PRODUCTION FROM AN EXHAUSTIBLE RESOURCE UNDER GOVERNMENT CONTROL IN AN LDC

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Discussion Paper No. 70 December 1977

ABSTRACT

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This paper investigates production from an exhaustible resource when the objective is to maximize the total value of output retained within the domestic economy rather than profit maximization. Maximization of retained value is more relevant in less developed countries and governments have in certain cases purchased a controlling share in extractive industries in order to produce at levels that are optimal under this objective. The conclusion of the paper is that optimal output will be higher than under profit maximization, and the larger the value of output going to domestic inputs, the larger the output differential in output.

Cet article examine le problème de la production d'une ressource non-renouvelable lorsque l'objectif à atteindre consiste à porter à son maximum la valeur totale de la production demeurant dans l'économie domestique plutôt que d'obtenir une valeur maximum de profits. La valeur retenue maximum est plus importante du point de vue des pays en voie de développement et dans certains cas leurs gouvernements se sont procurés une part majoritaire des industries extractives de facon à fixer la production à des niveaux qui correspondent le mieux à cet objectif. La conclusion de cette étude est que le niveau de la production sera plus élevé dans le cas ôu l'on poursuit l'objectif de valeur retenue maximum plutôt que celui du profit maximum, et que, plus la partie de la production réservée aux intrants domestiques s'élève, plus la différence en production sera-t-elle imporante.

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This paper combines the concept of maximizing returned value with the theory of exhaustible resources to see under what conditions optimal output would vary from the profit maximizing level. We consider a single country which is a price taker and where some form of a nationalization allows government objectives to be incorporated into production decisions. We also assume that some imported inputs will always be necessary in the production process, and that utilization of domestic inputs will not change the cost function, i.e. when available, domestic inputs are as efficient as imported inputs.

There have been two parallel developments in the areas of foreign investment in the export sectors of developing countries and production from an exhaustible resource. In the former, the possibility of significant outflow of the value of output through dividend payments by multinational companies led to the introduction of the concept of returned value.[1] Latin American countries producing raw materials for export and using foreign investments became interested in maximizing the value of output retained within the economy. Included in net retained value, in addition to tax revenues, are payments to domestic inputs on current account and capital expenditures. However, development literature implied that maximizing returned value was an afterthought, i.e. that production would be determined by profit, and, therefore government revenue maximization. After profit determined the optimal output, it was up to government to try to maximize the utilization of domestic inputs (if the private corporations were not already doing so) through subsidies to domestic industry or excise taxes on foreign inputs that lowered their relative competitive advantage. Where excise taxes or subsidies have been used, the result has been apparent inefficiency as production under private control moved away from the original to a new profit maximizing level.

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[1]See for example M. Mamalakis and C.W. Reynolds (1965), N. Girvan (1972) and R. Mikesell (1970).

The inefficiency has been partly due to the failure of governments to recognize the conflict involved in trying to maximize the sum of tax revenues and domestic input payments without changing output from the profit maximizing level, by affecting the costs of production. This discrepancy between what the corporation and government regard as optimal levels of output has been one of the reasons behind government intervention and nationalization of raw material export industries.[2]

The second development has been in the economic theory of exhaustible resources where past production has an influence on current costs. The general conclusion seems to be that optimal production would be such that the value of per unit of the ore remaining in the ground would grow exponentially at the rate of discount.[3] Mikesell among others applied the same conclusion to developing countries, thus assuming that domestic input payments had no effect on the optimal rate of production, even if the objective was to maximize returned value.[4] As the resources of a single country became depleted, costs of production may rise much faster than prices so that the major portion of the value of output is going to input payments. Unless technological change (which lowers costs, increases profits and thus increases government tax receipts) actually reverses the secular upward shift in marginal costs, a strategy that increases output could conceivably cost the country more in terms of development resources than an alternative which emphasized domestic input utilization but at a different level of production. The losses can be substantial, since costs sometimes constitute over 75% of the value of output and sometimes over 80% of the value of additional output.

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[2]The most discussed of these are in the cooper industries of Chile (1964-1969) and Zambia (1969-1974).

[3]See, for example Hotelling (1931), Solow (1974).

[4]R. Mikesell (1975).

