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Market Provision of Quality: Impact of Economic Growth

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Abstract

Over the past three decades, the world has witnessed economic growth accompanied by widening of income inequalities. In the face of rising income inequalities, it becomes imperative to ask what happens to the quality of various products provided in the market when economies experience economic growth. Would economic growth necessarily lead to improvement in quality of products for all income groups? Using a vertically differentiated product model, the paper aims to investigate the effects of economic growth on market provision of product quality. The quality attribute considered is environmental-friendliness of products. It shows that a uniform growth in income among all consumers improves the cleanup levels adopted by both firms. However, a heterogeneous growth in income may result in lowering of one of the two qualities. More specifically, if the growth in income is limited to the rich consumers (who are more likely to gain from economic growth), the quality of the (environmentally) inferior variant is reduced. This has serious implications for the poor consumers if the product has safety or health hazards. The paper suggests a regulatory measure to prevent such deterioration in the quality of the inferior variant.

JEL Classification: O1, O44, L15, L51.

Keywords: Economic growth; disparities in income; environmental quality; standards; vertical differentiation.

1 Introduction

Over the past three decades the world has witnessed economic growth accompanied by widening of income inequalities. According to the International Labor Organization Report 2008 (ILO 2008), between 1990 and 2005, approximately two thirds of the countries experienced an increase in income inequality. The gains from the expansionary period which ended in 2007 benefited high-income groups more than their medium and low -income counterparts. Similar trends are observed when looking at other dimensions of income inequality such as labor income vis-a- vis profits or top wages vis-a vis wages of low paid workers. Likewise, during the same period, the income gap between the top and bottom 10 percent of wage earners increased in 70 percent of the countries for which data is available.

It then becomes imperative to ask what happens to the quality of various products in the market when economies experience economic growth accompanied by rising income inequalities. This paper aims to investigate the effects of economic growth on market provision of product (environmental) quality in an economy where consumers have a preference for the environmentally superior goods. It uses a vertically differentiated product model where consumer preferences for environmental quality translate into a higher willingness to pay for superior goods creating a market for clean goods, and thus inducing firms to cleanup and differentiate their products in equilibrium.

A growing body of literature has been devoted to the analysis of such consumer preferences. The literature describes consumers that are willing to pay more for environmentally friendlier products as ”green consumers”, ”environmentally aware consumers”, etc. Green consumers appear to accept individual responsibility for the provision of public goods (Nyborg et al., 2006). A firm’s response to green consumers has been termed as strategic corporate social responsibility (Baron, 2001).

Various papers have examined implications of standard government policies such as standards, taxes and subsidies on environmental quality and welfare (Bansal, 2008; Lombardini Riipinen, 2005; Lutz, et al., 2000; Cremer and Thisse, 1999; Bansal and Gangopadhyay, 2003). Kotchen (2005) interprets green products as impure public goods with joint product of a private characteristic and an environmental public characteristic. It argues that corporate sector has an advantage over government in the provision of public goods when the public good is naturally bundled with the production of a private good.

Papers have also examined the effect of level of competition in a market on the amount of environmental corporate social responsibility firms undertake. Bagnoli and Watts (2003), show that if the market for "brown" (less environment friendly) products is highly competitive, then its price will be low, and fewer consumers will wish to buy "green" products. Considering an economy that comprises of green and brown consumers, and assuming environmental quality choices of firms to be given, Rodrigues-Ibeas (2007) examines the effects of an increase in the proportion of green consumers on environment and welfare through changes in the output of green and brown products. They find that the pollution may rise with an increase in the proportion of green consumers until a critical mass of green consumers has been reached. An increase beyond the critical mass would reduce total pollution. Nyborg et al. (2006) explore the influence of moral motivation in explaining the green consumer phenomenon.

The analysis in the above papers assumes the distribution of consumers' valuations for environmental attribute to be given. We contribute to the existing literature by examining the impact of changes in the distribution of consumers' valuation for environmental quality, which in our model changes due to economic growth. In an empirical investigation, Grossman and Krueger (1995) find that economic growth brings an initial phase of deterioration in environmental quality followed by a subsequent phase of improvement. The authors suggest that the improvement in environmental quality in the latter phase could be due to an increased demand for environmental protection at higher levels of income. We advance the research question of Grossman and Krueger (1995) by investigating the effects of different forms of economic growth on not only the average environmental quality but also the environmental quality consumed by different income groups. Does economic growth necessarily lead to improvement in quality of products for all income groups even when consumers care for the environmental quality of the products they buy?

Economic growth results in an increase in aggregate income. An increase in income could either be uniform or heterogeneous across consumers. We analyze both these cases and find that a uniform rise in income improves the quality of all variants of the product, while a heterogeneous rise may improve the quality of some variants and reduce the quality of the others. When each consumer's income rises uniformly, her willingness to pay for improved quality also rises uniformly. Firms respond to this by improving the quality as well as increasing the price of both variants of the good.

Heterogeneous growth in income may be limited to particular sections of a society. When the growth in income is limited to the upper end of the income distribution, the high end consumers are willing to pay more. The firm supplying superior quality responds by improving the quality supplied, and increases its profit by charging a higher price. Bur what happens to the quality choice of the firm supplying low quality product? It faces a situation, where its competitor has differentiated away from it but the willingness to pay of the lower end consumers has not increased. It can lower its quality, and extract greater surplus from the marginal consumers at the upper end. By doing so, it will not lose demand as these consumers cannot move to the cleaner firm. This is because it is more expensive now and their willingness to pay has not increased proportionately. This way the firm is able to retain its demand even by lowering its quality. The price and quality pairs adjust in such a manner that both firms enjoy a higher profit.

