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Can health hazards be eliminated through Cournot competition?

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Abstract

The extraction of natural resources can have a negative impact on the health of the local workers involved. This paper focuses on the economic features that impact the abatement (or otherwise) of the health hazards associated with the extraction of a natural resource (in this instance, gold) in a developing country. I use a simple community-based economic model of market competition between producers that considers egalitarian cost sharing in the community relating to health hazard abatement. I shall clarify that if an egalitarian cost burden rule can be shared in a community consisting of poor workers, then it is possible for both the promotion of Cournot competition and improvement of the hazardous working environment to be compatible.

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Keywords: Cournot competition, Communities, Egalitarian, Gold mining, Pollution abatement.

Introduction

Gold ore mining and refining is mainly carried out by small-scale, rural communities in developing countries (Marcello et al. 2004). Mercury is used in refining gold ore, which presents an extremely hazardous working environment.

Bose-O'Reilly et al. (2008) examined the health hazards faced by children engaged in gold ore refining in rural communities of Indonesia and Zimbabwe during 2003–2004. They note that such children exhibited symptoms of ataxia, a typical type of mercury poisoning.

The method of ore refining that is prevalent in these communities involves heating an amalgam of gold ore and mercury at a high temperature and evaporating the mercury from the amalgam. Therefore, workers—including any child workers—are exposed to high concentrations of mercury.

Hilson (2003) claims that the health hazards caused by inhaling vapor that contains mercury can be prevented by using a device called a *retort* that condenses and collects the mercury vapor. However, retorts are not widely used because of their relatively

expensive.

The purpose of this paper is to clarify that if an egalitarian cost burden rule can be shared among communities with poor people, it is possible for both à la Cournot competition and improvement of the hazardous working environment to be compatible. Cournot competition means market competition in which firms in a homogeneous (or undifferentiated) product market choose a quantity to produce independently. Also, this paper suggests that promoting such competition may also reduce the level of corruption relating to the extraction of natural resources in developing countries.

In the economic literature, Basu et al. (2013) conclude that when a polluting firm conducts pollution abatement at its own expense—leading to a sufficient increase in the number of firms—all firms then discharge pollution. This is because the price of the product falls as Cournot competition increases.

Unlike Basu et al.'s (2013) model, the model used in this paper is community-based. We assume that all communities consist of poor people. For each individual producer, the capital goods are expensive. Based on this premise, this paper shows that if there is an egalitarian cost burden sharing rule among the members of a community in relation to the introduction of capital goods to eliminate a health hazard, then pollution

discharge will not occur. This result is in stark contrast to Basu et al. (2013).

Furthermore, the model developed in this paper is readily transferable to related fields and subject areas, and is a tool to evaluate community involvement in resource exploitation.

The remainder of the paper is structured as follows. Section two establishes the theoretical framework. Cournot equilibrium is derived in section three, and section four presents the concluding remarks.

1. The model

Communities that produce a particular homogeneous product (in this instance, gold) exist, and among these communities there are $n \geq 2$ producers. Among these producers, the quantity of the product for the i^{th} producer is denoted as $q_i, i = 1, \cdots, n$. The inverse demand function related to the product is given by:

$$p = a - b\sum_{i=1}^{n} q_i , \qquad (1)$$

where, p denotes the price of the product, a and b are assumed to be positive constants.

In all communities, health hazards occur in the process of production. Such health hazards can be eliminated if capital goods with cost c can be input.

This paper assumes sales maximization for all producers. In other words, the objective function of the i^{th} producer is defined as,

$$S_i = pq_i - \theta_i c / m, \qquad (2)$$

where, c is the group purchase cost of the capital goods (assumed to be exogenously given), m is the number of group purchase producers for the capital goods, and $m = kn, \quad 0 < k < 1$. Further, θ_i expresses the preference of producer i with respect to the group purchase as shown below: either 1 or 0.

$$\theta_i = \begin{cases} 1 & \textit{if the removal cost is borne} \\ 0 & \textit{otherwise} \end{cases}$$

That is, if producer i jointly purchases the capital goods, and shares the cost of

purchasing the goods with the other producers to eliminate the health hazard, then $\theta_i = 1$.

Here, all of the communities are uniformly poor, and for each individual producer the capital goods are expensive. However, if the cost is shared among several producers who want to eliminate the health hazard, then it is possible to make the investment. Moreover, by assuming an egalitarian cost sharing rule among the community members, then the cost per person is c/m.

However, if producer i is not willing to eliminate the health hazard, then $\theta_i = 0$. According to equation (2), this producer pursues only sales, and hence pollution will be discharged.

All producers (n persons) pursue sales competitively, and some producers (m persons) intend to eliminate the health hazard even if they have to incur a cost.

Section three indicates that the incentive to eliminate health hazards in the community has been not extinguished, irrespective of how fierce the sales acquisition competition gets among all of the producers.

