_L/\xi| \quad (19)$$

The equilibrium conditions imply that that Firm 1 and Firm 2 will accommodate an increase in K by lowering ε_i in their respective products. The decline in ε_1 will be much larger in the Firm 1's case, which indicates the qualities of Firm 1 and Firm 2 will diverge.[7]

Changes in K will affect prices and net revenues for both firms in the same direction but with different magnitudes: $dP_1/dK = 0.10766NK\varepsilon_L/\xi$, $dP_2/dK = 0.01026NK\varepsilon_L/\xi$, $d\pi_1/dK = 0.02443864KN^2\varepsilon_L/\xi$, and $d\pi_2/dK = 0.001015KN^2\varepsilon_L/\xi$. An increase in K will increase the prices and revenues and also lead to both the difference between the prices and the difference between the net revenues increasing. In summary, an increase (decrease) in K decreases (increases) both ε_1 and ε_2, and the values diverge (converge), prices increase (decrease) and diverge (converge) and net revenues increase (decrease) and diverge (converge). This means that if consumers become more demanding with respect to impurity levels, as represented by an increase in K, then Firm 1 and Firm 2 will become less similar, and the impurity levels will decline.

Since the term (NK) appears in the expressions for prices, net revenues, and ε_i, it should be obvious that an increase in the

[5] The first-order conditions yield reaction functions in the plane defined by ε_1 and ε_2. The first order conditions give: $\varepsilon_2 = 5.25123\varepsilon_1 - 4.25123\varepsilon_L$; therefore when an equilibrium combination of ε_2 and ε_1 exists, it is unique. The second-order conditions are satisfied: $d^2\pi_1/d\varepsilon_1^2 = -8NK(\delta_{L,2}+5\delta_{L,1})\delta_{L,2}^2/\omega^4 < 0$; $d^2\pi_2/d\varepsilon_2^2 = -2NK(7\delta_{L,2}+8\delta_{1,L})\delta_{1,L}^2/\omega^4 < 0$.

[6] This depends upon our assumption that $U > P1 + \kappa\varepsilon1$ for all the consumers, i.e., P1 and $\varepsilon1$ are not so high as to eliminate some possible consumers with high values of κ.

[7] One reason that the choice variables for the Firm 2 are less responsive is that ε_L is exogenous. If K decreases, both firms will allow ε_1 and ε_2 to increase, but the Firm 2 cannot allow ε_2 to increase too much because ε_L does not change. Future research can explore the implications of allowing ε_L to be endogenous.

number of potential consumers will affect the equilibrium in basically the same way as an increase in K. With a larger number of potential consumers, Firm 1 and Firm 2 find that they can increase profits by decreasing their respective ε_is and increasing the prices.

Each firm incurs costs for lowering ε_i, and a scale factor affects the choice levels:

$$\varepsilon_1/d\xi = 0.12665NK\varepsilon_L/\xi^2 > d\varepsilon_2/d\xi = 0.02412NK\varepsilon_L/\xi^2 \qquad (20)$$

The impurity levels go up from an increase in ξ, but $d(\varepsilon_2\text{-}\varepsilon_1)/d\xi=-0.10253NK/\xi^2$. In summary, an increase (decrease) in ξ will increase (decrease) both ε_1 and ε_2, and the levels converge (diverge), i.e., the quantity ε_2-ε_1 decreases (increases). An increase (decrease) in ξ will decrease (increase) net revenues and the absolute difference between the net revenues will converge (diverge). An increase (decrease) in ξ will decrease (increase) the prices as the firms increase (decrease) the ε_is, and the prices will converge (diverge).

These results can help analysts answer some interesting questions. If technology improves so that reducing impurity is less costly, for example, it is interesting to note that the products will become less similar. If the ability of consumers for dealing with the impurities improves, the level of impurities may rise and converge. The next section discusses the model and the implications of these findings given potential trends in the world.

IV. Discussion

This paper demonstrates a methodology for analyzing how less-impure and more-impure products can coexist in a given market. Established research supports the proposition that an equilibrium is possible in a competition where firms differentiate themselves with the indicated choice variables. Instead of examining the question with respect to quality improvement, our model looks at impurity reduction and demonstrates how exogenous variables determine the levels of impurities, the prices, and net revenues, and it gives insights into how the characteristics of the products might change in absolute terms and relative to each other in reaction to changes in exogenous variables.

The model can help predict how global trends will affect the availability and quality of consumer staples such as water and basic agricultural products. As populations grow and their tastes change, the model can help in the analysis of the changing nature of products offered to consumers. One general question issue is how the products will change over time both in absolute and relative terms. What domestic and world trends will lead to the higher and lower products becoming more or less similar in terms of their level of impurity? What trends will raise and lower the levels of impurities?

If the number of potential consumers increases, for example, the model predicts that the impurity levels will fall. This is a favorable result from a trend that is likely to continue. It is important to note that changes in the aversion to the impurities have similar effects. This means that if the consumers become more sophisticated and sensitive to impurities, the impurity levels will fall. On the other hand, if populations that are more tolerant of impurities enter the market, the impurity levels will increase. The costs for lowering impurities will also play an important role in the outcomes. Also, the level of impurity of the non-industrial product is important. The model predicts that the firms will allow impurity levels to increase in the products they offer if the non-industrial product becomes less pure from pollution.

These results provide a foundation for a great deal of empirical work that can provide insights into the expansion of markets for basic staples around the world. The results provide a foundation for additional theoretical work where future research can address the implications of relaxing assumptions, e.g., assumptions concerning the distribution of the tastes of consumers and the utility from consuming the product. Although game-theory models can become very complex, continued work in this field will allow researchers and practitioners to better understand the development of markets around the world as more and more of the world's population demand basic goods.

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