Such heterogeneous growth in income that deteriorates the lower quality may have serious implications for the poor (the consumers at the lower end of the income distribution), especially if the product has a direct health or safety hazard for the user. For instance, as economies become prosperous, the richer sections of the society move towards packaged and organic foods that are considerably more expensive, food quality consumed by poorer sections of the society, on the other hand, may deteriorate due to adulteration, chemical and pesticide residues, etc.

In the paper we refer to the quality attribute as environmental friendliness of products, our results are equally valid for other quality attributes as well such as food safety, bio-safety of transgenic food crops, nutritional quality, quality of education, safety of electrical appliances, safety norms at work place, etc. Thus the results obtained in this paper can be used for designing appropriate policy instruments when the objective is social rather than environmental.

Blimpo (2012) finds empirical evidence that supports our results in the context of quality of education. According to the report although most African countries have achieved substantial progress in terms of universal access to education over the period 1996 to 2006, test scores reveal deterioration in the learning outcomes in nearly all the countries. At the same time, countries in which the demand for quality education is high, such as Brazil, high-quality private schools emerge through the market process. The authors suggests that there needs to be an effort from governments to provide access to those schools to the poor on a merit basis.

The rest of the paper is planned as follows. We begin by characterizing economic growth and the associated inequality in income distribution in the next section. The model is described in section 3. Section 4 analyzes the effect of economic growth on product quality. Section 5 provides results for a specific cost function. While section 6 analyzes uniform increase in income, greater heterogeneity in income distribution is analyzed in section 7. Finally section 8 contains the concluding remarks.

2 Economic Growth and Income Inequality

Consider an economy with a continuum of consumers having an income, y, that is distributed uniformly with support $[\underline{y}, \overline{y}]$.

A.1 y is distributed uniformly over $[\underline{y}, \overline{y}]$.

Let population density be 1. Using A.1, the aggregate income in the economy is given by

$$Y = \int_{\underline{y}}^{\overline{y}} xf(x)dx$$
$$= \frac{(\underline{y} + \overline{y})}{2}$$

It is evident from the above equation that for a given size of the population, the economic growth can take place via an increase in net $(\underline{y} + \overline{y})$, that is, with an increase in either $\underline{y}$ or $\overline{y}$ or both, or changes in supports of the distribution such that the rise in one is larger than the fall in the other. For simplification, we focus on changes in income distribution such that the new distribution dominates the original distribution in the sense of first order stochastic dominance. In other words, we allow for $\underline{y}$ and $\overline{y}$ to rise but not decline.

Variance of the income distribution is

$$V(y) = \frac{1}{12}(\overline{y} - \underline{y})^2$$

It can be trivially noted that the variance increases with an increase in $\overline{y}$ and decreases with an increase in $\underline{y}$.

The percentage share of income of the bottom 50 percent of the population, y_{50}, is given by

$$y_{50} = \int_{\underline{y}}^{\frac{(\underline{y}+\overline{y})}{2}} yf(y)dy$$
$$= \frac{(3\underline{y} + \overline{y})}{4(\underline{y} + \overline{y})} \quad (1)$$

where $[(\underline{y} + \overline{y})/2]$ is the median of the income distribution. Similarly, the percentage share of income of the top 50 percent of the population is given by

$$y^{50} = \frac{(\underline{y} + 3\overline{y})}{4(\underline{y} + \overline{y})} \quad (2)$$

Lemma 1: *Income inequality increases with an increase in $\overline{y}$ with $\underline{y}$ constant, and decreases with an increase in $\underline{y}$ with $\overline{y}$ constant.*

Proof: Follows immediately from the expressions of the percentage share of the bottom and top 50 percent of the population given in (1) and (2), respectively. With an increase in $\overline{y}$, the curvature of the Lorenz curve (and correspondingly the Gini coefficient) increases indicating an increase in income inequality. Similarly, with an increase in $\underline{y}$, the curvature of the Lorenz curve decreases indicating a decrease in income inequality.

After characterizing economic growth and inequality in income, we develop a vertically differentiated product model in the next section that closely follows Bansal (2008).

3 Model

Two firms produce a single variant of a potentially quality-differentiated product. The product quality is measured by environment friendliness, i.e., the impact of consuming or producing the product on the environment. An environmentally friendlier product is considered as being of higher quality. Let s_1 and s_2 be the qualities produced by firm 1 and 2, respectively, $s_i \in [0, \overline{s}], i = 1, 2$, where $\overline{s}$ is the highest possible level of product quality at the current technology level. We assume $\overline{s}$ to be sufficiently high in order to have interior solutions. Without loss of generality, we assume $s_1 \leq s_2$. We will refer to s_i as the clean-up level of firm i.

Total costs of quality provision are increasing in the output produced and the unit cost is increasing and convex in the quality chosen. The marginal production costs are normalized to zero. The cost function is same for both firms and is given as follows

A.2: $C(s, q) = qc(s)$, $c(0) \geq 0$, $c'(0) = 0$, $c'(s) \geq 0$, $c''(s) > 0$
where q denotes quantity produced.

Lemma 2. *Given Assumption 2, for* $s_2 > s_1$,

$$c'(s_2) > h > c'(s_1) \quad where \quad h = \frac{c(s_2) - c(s_1)}{(s_2 - s_1)}$$

Proof: Follows immediately from using mean value theorem and convexity of the cost function.

As in a standard vertically differentiated product model, the firms play a two-stage game, choosing quality in the first stage of the game and competing in prices in the second.