<u>Returned Value</u>

There is an extensive literature on the subject of development through trade.[5] Returned value is an empirical concept that estimates the benefits to a host country from the production of an export by a foreign corporation whose shareholders reside in other countries. When there is very little direct domestic consumption (the case with most mineral exports), the major contribution of the export becomes the generation of resources that can be turned into consumer and capital goods. This is what Marmalakis calls "the resource availability effect" (or returned value) which is measured by the sum of taxes and expenditures on domestic inputs.[6] Domestic input payments are resources that can be used to generate more extensive benefits from such an export sector to the domestic economy. Their ability to generate capital goods however, may be less than that of tax revenues. Since capital goods are considered more necessary to development in the early stages, this means input payments should have a lower weight than taxes in the objective function, at least in the eyes of government planners. Inclusion of domestic input payments recognizes the existence of unemployment caused by market imperfections that hinder the automatic spread of technological change or transfer of skills. The paper assumes that domestic inputs will never completely replace imports, but that the government pushes for the retention of as much of the value of output within the domestic economy as possible while still providing enough of an incentive (through an appropriate tax rate) for foreign capital.

The problem of maximizing returned value can then be stated as follows:

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[5] For a theoretical discussion as well as bibliography, see for example, G. Meier (1968), Chap. 8, and The United Nations (1964), Chap. 1.

[6] M. Marmalakis, "Copper and Chilean Development," Chap. 16 in R.F. Mikesell (1971). A more comprehensive concept but one that is difficult to measure would be his "net overall resource availability effect" which includes (in addition to tax receipts and domestic input payments) some measure of the contribution to a "business climate" that attracts more foreign investment. The assumption is that domestic inputs have a zero or low opportunity cost.

$$(1)\quad \underset{q_t}{\text{Max.}}\ L = \sum_{t=o}^{T}\left[\theta(p_t q_t - C(x_{t-1},q_t)) + (1-\theta)k_t C(x_{t-1},q_t)\right]e^{-rt}$$

subject to

$$(2)\quad \sum_{t=1}^{T} q_t \leq \bar{x}\ ;\ \bar{x}\ \text{ is given, and } x_{t-1} - x_t = q_t$$

$$(3)\quad C_x \leq 0,\ C_q \geq 0,\ \text{where } C_x = \partial C/\partial x,\quad C_q = \partial C/\partial q$$

$$(4)\quad 0 < \theta < 1,\quad 0 < k_t < 1$$

where q_t is the level of production in period t, x_t the amount of deposits of the resource at the end of period t and that affect costs in period t+1. Equation (1) states the objective is to maximize returned value which consists of government revenues from profit taxes (for convenience we assume a 100% tax rate on profits; actually this assumption can be easily relaxed) and payments to domestic factor inputs ($k_t C_t$). Both are weighted by some measure of their relative importance in the development process, and the weights (θ, $1-\theta$) add up to one. We assume for the moment that θ is determined independent of variables in the model, an assumption to be relaxed later in the paper. Equation (2) states that production cannot exceed the initial reserves, and the only change in deposits occurs through production. We assume a smooth, convex cost function that is twice differentiable, and (3) says costs are positively related to the level of production but negatively to the level of deposits. Finally, the weight attached to government revenues is less than one (it is equal to one under profit maximization), and imported inputs will always be necessary. The level of domestic input utilization is assumed to be independent of the level of production. This may be an unrealistic assumption but is made in order to simplify the analysis.

If we assumed a 2-period horizon (T=2) then the problem could be stated as:

$$(5)\quad \underset{q}{\text{Max.}}\ L = \theta\left[p_o q_o + s_o C(\bar{x},q_o)\right] + \theta\left[p_1 q_1 + s_1 C(\bar{x} - q_o, q_1)\right]e^{-r}$$

subject to

(6) $q_o \geq 0,\ q_1 \geq 0$

(7) $\bar{x} - q_o - q_1 \geq 0$

where $s_i = \frac{-\theta + (1-\theta)k_i}{\theta}$, i=o, 1, is a measure of the net contribution of a single unit of costs to returned value. If costs went up by one dollar, given prices, weighted tax revenues would decline by $\$\theta$ while domestic input payments would increase returned value by k_i. The expression $\frac{1-\theta}{\theta}$ converts domestic input payments into their tax revenue equivalent. Thus, if θ was 0.6 then each dollar of domestic input payments would be the equivalent of \$0.67 of revenues from profit taxes. The objective function therefore is expressed in the same units. From the Hamiltonian

(8) $H = L + \lambda_o q_o + \lambda_1 q_1 + \lambda_2\ (\bar{x} - q_o - q_1)$

we obtain the usual first-order conditions

(9) $H_{q_o} = \theta\left[p_o + s_o C_q\ (\bar{x}, q_o) + s_1 C_x(\bar{x} - q_o, q_1)e^{-r}\right] + \lambda_o - \lambda_2 \leq 0$

