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NATURAL RESOURCE PRICING AND ECONOMIC DEVELOPMENT

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Abstract

In a competitive equilibrium the price of a natural resource will be increasing at a rate equal to the social time preference rate, but in a monopoly market, the price will be increasing at less than social time preference rate. If the producer countries utilise their monopoly of production and sale of a natural resource for the purpose of developing their economies, the price of the natural resource will be growing at the rate at which the producer countries' economies are growing, whether or not the sales proceeds are used to finance their investment programmes, fully or partly.

I. Introduction

The problem of analyzing the price-behavior of a non-renewable natural resource has, of late, attracted considerable attention. The quadrupling of petroleum prices has prompted the persistent question whether the countries having large and nearly exclusive reserves of a natural resource, can fix the price and limit the supply of their product at will. Since the petroleum exercise has apparently achieved considerable success from the producers' point of view, there seem to be some efforts in motion to create institutional structures aimed at achieving similar successes in other areas. The problem, however, is not a new one. It was analyzed from a conservationist point of view by Hotelling (1931). Scott (1965) discussed the problem of output regulation of a natural resource when shifts over time occurred in costs and prices, due to changes in technological and demand conditions. Gordon (1967) emphasized the influence of market conditions in the future on current output decisions. Little study, however, has been made of how the prices and quantities to be supplied are determined in a market which is nowhere near being perfectly competitive and in which the producers have the avowed aim of developing their national economies at a faster rate of growth.

Section II presents a simple model of a non-renewable natural resource being traded in a competitive market and discusses the conditions that affect the price-behavior. Section III presents a monopoly market situation and analyses how the changed market situation affects the prices. Section IV raises the problem of unequal geographical distribution of natural resources and discusses the issues implied in this discrepancy between production and consumption among nations. It analyses further what happens to the price behavior when the investment funds for the accelerated development of producer country come, fully or partly, from the sale proceeds of the natural resource. Section V summarizes the results.

II. The Simple Model

We start with a simple model of a resource which is non-renewable. The producer has complete knowledge of the total stock of the resource that could be extracted at zero costs almost fully and once it is extracted, it cannot ever be replaced. Let the total quantity of known and extractable resource be q *and let* q_t *be the quantity produced in period* t *such that*

$$\sum_{t=0}^{\infty} q_t \leq q \qquad (1)$$

Assume perfectly competitive market conditions, with a risk-free interest rate r*, which could be used as a proxy for the* *social time preference rate. Let the period-wise demand function for that particular natural resource be given by*

$$p_t = d_t\ (q_t) \qquad (2)$$

In these conditions the optimum course for the producers would be to maximise the present value of the discounted sum of the total revenue (= total profits) which is given by the quantity

$$P.V. = \sum_{t=0}^{\infty} (1+r)^{-t}\ d_t(q_t)\ q_t \qquad (3)$$

Subject to the supply constraint (1). Associated with the optimum solution would be an output stream given by the sequence $\{\bar{q}_t\}$. Setting a Lagrangean and differentiating it with respect to q_t, we get the solution

$$d_t(\bar{q}_t) = \lambda\ (1+r)^t\ (t = 0,1,2,\ldots) \qquad (4)$$

The value of λ, the shadow price of the natural resource, can be obtained by substituting t=0, in (4), which would be equal to $d_o(\bar{q}_o) = \bar{p}_o$, so that (4) can be written as

$$d_t(\bar{q}_t) = d_o(\bar{q}_o)\ (1+r)^t\ (t = 0,1,2,.) \ (5)$$

This shows that in a perfectly competitive market the price of the natural resource will be increasing at the rate r.

Given the demand function, the constraint condition (1) and the assumption t=T, the period in which the resource is completely exhausted, the initial and the maximum prices, $d_o(\bar{q}_o)$ and $d_T(q_T)$, can be easily obtained.

Let the demand be represented by the linear function

$$q_t = \alpha - \beta p_t \qquad (6)$$

At t=T, since q will be completely exhausted, $q_T = 0$. So $p_T = \alpha/\beta$, will be the maximum price that could be obtained in a competitive market.

Using (1) and (5), (6) can be summed up and written as

$$\Sigma q_t = q = \Sigma\alpha - \beta\Sigma p_o\ (1+r)^T$$

which gives the solution

$$d_o(\bar{q}_o) = \frac{n\alpha - q}{\beta r^T}$$

The two values represent the p intercept of the long-run demand function and the point of intersection of the demand function and the long-run perfectly inelastic supply function. If the demand function doesn't ever intersect the price axis, then the total stock of the natural resource will never be fully exhausted and the price will remain undetermined. The initial price could be zero when the total known reserves are large enough for the demand function to intersect the quantity axis and thus become a free good.