The consumers care for the environmental attribute of the product they buy and are willing to pay more for environmentally friendlier products. They, however, differ in their marginal valuation of the green features of the product. Consumer heterogeneity is captured by the utility function U. The utility is given by

$$U = y + v + \theta(y)s_i - p_i,$$

where y is the money endowment or income of the consumer; v is the utility derived from one unit of the physical quality of the product; $\theta(y)$ represents marginal willingness to pay for the environmental quality of the variant that she buys; and p_i is the price charged for the quality $s_i, i = 1, 2$. We assume θ is a monotonically increasing function of income, people are willing to pay more for environmental quality if they have higher incomes (Tirole 1988). We further assume that $\theta(y)$ is uniformly distributed on $[a, b]$[1]. Here $a \equiv \theta(\underline{y})$ and $b \equiv \theta(\overline{y})$. From now on we'll characterize consumers by θ rather than y, a higher θ implying a consumer with greater money endowment. Henceforth we will suppress the argument y from $\theta(y)$. Each consumer buys one unit of the good, that is, the market is fully covered.

A.3: The parameter θ is distributed uniformly with support $[a, b]$, and the distribution function of θ is denoted $F(\theta)$.

In our setup the consumers' decisions to buy products with particular environmental characteristics are a function of the net surplus resulting from buying that product. A consumer will buy from the firm that gives her a higher net surplus. Normalizing v to 0, the net surplus enjoyed by the consumer when she buys one unit of the product of quality s at price p is $u = \theta s - p$. The marginal consumer indifferent between buying qualities 1 and 2 is

[1] If we assume θ to be a linear transformation of y, A.3 follows trivially from A.2.

given by $(p_2 - p_1)/(s_2 - s_1) \equiv \theta_1$. It follows that all consumers with a $\theta \geq \theta_1$, would prefer to buy from firm 2 and the remaining from firm 1. This division of consumers between the two firms determines demand for them.

We follow backward induction to solve the game. We, therefore, first solve for the equilibrium prices in the second stage of the game, then substituting them in the firms' profit functions, we determine equilibrium qualities in the first stage.

Let π_i be the second stage profit of firm i.

$$\pi_i(s,p) = (p_i - c(s_i))q_i(s,p), i = 1,2$$

The demand functions are given by

$$q_2(s,p) = \int_{\theta_1}^{b} dF(\theta) = \frac{1}{(b-a)}(b-\theta_1) = \frac{1}{(b-a)(s_2-s_1)}(b(s_2-s_1) - p_2 + p_1) \tag{3}$$

$$q_1(s,p) = \int_{a}^{\theta_1} dF(\theta) = \frac{1}{(b-a)}(\theta_1 - a) = \frac{1}{(b-a)(s_2-s_1)}(p_2 - p_1 - a(s_2-s_1)) \tag{4}$$

Maximizing the second stage profits with respect to prices, the second stage equilibrium prices are given by

$$p_2 = \frac{(s_2-s_1)(2b-a) + 2c(s_2) + c(s_1)}{3}$$

$$p_1 = \frac{c(s_2) + 2c(s_1) - (s_2-s_1)(2a-b)}{3}$$

Inserting second stage equilibrium prices in profit expressions, we obtain the first stage profit expressions as

$$\Pi_i(s) = \pi_i(s, p(s)) = q_i(s)[p_i(s) - c(s_i)], i = 1,2$$

which can be written as

$$\Pi_2 = \frac{(s_2-s_1)}{9(b-a)}[(2b-a) - h]^2 \tag{5}$$

$$\Pi_1 = \frac{(s_2-s_1)}{9(b-a)}[h - (2a-b)]^2 \tag{6}$$

where

$$h(s_1,s_2) = \frac{c(s_2) - c(s_1)}{(s_2-s_1)}$$

Assuming interior solution the first order necessary conditions for profit maximization are

$$(2b - a) - 2c'(s_2) + h = 0 \tag{7}$$

$$(2a - b) - 2c'(s_1) + h = 0 \tag{8}$$

The conditions $c''(s_1) > (\partial h/s_1)$ and $c''(s_2) > (\partial h/s_2)$ ensure that the second order conditions for profit maximization hold and the equilibrium is stable. It can also be checked from (7) and (8) that the two reaction functions in clean-up levels are positively sloped, i.e., the first stage marginal profit of each firm is increasing in the clean-up level of the other firm. Thus the clean-up levels chosen by the firms are strategic complements. Also the reaction function of firm 2 is steeper than that of firm 1. This gives us a unique equilibrium. The reaction functions and their point of intersection is shown in Figure 1. $R_1(s_2)$ and $R_2(s_1)$ represent the reaction functions of firm 1 and 2, respectively.

Using A.3 the aggregate consumer surplus can be obtained as follows

$$CS = \int_a^{\theta_1} (\theta s_1 - p_1) dF(\theta) + \int_{\theta_1}^{b} (\theta s_2 - p_2) dF(\theta) \tag{9}$$

$$= \frac{(\theta_1 - a)}{(b - a)} \left[\frac{s_1}{2}(\theta_1 + a) - p_1 \right] + \frac{(b - \theta_1)}{(b - a)} \left[\frac{s_2}{2}(\theta_1 + b) - p_2 \right] \tag{10}$$

While, the first term in the right hand side of (10) represents consumer surplus enjoyed by the consumers of the lower quality product, the second term represents consumer surplus enjoyed by the consumers of the higher quality product.

We will now study how the equilibrium qualities change as the economy experiences economic growth.

4 Comparative Statics

As explained in section 2, economic growth takes place via an increase in either $\overline{y}$ or $\underline{y}$ or both.[2] The inequality in income distribution increases when $\overline{y}$ increases, and decreases when

[2]It can be checked that these three cases exhaust all possible forms of first order stochastic dominant distributional changes.

$\underline{y}$ increases. Given the monotonic relationship between y and θ, a change in the distribution of y changes the distribution of θ. We are considering distributional changes such that the new distribution continues to be uniform and only its support changes.

To gain insights into how changes in the support of distribution of θ change optimal qualities chosen by the firms, we first examine changes in a or b on the reaction functions of the two firms.