(10) $H_{q_1} = \theta\left[p_1 - s_1 C_q(\bar{x} - q_o, q_1)\right] e^{-r} + \lambda_1 - \lambda_2 \leq 0$

(11) $H_{\lambda_o} = q_o \geq 0,\ H_{\lambda_1} = q_1 \geq 0,\ H_{\lambda_2} = \bar{x} - q_o - q_1 \geq 0$

where the letter subscripts denote partial derivatives, and $C_q(\bar{x}, q_o)$, for example, denotes the change in total costs due to a unit change in output, evaluated during the first period. The λ_i are the Lagrange multipliers. The Kuhn-Tucker conditions, for $\lambda_i \geq 0$, i = 0, 1

(12) $\lambda_i q_i^* = 0$

(13) $\lambda_2\ (\bar{x} - q_o^* - q_1^*) = 0$

together with conditions (9) and (10) give us the following

(14) $q_o^*(L_q - \lambda_2) = 0$

(15) $q_1^*(L_{q_1} - \lambda_2) = 0$

where q_o^*, q_1^* are optimal levels of output. From this we can conclude that, for q_o^*, $q_1^* > 0$, production in both periods will occur up to the point where the marginal returned values in the two periods are equal, with the second period's marginal returned value discounted to its present value. The shadow price of ore left in the ground (λ_2) would be a constant which would grow at the rate of discount, as is seen from $\lambda_2 = L_{q_o} = L_{q_1}$.

The difference between production under private ownership and under government control thus lies not only in the rate of discount but in the figure being discounted. Under government ownership it is net marginal returned value as opposed to the net rent in the case of profit maximization. The difference between the two figures depends on the quality of the deposits and thus any differences in the rates or change of costs and market prices. These rates of change could be the same worldwide for a given commodity, but need not be the same within a given country.

If $q_o^* = 0$, $q_1^* > 0$ then $\lambda_o \geq 0$, $\lambda_1 = 0$, and

(16) $-\lambda_o \geq \theta p_o + s_o C_q(\bar{x}, q_o) + s_1 C_x(\bar{x} - q_o, \bar{x} - q_o)e^{-r}$

(17) $L_{q_1} = p_1 - s_1 C_q(\bar{x} - q_o, \bar{x} - q_o) = \lambda_2$

Production would be postponed into the second period only if weighted marginal tax revenues plus the foregone domestic share of marginal costs are less than the shadow price of postponing production by one period. Production in the second period would be such that the net returned value is equal to the opportunity cost of leaving ore in the ground at the end of the period.

The focus of this section is to determine the effects of changes in the domestic share of costs on optimal output. To illustrate this, we assume that deposits are exhausted at the end of the second period ($\bar{x} = q_o + q_1$). Then equation (8) becomes

$$H = L + \lambda_o q_o + \lambda_1(\bar{x} - q_o)$$

and the conditions for an optimum

$$(18)\quad L_{q_o} + \lambda_o - \lambda_1 \leq 0$$

$$(19)\quad \lambda_o q_o^* = 0$$

$$(20)\quad \lambda_1(\bar{x} - q_o^*) = 0$$

If $q_o^* > 0$ then $\lambda_o = 0$ and $L_{q_o} = \lambda_1$, and equations (14) and (15) imply that, for $q_o^*, q_1^* > 0$,

$$(21)\quad p_o - p_1 e^{-r} + s_o C_q(\bar{x},q_o) - s_1\left[C_x(\bar{x}-q_o,\bar{x}-q_o) + C_q(\bar{x}-q_o,\bar{x}-q_o)\right] e^{-r} = 0$$

where $\bar{x} - q_o$ represents both the deposits at the beginning of period 1 and production during that period. Again, production will be optimal only if the marginal net returned value in the first period is equal to the present value of the second period's net marginal returned value. Differentiating (21) with respect to s and setting the result equal to zero we obtain[7]

$$(22)\quad \frac{dq_o^*}{ds_o} = \frac{C_q(\bar{x},q_o)}{s_1\left[C_{xx}(\bar{x}-q_o,q_1) + 2C_{xq}(\bar{x}-q_o,q_1) + C_{qq}(\bar{x}-q_o,q_1)\right] e^{-r} - s_o C_{qq}(\bar{x},q_o)}$$

Since we assume exhaustion, equation (22) also represents $-\frac{dq_1^*}{ds_o}$. The numerator is positive, but both s_o and s_1 can be positive or negative. We assumed a convex cost function, so the quantities multiplied by s_o and s_1 in the denominator are positive. The sign of the denominator will thus depend on the signs of s_o and s_1, the net contribution of each dollar of costs to net returned value, expressed in terms of tax revenues. Under conditions of profit maximization, however, optimal output is independent of the value of s. Since we are assuming a 100% profit tax rate the same applies to maximizing tax revenues. Equation (22) however implies that, under returned

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[7]To obtain $\frac{dq^*}{dk_o}$ multiply (22) by $\frac{1-\theta}{\theta}$. Since this is always positive the results remain unchanged.

value maximization, optimal output has to respond to changes in domestic input utilization since $\frac{dq_o^*}{ds_o}$ cannot be zero.