III. The Monopoly Behavior

The optimum course for a monopolist is to maximise the discounted sum of the total revenue stream (3) subject to the constraint (1). Associated with this maximum value for the monopolist would be an output stream represented by the sequence of quantities $\{\bar{q}\}$. The Lagrangean that is set up, when differentiated with respect to q_t, now gives a different solution, which is

$$d_t(q_t) + d_t'(q_t)q_t = \lambda\ (1+r)^t (t=0,1,2,..)(7)$$

Noting that the LHS of (7) is the marginal revenue in period t and by obtaining the value of λ by substituting t = 0, (7) can be written as

$$m_t = m_o\ (1+r)^t \qquad (8)$$

Where m_t is the marginal revenue in period t. This solution indicates the price behavior modification in a monopoly market relative to a competitive market. It is not the price, but the marginal revenue that increases at the rate r. Since for any given positive quantity marginal revenue is smaller than price, the price will increase at a rate less than r.

For the demand function (6)

$$q_t = \alpha - \beta p_t$$

the marginal revenue is given by

$$m_t = \frac{\alpha - 2q_t}{\beta}$$

and the price

$$p_t = \left(\frac{\alpha}{\beta} + m_t\right) / 2$$

The maximum price that the monopolist could charge would be equal to the price-intercept of the demand function (i.e. α/β and the minimum initial price would be the same as in the competitive conditions, unless the known reserves are large enough as not to effect the supply constraint (1). When the marginal revenue is zero, the monopolist will still be charging $\frac{1}{2} \cdot \frac{\alpha}{\beta}$ as the price.

IV. Less Developed Countries and the natural resources

The geographical distribution of natural resources, viewed at the present time, has given rise to a peculiar problem. At least in respect of some important natural resources, the consuming countries are endowed with little or no known reserves, while the producing countries, which have the most reserves, (and which are 'poor' otherwise), find that their reserves of natural resources are a sure source of investment funds, so badly needed to transform their economies. Realizing that the present prices are too low, they feel that they should price their product in such a way that they get the maximum amounts of investment funds, without having to exhaust the stock of the reserve too rapidly. This feeling stems from the thought that once they exhaust their known reserves they would be left with no source to fall back upon, and that their economies will continue to remain backward.

Let us assume a simple economy, growing at a steady-state rate, g. Let the investment funds required to sustain this rate of growth in period t be $p_t\ q_t$, the total revenue obtained by the sale of the natural resource, under the assumption that the sale of the natural resource output is the only source of investment. The quantity $p_t\ q_t$ will be growing at rate g, as in a steady state

$$p_t\ q_t = p_o q_o\ (1+g)^t \qquad (9)$$

It is obvious that the funds equalling $p_t q_t$ will make the same contribution to the process of growth in period t, as will do $p_t q_t\ (1+g)^{-t}$ in the initial period. Therefore, the producer countries will adopt an optimum course when they maximise the quantity

$$\sum_{t=0}^{\infty} p_t q_t\ (1+g)^{-t} \qquad (10)$$

under the constraint (1).

Associated with this maximisation course would be a sequence of quantities $\{\hat{q}_t\}$, which they will be selling in the market. The relevant Lagrangean will give the following solution.

$$\hat{p}_t = \lambda\ (1+g)^t \quad (t = 0,1,2,....)$$

Where λ could be interpreted as the shadow cost of development per unit of natural resource. The price, therefore, will be growing at the rate g. But by (4), we know that in competitive conditions $d_t(\bar{q}_t)$ grows at the rate r. If g = r, then both the quantities will be the same. In the event g > r, $\hat{p}_t > d_t\ (\bar{q}_t)$ and if $\hat{p}_t < d_t(\bar{q}_t)$ when g<r, an unlikely event. Similarly modified relationship we would observe in the behavior of marginal revenue in a monopoly market situation, where the price of the natural resource will be increasing at a rate less than g. Cartelization of oil trade could indeed be better for consuming countries.

Let us relax the assumption that all the investment funds are acquired through the sale of the natural resource. If they form only a part of the total requirements, the other part coming from the domestic savings, then the quantity to be maximised could be expressed as

$$\Sigma\ (p_t\ q_t - svp_t q_t)\ (1+g)^{-t} \qquad (11)$$

Where s is the savings propensity and v is the constant output capital ratio. Adjoining (11) and (1) and differentiating the Lagrangean with respect to q_t, we get.

$$\hat{p}_t\ (1-sv) = \lambda\ (1+g)^t\ (t=0,1,2,...) \qquad (12)$$

or

$$\hat{p}_t = \frac{\lambda}{1-sv}\ (1+g)^t$$

Since sv is likely to be much less than unity, the initial price will be set at a higher level. The annual increase will however, take place at the same rate g.

V. Summary and Conclusions

In a competitive equilibrium the price of a natural resource will be increasing at a rate equal to the social time preference rate, r. In a monopoly situation the rise in prices will be *at a rate less than the social time preference rate, as it is the marginal revenue which will be increasing at the social time preference rate. If the producing countries have the aim of using the sales proceeds of their natural resource reserves to develop their economies at the rate of growth, g, then the price of the natural resource will also be growing at the rate g. g could be greater than r or equal to r, or less than r, in which case the price will be rising at the higher rate. If part of the funds for investment are however, provided by the domestic savings then the price-rise will take place at the rate, g, but the initial price will be set at a higher level.*

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