Lemma 3: *(i) With an increase in* b, *the reaction functions of both firms shift towards right. (ii) With an increase in* a, *the reaction functions of both firms shift towards left.*

Proof: See the appendix.

The shift in the reaction functions due to an increase in b is illustrated in Figure 1. With an increase in b the marginal benefit of clean-up increases for firm 2. This induces firm 2 to choose a higher clean-up level for each clean-up level chosen by firm 1. Hence, the reaction function of firm 2, $R_2(s_1)$, shifts towards right. Since the marginal benefit of clean up reduces for firm 1, it is induced to choose a lower clean-up level for each given level of clean-up chosen by firm 2, and hence, the reaction function of firm 1, $R_1(s_2)$ also shifts towards right. The point of intersection moves from A to B. At the new intersection point, the clean-up level of firm 2 is un-ambiguously higher, while that of firm 1 could be higher or lower. Similar effects work when a increases, the reaction functions of both firms shift towards left.

Figure 1

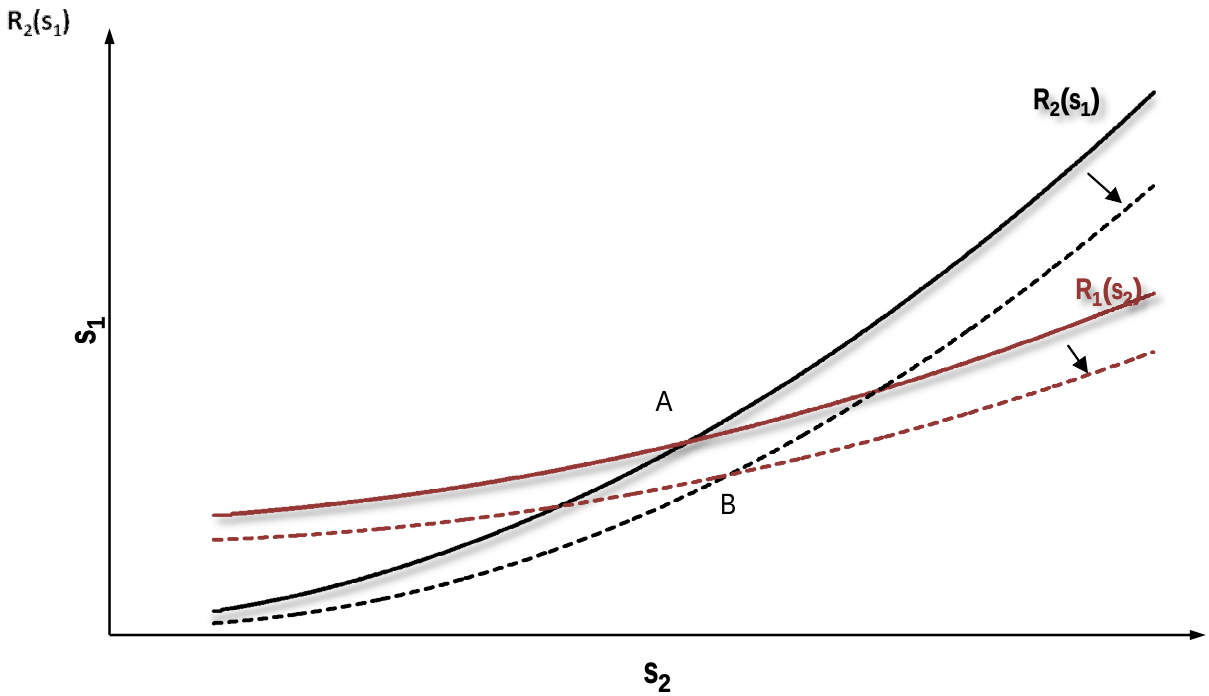

Figure 1: Shift in firms' reaction functions in clean-up levels. With an increase in *b*, both reaction functions shift towards right moving the equilibrium in clean-up levels from *A* to *B*. As compared to *A*, at *B*, the clean-up level of the cleaner firm, s_2, is higher and that of the inferior firm, s_1, is lower.

We can now investigate the effect of economic growth on the quality choices of two firms.

Proposition 1: *Assume interior solutions. An increase in income at the upper end of the income distribution, $\overline{y}$ (keeping the lower end constant),*
a) unambiguously increases the quality chosen by the environmentally superior firm
b) has ambiguous impact on the quality of the environmentally inferior firm
c) lowers environmental quality of the environmentally inferior firm for $2c''(s_2) > 3(\partial h/\partial s_2)$.

Proof: See the appendix.

Proposition 1 shows that economic growth may not improve quality provision for all the consumers. When economic growth is accompanied by increased income inequalities, the quality of the variant consumed by high end consumers improves but the quality consumed by the low- income consumers may deteriorate. Trivially, the gap between two qualities would rise. Bansal (2008) shows that in a duopolistic market equilibrium firms differentiate their products more than the socially optimal level. An increase in income inequality would further increase the quality-gap between two products, which could have an adverse effect on the welfare of the poor consumers. The condition $2c''(s_i) > 3(\partial h/\partial s_i), i = 1, 2$ holds for quadratic cost functions and also for more convex cost functions. Thus the result that an increase in income inequality deteriorates the quality choice of the inferior firm holds for a large class of cost functions that are sufficiently convex.

Proposition 2: *Assume interior solutions. An increase in income at the lower end of the income distribution, $\underline{y}$ (keeping the upper end constant),*
a) unambiguously increases the quality chosen by the environmentally inferior firm
b) has ambiguous impact on the quality of the environmentally superior firm
c) reduces environmental quality of the environmentally superior firm for $2c''(s_1) > 3(\partial h/\partial s_1)$.

Proof: See the appendix.