We consider the behavior of (22) under four different assumptions about s_o and s_1.

Case 1: Both s_o and s_1 are positive, i.e. $\frac{-\theta + (1-\theta)k_i}{\theta} > 0$. This means a dollar increase in costs will increase net returned value because it increases domestic factor payments by more than it reduces tax revenues. For $k < 1$, this can only happen if the weight attached to government revenues is less than that attached to domestic factor payments. Then (22) will be positive if the resultant increase in marginal costs adds more to returned value through domestic payments than it reduces tax revenues over the two periods, i.e.

$$\frac{(1-\theta)}{\theta}k_1\left[C_{xx} + 2C_{xq} + C_{qq}\right]e^{-r} - \frac{(1-\theta)}{\theta}k_o C_{qq}(\bar{x}-q_o,q_1) > -\theta(C_{xx} + 2C_{xq} + C_{qq})e^{-r} + C_{qq}$$

Given the low value of θ this can happen if the domestic input content of cost (k_i) rises sharply between the two periods, or alternatively marginal costs are rising much more sharply than prices in the second period.

Case 2: Both s_o and s_1 are negative. Increases in costs reduce net returned value because the reduction of tax revenues is much sharper than the increase of returned value through higher domestic input payments. This would happen if, for given values of k_o and k_1, θ was greater than 0.5. Increases in k_o (which would reduce the negative s_o) would increase output in the first period only if the resultant increase (reduction of the decline) in returned value during period 0 less that of period 1, is greater than the resultant difference in tax revenues over the two periods, i.e.

$$\frac{(1-\theta)}{\theta}k_o C_{qq}(\bar{x},q_o) - \frac{(1-\theta)}{\theta}k_1 C_{qq}(\bar{x}-q_o) > \theta(C_{xx} + 2C_{xq} + C_{qq})e^{-r} - \theta C_{qq}(\bar{x},q_o)$$

with the first term after the inequality sign evaluated at $(\bar{x}-q_o)$.

Otherwise, an increase in k_o would result in an increase in the optimal output of period 1.

Case 3: s_o is negative but s_1 is positive. Expression (22) will always be positive, and so an increase in k_o will raise q_o^* until (21) is satisfied.

Case 4: s_o is positive but s_1 is negative. The denominator is always negative and an increase in the domestic component of costs in the first period will result in a postponement of production into the second period.[8]

The above results would be reversed if the cost function were concave, and would be inapplicable if the marginal costs were zero. It is also clear that, while we have simplified the analysis by not changing the value of θ and making it a function of k, it is probable that policy makers will adjust its value depending on the relative rates of increase of prices and costs as well as the changes in the domestic component of costs. It seems reasonable to make k_i independent of the level of production within the export industry under consideration. Rather, its size will be influenced more by development in other sectors of the economy and technological change there than by the immediate activities in the sector itself.

Cases 2 and 3 are more likely than either 1 or 4 in any developing economy because θ is more likely to be greater than 0.5. Given the value of θ, k_1 is likely to be greater than k_o except in the industry where technological change is so rapid, or favors imported inputs so much that the domestic content of inputs on an average actually declines. Then Case 4 would be relevant. It is more likely that the pace of technological change within the industry in fact depends partly on the value of θ, and its effects on k usually are temporary as long as the rest of the economy is going through a transformation. Sooner or later domestic inputs will replace imports, and k will increase.