2. Cournot competition

Consider Cournot competition among the producers in the model given in section two. Deriving the equilibrium quantity q_i^* of the product for producer i using equations (1) and (2), gives:

$$q_i^* = \frac{a - b\sum_{j \neq i} q_j^*}{2b} i, j = 1, \cdots, n \ . \tag{3}$$

Aggregating this for all i, and substituted to equation (1), the equilibrium price p^* for the product can be obtained. That is:

$$p^* = a - \frac{na}{n+1} \ . \tag{4}$$

Substituting q_i^* and p^* to equation (2), the gains of producer i in the Cournot equilibrium are determined as:

$$S_i^* = \frac{a}{n+1}\left(\frac{a - b\sum_{j\neq i} q_j^*}{2b}\right) - \theta_i c / m \,. \qquad (5)$$

Putting the first term on the right side of equation (5) to $R_i^*(n)$, then in the case of a duopoly (i.e., $n = 2$), $R_i^*(2) > 0$. However, in the case of perfect competition (i.e., $n \to \infty$), $p^* = 0$ according to equation (4), and hence $R_i^*(\infty) = 0$.

3.1 Independent purchase scenario

Before analysing the joint purchase of capital goods, as a benchmark we clarify the incentive of producer i, when $m = 1$, regarding equation (5). That is, in the case of the individual investment in the capital goods that can eliminate the health hazard.

As shown in Figure 1, when c is a positive number smaller than $R_i^*(2)$, then $\bar{n}$ (that is, $\bar{n} = (aq_i^* / c) - 1$) that satisfies $R_i^*(\bar{n}) = c$ exists. If the competitors are sufficiently fewer in number ($n < \bar{n}$), then producer i can obtain a sufficiently large sales and has the incentive to independently purchase the capital goods that can eliminate the health hazard (that is, $S_i^* > 0$).

Consider the two cases when c is greater than $R_i^*(2)$, and when the number of competitors are large in number (that is, $n \geq \bar{n}$). In these cases, the producers have no incentive to independently purchase the capital goods.

Particularly, with respect to $n \geq \bar{n}$, when $n \to \infty$, then, as $p^* = 0$ according to equation (4), $S_i^*(\infty) < 0$. In other words, as long as the elimination of a health hazard is costly—even if the cost may be sufficiently small, and even with $\theta_i = 1$ producers—then there is no incentive to purchase the capital good. Conversely, if $\theta_i = 0$ producers, since $S_i^*(\infty) = 0$, the capital good is not purchased and the health hazard prevails to the whole community.

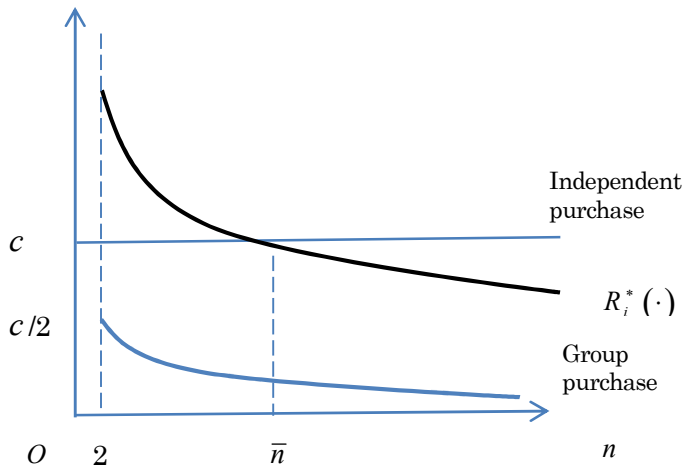

Figure 1 Independent purchase and group purchase

3.2 Group purchase scenario

We now analyse the case of the group purchase of a capital good: i.e., the case where $m \geq 2$ in equation (5). Here, if an egalitarian cost sharing rule is assumed among the group purchase members, then the cost burden (because $c/m = c/kn, \quad 0 < k < 1$) per capita producer $\theta_i = 1$ will start decreasing in n. In contrast to the individual purchase case, in the group purchase case the incentive for buying the capital good does not become extinct, even if the elimination of the health hazard is costly.

When c is not more than $R_i^*(2)$, in the case of independent purchase when $n \geq \bar{n}$ then, $S_i^* < 0$, but in the case of group purchase, $S_i^* > 0$. In this group purchase case, as $S_i^*(\infty) = 0$ for all producers, the health hazard does not spread to the entire community. The results are summarized in the following propositions.

Propositions:

i. As long as the health hazard is costly—no matter how small the cost—then promoting Cournot competition leads to the spread of the health hazard throughout the community.

ii. Even if the elimination of the health hazard is costly, if there is an egalitarian cost sharing rule within the community, then the health hazard does not spread to the community, even if Cournot competition is promoted.

4. Concluding remarks

This paper offers a simple community-based economic model of competition between producers and focuses on the producer's cost structure in relation to the extraction of natural resources. We clarify that if a community that is composed of poor people has an egalitarian cost sharing rule among its members, then—even if the reduction of the health hazard is costly—reducing the health hazard is compatible with the promotion of competition.

Some producers who are not concerned about health hazards may get tacit approval from public officers—even if pollution is actually discharged—by bribing them with a portion of the sales. However, as the market approaches perfect competition (that is, as the number of producers approaches infinity), the amount of payable bribes for the producers who are likely to discharge pollution will gradually decrease. Therefore, the promotion of competition not only leads to the retention of the producers concerned about health hazards in the community, but may also improve the so-called corruption problem. The results of this study are consistent with those of Ades and Di Tella (1999) that empirically show that the promotion of competition is effective with respect to the question of what governments should do when, even after huge resources are invested in law enforcement, corruption still does not decline (Rose-Ackerman 1975).

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