When economic growth is accompanied by a reduction in income inequalities, the quality choice of the inferior firm improves but that of the environmentally superior firm may deteriorate, the gap between two qualities may reduce having a welfare improving effect. Again the result holds for a large class of sufficiently convex cost functions. In the next section, we show additional results by assuming a specific cost function.

5 Specific Cost Function

In this section we assume that the cost function takes the quadratic functional form. We will also introduce some new notations that will be used in the remaining sections. To take care of economies with varying distributions of income, we will index the economy by the support of the distribution of θ. Consider the ordered pair $(m, n), m, n \geq 0$. We define an economy $E(m, n)$ as one where the distribution of the willingness to pay, θ has the support $[a + m, b + n]$. Observe that, if $m = n = 0$, we have the original economy before the growth in income. We will compare the $E(0, 0)$ economy with two particular types of $E(m, n)$ economy. The economy characterized by $m \neq n, m, n \geq 0$ can be distinguished from the $E(0, 0)$ economy as one in which the rise in income among the richer classes (higher θ) is different from the poorer classes. The economy with $m = n > 0$ is one where the rise in income is uniformly higher, among all income classes, compared to the $E(0, 0)$ economy. We state the modified assumptions below. A.4 specifies the functional form of the cost function, A.5 assumes that the new distribution is uniform, and A.6 ensures that all consumers are buying the product in the $E(m, n)$ economy, i.e., the market continues to be fully covered.

A4 : $C(s, q) = qc(s), \quad where \quad c(s) = ks^2/2, k > 0, 0 \leq s \leq \overline{s.}$

A.5 : θ is distributed uniformly over $a + m, b + n$.

A.6 : $9(a + m) \geq 5(b + n)$

Plugging the above specified functional form in equations (7) and (8), we can obtain closed form expression of various variables in equilibrium in the E(m, n) economy.

(a) The cleanup levels are given by

$$s_2 = \frac{(5b-a)}{4k} + \frac{(5n-m)}{4k} \tag{11}$$

$$s_1 = \frac{(5a-b)}{4k} + \frac{(5m-n)}{4k} \tag{12}$$

(b) The degree of differentiation, given by the gap between the two variants is,

$$s_2 - s_1 = \frac{3(b-a)}{2k} + \frac{3(n-m)}{2k}$$

(c) Recall that θ_1 segregates the consumers between two qualities.

$$\theta_1 = \frac{(b+a)}{2} + \frac{(m+n)}{2}$$

The demand faced by each firm

$$q_1 = q_2 = 1/2$$

(d) Prices charged by the two firms are

$$p_2 = \frac{1}{32k}[49(b+n)^2 + 25(a+m)^2 - 58(b+n)(a+m)]$$

$$p_1 = \frac{1}{32k}[25(b+n)^2 + 49(a+m)^2 - 58(b+n)(a+m)]$$

Alternatively

$$p_2 = p_2^* + \frac{((7n-5m)^2 + 16mn + 2b(49n-29m) + 2a(29n-25m))}{32k}$$

$$p_1 = p_1^* + \frac{(5n-7m)^2 + 16mn + 2b(25n-29m) + 2a(49m-29n)}{32k}$$

where superscript * denotes the equilibrium value of the variable in the $E(0,0)$ economy.

(e) Using the demand, price and cost expressions, we obtain profit obtained by two firms

$$\Pi_1 = \Pi_2 = \frac{3}{8k}(b-a+n-m)^2$$

(f) Again using demand and price expressions in (10), the consumer surplus is given by

$$CS = \frac{1}{64k}[62(a+m)(b+n) - 19(a+m)^2 - 27(b+n)^2]$$

$$+\frac{1}{64k}[62(a+m)(b+n) - 27(a+m)^2 - 19(b+n)^2] \tag{13}$$

$$= \frac{1}{32k}[62(a+m)(b+n) - 23(a+m)^2 - 23(b+n)^2] \tag{14}$$

6 Uniform Increase in Income

In this section, we compare the $E(0,0)$ economy with an $E(m,n)$ economy where $m = n = r > 0$, satisfying A.4 - A.6. For each level of θ in $E(0,0)$, the corresponding person in $E(r,r)$ has a higher income and a higher utility of $\theta + r$ per unit of environmental quality. We term the agents in $E(r,r)$ as having a uniformly higher income compared to the agents in $E(0,0)$.

Proposition 3: *Assume A.4 - A.6,* $m = n = r > 0$, *and interior solutions. Compared to the* $E(0,0)$ *economy, in* $E(r,r)$,
(i) both firms have higher cleanup efforts and, hence, total pollution is less,
(ii) the gap between the two qualities, measured by the difference $s_2 - s_1$, *is the same,*
(iii) the proportion of consumers served by each firm is the same,
(iv) the profits of both firms are the same,
(v) the aggregate consumer surplus as well as consumer surplus enjoyed by each of the groups, low quality consumers and high quality consumers, is higher.

Proof: See Appendix.

When each consumer's income rises uniformly, firms respond to this by improving the quality as well as increasing the price of both variants of the good. The price-quality pairs alter in such a manner that both firms obtain the same profit as before. Proposition 3 tells us that the $E(r,r)$ economy will be more environment friendly than the $E(0,0)$ economy. It also tells us that firms are equally well off in both economies (Proposition 3(iv)). The consumer surplus enjoyed by both the consumer groups, consumers of high quality product as well as consumers of low quality product increases, resulting in an increase in aggregate consumer surplus.

7 Greater Heterogeneity in Income Distribution

As discussed in the introduction, one of the problems in developing countries is that with economic growth income disparities increase. It is possible that while population at the upper end of the income distribution experiences a large increase in income, and that at the lower end gains small amounts. In this section, we analyze the case where growth in income is heterogeneous over consumers. We first compare the $E(0,0)$ economy with an $E(m,n)$ economy where $m = 0 < n = r$, satisfying A.4 - A.6. The growth in income is heterogeneous, having a higher effect on consumers with a higher θ.

Proposition 4: *Assume A.4 - A.6, $m = 0 < n = r$, and interior solutions. Compared to the $E(0,0)$ economy, in $E(0,r)$*
(i) the cleanup effort of the better quality firm is higher and that of the worse quality firm is lower, however, total pollution is lower
(ii) the gap between the two qualities is higher
(iii) the proportion of consumers served by each firm is same
(iv) the profit of both firms is higher
(v) the consumer surplus enjoyed by consumers of cleaner product is unambiguously higher, but consumer surplus enjoyed by lower quality product is lower for $a < (27/31)[b + r]$
(vi) the aggregate consumer surplus may be lower.

Proof: See the Appendix.

Since willingness to pay at the upper end of income distribution has increased, the cleaner firm improves the quality supplied, and increases its profit by charging a higher price. Its lower end consumers now enjoy a lower surplus than before as the increase in their willingness to pay is less than that of the upper end consumers. The demand faced by the firm remains constant. The lower quality firm faces a situation, where its competitor has differentiated away from it but the willingness to pay of the lower end consumers has not increased. It can lower its quality, and extract greater surplus from the marginal consumers at the upper end. By doing so, it will not lose demand as these consumers cannot move to the cleaner firm. This is because it is more expensive now and their willingness to pay has not increased proportionately. This way the firm is able to retain its demand even by lowering its quality. The price and quality pairs adjust in such a manner that both firms enjoy a higher profit. Further the consumer surplus enjoyed by the high-quality consumers rises and that of the low quality consumers may fall.

Such heterogeneous growth in income deteriorates the lower quality or creates fringes of heavily polluted quality. This may have serious implications for the consumers at the lower end of the income distribution, especially if the product has a direct health or safety hazard for the user. Despite of being aware of these hazards, the consumers at the lower end of income distribution are forced to consume these products due to two reasons. First, the good under consideration is an essential good, and therefore, consumers cannot do without it. Second, the better variant of the product has become more expensive (due to improvement in its quality) and poor consumers cannot afford it at that price. Often developing countries are not applauded for the improved quality of the better products but are blamed for the existence of fringes of heavily polluted products. Rapidly industrializing countries in South-East Asia and Latin America are experiencing pollution ills. Our results suggest that such a situation could be an outcome of increased disparities in income distribution. However, when the gains of economic growth percolate down to the entire economy, and each consumer becomes better off, both qualities improve.

This result of deterioration in the cleanup level of lower quality product may cause concern for the planner. The question then arises, can governments prevent deterioration in the quality of the inferior product and save its population from such hazardous exposure.

Since the clean-up levels are strategic complements, imposing a cleanup standard exceeding the lowest cleanup level produced in the economy improves the environmental quality of both variants of the product. Implementation of such a standard may face resistance from producers on the grounds of stringent environmental policy. The firms may complain about having to bear the cost of environmental protection.

In this paper, we are interested in a policy, which is voluntarily acceptable to the producers. For that, the policy should not have adverse political economy implications for the firms.

Consider an $E(0,0)$ economy, which is in the process of economic growth. We will restrict ourselves to the economies that are characterized by undercleaning in the absence of market intervention. Let the government impose a standard $\hat{s} = s_1^*$. Observe that as of now, this standard is not binding as it does not affect the equilibrium choice of cleanup levels. The adopted standard does not have any political economy implications, and therefore, is not opposed by producers.

The imposed standard assumes significance when the economy experiences economic growth, which increases the willingness to pay for the cleaner product. In the initial period, i.e., the intermediate phase, the growth is likely to be heterogeneous and limited to the consumers at the upper end of the income distribution. That is to say that the economy is now characterized as $E(0,r)$ economy. Proposition 4 (i) tells us that the lower quality firm has an incentive to reduce the cleanup level. The standard now becomes binding for it and prevents the firm from lowering the adopted cleanup level. We can find the new equilibrium choice of cleanup levels

$$s_2 = s_2^* + \frac{4r}{3k}; s_1 = \hat{s} = s_1^*$$

In the intermediate phase, the standard ($\hat{s} \geq s_1^*$) on cleanup levels prevents the lower quality firm to reduce its quality, at the same time, the higher quality firm improves its quality. The standard would again become ineffective, when the growth in income percolates down to the consumer with the least income. Then, we are in the equilibrium of Section 6. An interesting application of our results is in the formulation of bio-safety laws for transgenic crops. Our results support strict bio-safety standards before approval of transgenic crops for commercial cultivation.

Finally we can analyze the effect of growth in income where the consumers at the lower end of the income distribution gain more than those at the upper end. More specifically, we consider an increase in income such that $0 < n < m$. From section 4 we know that such a rise in income may reduce clean-up of the high-quality firm, improves the clean-up of the low-quality firm, reduces the degree of differentiation between the two variants of the products. It is easy to see that with a growth in income of ($n < m$) type, profits of both firms are reduced.

8 Conclusion

In this paper, we examine the effect of economic growth on the cleanup activity of firms in an economy where consumers are environmentally aware and are willing to pay a price premium for environmentally superior qualities. Growth in income affects consumers' willingness to pay for the product, which in turn, determines the qualities that will be served in the market. A change in income distribution changes the distribution of the parameter that reflects marginal willingness to pay for environmental quality.

The growth in income may take two forms. It can be uniform across all consumers or could be limited to a specific section of the population. Both these forms are analyzed. When the growth in income is uniform for all consumers, cleanup levels rise for both firms, resulting in improved environmental quality. When the growth in income is heterogeneous, it may not improve both qualities. In particular, if the increase in income is limited to the richer consumers (who are more likely to gain from economic growth) resulting in an increase in the disparities in income distribution, the quality of the inferior product gets adversely affected. This has serious implications for the poor consumers. They are now forced to buy a quality, which is even lower than the one they were buying before. This causes concern for the government. It is indeed often observed that growth concerns in developing countries centre almost exclusively on the upper socio-economic echelon of society. These economies are characterized by the presence of elite premium quality products accessible to the high end consumers co-existing with very low qualities for the lower end consumers.

One of the ways to prevent deterioration in quality is to impose a cleanup standard equal to the quality of the inferior product. Such a standard does not face opposition from firms as it is ineffective at the current levels of income. If there is uniform growth in income, this standard continues to be ineffective. However, if only the rich consumers experience growth in income, and the inferior quality firm has an incentive to reduce the quality further, the imposed standard prevents it from doing so. If the consumers at the lower end of the income distribution are targeted for an increase in income, then not only does the quality of the inferior variant improve, but the degree of differentiation between the two qualities also reduces. For simplification, we have assumed income or money endowment of the consumers to be uniformly distributed. All our results will hold even for a more general distribution of income as long as θ is monotonically increasing function of y, is uniformly distributed and income inequalities increase with an increase in the upper end of the support of the income distribution and decrease with an in increase in the lower end of income distribution.

An alternative way of changing distribution of marginal willingness to pay for environmental quality is through changing consumer awareness. The government and non-governmental organizations through information and peer pressure are making efforts to raise the awareness of the harmful effects of pollution. The decision of consumers regarding the quality of the product is determined also by their knowledge of the environmental bad. If a poor household is aware of the health hazard to children of smoke filled homes, it will be more inclined to move towards cleaner fuels (to kerosene from firewood) even if it cannot afford the cleanest fuel (cooking gas or electricity). Alternatively, if people are aware of the damage caused to future generations (their children) by deforestation, they will be more inclined towards buying kerosene rather than cut trees. The effects of increase in the degree of environmental awareness among consumers are similar to the effects of increased incomes. Our results suggest that these awareness campaigns should be carefully designed. If they target only the richer sections of the society, they could lead to deterioration in the quality consumed by the poorer consumers. It may be a better policy to first target poorer households for the awareness campaigns.

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References

[1] Bagnoli, M., and Watts, S.G., 2003. Selling to socially responsible consumers: Competition and the private provision of public goods. *Journal of Economics & Management Strategy* 12 (3), 419445.

[2] Bansal, S., 2008. Choice and design of regulatory instruments in the presence of green consumers. *Resource and Energy Economics* 30, 345-368.

[3] Bansal, S., Gangopadhyay, S., 2003. Tax/subsidy policies in the presence of environmentally aware consumers. *Journal of Environmental Economics and Management* 45, 333-355.

[4] Baron, D., 2001. Private politics, corporate social responsibility and integrated strategy. *Journal of Economics & Management Strategy* 10, 745.

[5] Blimpo, M., P., 2012. Access versus quality: Challenges of educational policies in African countries, Stanford Institute for Economic Policy Research (SIEPR) Policy Brief.

[6] Cremer, H. and Thisse, J-F., 1999. On the taxation of polluting products in a differentiated industry. *European Economic Review* 43, 575-94.

[7] Gabszewicz, J. and Thisse, J-F., 1979. Price competition, quality and income disparities. *Journal of Economic Theory* 20, 340-359.

[8] Grossman, G.M., and Krueger, A.B., 1995. Economic growth and the environment. *The Quarterly Journal of Economics* 110(2), 353-377.

[9] Kotchen, M.J., 2005. Impure public goods and the comparative statics of environmentally friendly consumption. *Journal of Environmental Economics and Management* 49, 281300.

[10] Lombardini-Riipinen, C., 2005. Optimal tax policy under environmental quality Competition. *Environmental and Resource Economics* 32, 317-336.

[11] Lutz, S., Lyon, T.P., Maxwell, J.W., 2000. Quality leadership when regulatory standards are forthcoming. *Journal of Industrial Economics* 48 (3), 331-348.

[12] Nyborg, K., Howarth, R.B., Brekke, K.,A., 2006. Green consumers and public policy: On socially contingent moral motivation. *Resource and Energy Economics* 28, 351-366.

[13] Rodriguez-Ibeas, R., 2007. Environmental product differentiation and environmental awareness *Environmental & Resource Economics* 36, 237-254.

[14] Tirole, J., 1988, The Theory of Industrial Organization (Cambridge: MIT).

[15] World of Work Report 2008: ilo.org/public/English/bureau/inst/download/world08.pdf

Appendix

Proof of Lemma 3

Taking a partial derivative of equation (7) with respect to b, taking a and s_1 as given,

$$\frac{\partial s_2}{\partial b} = \frac{2}{2c''(s_2) - \frac{\partial h}{\partial s_2}} > 0 \;\; for \;\; all \;\; s_1$$

Again taking a partial derivative of (8) with respect to b, taking a and s_2 as given,

$$\frac{\partial s_1}{\partial b} = \frac{-1}{2c''(s_1) - \frac{\partial h}{\partial s_1}} < 0 \;\; for \;\; all \;\; s_2$$

Since the denominators are positive from the second order conditions, the sign of the derivative is determined by the sign of the numerator. $(\partial s_2/\partial b) > 0$ for all s_1 implies that the reaction function of firm 2 shifts towards right with a rise in b.

Similarly differentiating equations (7) and (8) with respect to a, it can be checked that

$$\frac{\partial s_2}{\partial a} = \frac{-1}{2c''(s_2) - \frac{\partial h}{\partial s_2}} < 0 \ \ for \ \ all \ \ s_1$$

$$\frac{\partial s_1}{\partial a} = \frac{2}{(2c''(s_1) - \frac{\partial h}{\partial s_1})} > 0 \ \ for \ \ all \ \ s_2$$

The direction of the shift of the reaction functions follows.

Proof of Proposition 1

Totally differentiating equations (7) and (8), we obtain the following matrix

$$\begin{pmatrix} 2c''(s_2) - \frac{\partial h}{\partial s_2} & -\frac{\partial h}{\partial s_1} \\ -\frac{\partial h}{\partial s_2} & 2c''(s_1) - \frac{\partial h}{\partial s_1} \end{pmatrix} \begin{pmatrix} ds_2 \\ ds_1 \end{pmatrix} = \begin{pmatrix} 2 & -1 \\ -1 & 2 \end{pmatrix} \begin{pmatrix} db \\ da \end{pmatrix} \tag{15}$$

Given the monotonic relationship between θ and y, an increase in $\overline{y}$ increases $b \equiv \theta(\overline{y})$. Thus to check the effect of an increase in $\overline{y}$, it suffices to check the effect of an increase in b. From equation (15), it can be checked that

$$sign\frac{ds_2}{db} = sign[4c''(s_1) - 3\frac{\partial h}{\partial s_1}] > 0$$

$$sign\frac{ds_1}{db} = sign[-2c''(s_2) + 3\frac{\partial h}{\partial s_2}] < 0$$

$$for \quad 2c''(s_2) > 3\frac{\partial h}{\partial s_2}$$

The first inequality follows from the second order conditions.

Proof of Proposition 2

Again from (15), it can be checked that

$$sign\frac{ds_1}{da} = sign[4c''(s_2) - 3\frac{\partial h}{\partial s_2}] > 0$$

$$sign\frac{ds_2}{da} = sign[-2c''(s_1) + 3\frac{\partial h}{\partial s_1}] < 0$$

$$for \quad 2c''(s_1) > 3\frac{\partial h}{\partial s_1}$$

Proof of Proposition 3

Let a superscript ˜ denote the equilibrium value of the variables for the $E(r,r)$ economy. Plugging $m = n = r > 0$ in (a)-(f) in section 5, it is straightforward to see

(i) The cleanup levels

$$\tilde{s_1} = s_1^* + \frac{r}{k}$$
$$\tilde{s_2} = s_2^* + \frac{r}{k}$$

The degree of differentiation,

$$\tilde{s_2} - \tilde{s_1} = s_2^* - s_1^*$$

The demand faced by each firm

$$\tilde{q_1} = \tilde{q_2} = q_i, i = 1, 2$$

The prices charged by the two firms are

$$\tilde{p_2} = p_2^* + \frac{r^2}{2k} + \frac{r(5b-a)}{4k}$$
$$\tilde{p_1} = p_1^* + \frac{r}{2k} + \frac{r(5a-b)}{4k}$$

and

(iv) The profit obtained by the two firms are

$$\tilde{\Pi_1} = \tilde{\Pi_2} = 3/8k(b-a)^2$$

(v) The consumer surplus enjoyed by consumers

$$\tilde{CS} = \frac{1}{64k}[62(a+r)(b+r) - 19(a+r)^2 - 27(b+r)^2]$$
$$+\frac{1}{64k}[62(a+r)(b+r) - 27(a+r)^2 - 19(b+r)^2] \quad (16)$$
$$= \frac{1}{32k}[62(a+r)(b+r) - 23(a+r)^2 - 23(b+r)^2] \quad (17)$$

While, the first term in the right hand side of (16) is the consumer surplus enjoyed by the consumers of the lower quality product ($\tilde{CS_1}$), the second term is the consumer surplus enjoyed by the consumers of the higher quality ($\tilde{CS_2}$).

$$\begin{aligned}\frac{\partial \tilde{CS_1}}{\partial r} &= \frac{1}{8}[3(a+r)+(b+r)] > 0\\ \frac{\partial \tilde{CS_2}}{\partial r} &= \frac{1}{8}[(a+r)+3(b+r)] > 0\\ \frac{\partial \tilde{CS}}{\partial r} &= \frac{1}{2}(a+b+2r) > 0\end{aligned}$$

Proof of Proposition 4

The proof follows from plugging $m = 0, n = r$ in (a)-(f) in section 5. Let a superscript $'$ denote the value of the variables in equilibrium in $E(0, r)$ economy.

(i) The cleanup levels

$$s_2' = s_2^* + \frac{5r}{4k}$$
$$s_1' = s_1^* - \frac{r}{4k}$$

(ii) The degree of differentiation

$$s_2' - s_1' = s_2^* - s_1^* + \frac{3r}{2k}$$

(iii) The demand faced by each firm

$$q_1' = q_2' = 1/2$$

Prices charged by the two firms are

$$\begin{aligned}p_2' &= p_1^* + \frac{49r^2}{32k} + \frac{r(49b-29a)}{16k} > p_2^*\\ p_1' &= p_2^* + \frac{25r^2}{32k} + \frac{r(25b-29a)}{16k}\\ \frac{\partial p_1'}{\partial r} &= \frac{1}{32k}(50(b+r)-58a) \gtreqqless 0 \;\; as \;\; [25(b+r)/29] \gtreqqless a\end{aligned}$$

Finally, profit obtained by each firm

$$\Pi_1' = \Pi_2' = \frac{3}{8k}(b+r-a)^2$$

(iv)Plugging $m = 0, n = r$ in (13), it can be checked that

$$\frac{\partial CS_2'}{\partial b} = \frac{1}{32k}(31a - 19b) > 0$$

under condition $9a > 5b$.

$$\frac{\partial CS_1'}{\partial r} = \frac{1}{32k}[31a - 27(b + r)] < 0 \quad for \quad a < (27/31)b$$