General Case

Until now the weight θ has been assumed to be given, but it is clear that it is probably an economic instrument that is subject to control as

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[8] Cases 1 through 4 similar to the 'bang-bang' solutions in a continuous time model.

much as output.[9] This possibility is now considered, along with a more general model. Equation (1) can now be stated as

$$(23)\quad \underset{q,\theta}{\text{Max}}\ L = \sum_{t=o}^{T} \theta_t (p_t q_t + s_t C(x_{t-1}, q_t)) e^{-rt}$$

where the subjective weight θ, $0 \leq \theta \leq 1$ is now subject to change every production period. This could be in response to changes in factor incomes or activity in other sectors of the economy. The Hamiltonian becomes

$$(24)\quad H = L + \sum_{t=o}^{T} \lambda_t q_t + \lambda_{T+1}(\bar{x} - \sum_{t=o}^{T} q_t) + \sum_{t=o}^{T} \mu_t \theta_t + \sum_{t=o}^{T} v_t (1-\theta_t)$$

and the first order conditions for a maximum

$$(25)\quad H_q = \theta(p + sCq)e^{-rt} + \lambda_t - \lambda_{T+1} \leq 0$$

$$(26)\quad H_x = (-\theta + (1-\theta)k)C_x e^{-rt} \leq 0$$

$$(27)\quad H_\theta = (pq - (1+k)C(x,q))e^{-rt} + \mu_t - v_t \leq 0$$

$$(28)\quad H_{\lambda_t} = q_t \geq 0,\ H_{\mu_t} = \theta_t \geq 0,\ H_{\lambda_{T+1}} = (\bar{x} - \sum_{t=o}^{T} q_t) \geq 0,\ H_{v_t} = (1-\theta_t) \geq 0.$$

The time subscripts have been dropped on some variables (except on the Lagrange multipliers) for simplicity. The other subscripts as before represent partial derivatives. Conditions (25), (26) and (28) are analogous to (9), (10) and (11), while (27) adds the new constraint imposed by the weight θ. We can show that, for $0 < \theta < 1$, $q_t^* > 0$, and $(\bar{x} - \sum_{t=0}^{T} q_t) > 0$ then

$$(30)\quad L_q - L_x = L_\theta$$

Production will be optimal only if the change in net returned value due to a change in output is now equal to the change due to a change in the weight. If exhaustion occurs $\left[(\bar{x} - \sum_{t=o}^{T} q_t) = 0\right]$ then

$$(31)\quad L_q - L_x - \lambda_{T+1} = L_\theta$$

[9] The previous discussion would apply as well to the case where θ was determined by political considerations, e.g. labor union wage demands, regional concerns, etc. In that case θ is likely to fluctuate more frequently, and the problem may be one of step-wise (sequential) decision making.

Production in any period is optimal only if the marginal net returned value due to increased production less the shadow price of leaving ore in the ground at the end of period T is equal to the addition to net returned value due to changing weights. Using equation (25), together with the Kuhn-Tucker conditions, it can be seen that $q_t^* = 0$ only if the marginal net returned value plus the shadow price of output is less than the shadow price of a unit of ore in the ground at period T. If $\theta = 1$ we obtain the profit maximizing conditions.

Empirical Results

The model was applied to the Zambian copper mining industry, the third largest producer of refined copper after the United States and Canada. Until 1969 the industry was foreign-owned. In 1970 the government purchased a controlling share of the industry and signed 10-year management contracts with the original owners, Anglo American Corporation (AAC) and American Metal Climax (AMAX). The contracts were abrogated by the Government in 1975 due to dissatisfaction with what it considered to be slow rates of capacity expansion and "Zambianization" of the labor force.

Cost Functions

The cost functions estimated for the six major mines were of the Cobb-Douglas variety, which, in log-linear form, was

$$(32) \quad \log C_t = \log b + \alpha_1 \log q_t - \alpha_2 \log x_{t-1} - \alpha_3 \log g_t$$

where q_t is the production of refined copper wirebars, in metric tons, x_t estimated ore reserves by mine and by grade, in thousands of tons, and g_t the grade of ore going through the mill, expressed as a percentage of the average copper content.[10] The production costs were deflated by a combined weighted index of import prices for intermediate goods and the consumer price index. The results shown in Table I, indicate no apparent economies of scale with regard to capacity. Depletion of reserves and declining grades do not occur at the same time (the correlation coefficient was low), and both have a negative effect on costs, regardless

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[10] This information is published in the Roan Selection Trust Annual Reports (the local subsidiary of AMAX) and The Nchanga Consolidated Copper Mines Annual Report.

of the type of mining method. Production costs in 1975 averaged $583 a ton for the open pit mines and between $589 and $622 for the underground mines. Direct and indirect domestic factor payments constituted 45% of total costs.

Table I

Cost Functions for Zambian Copper Mines 1955-75

Mine Capacity (Metric tons per year)	Type of Operation	log b	α_1	α_2	α_3	R^2	Durbin-Watson
170,000	Underground	30.040 (5.83)	0.488 (3.39)	-1.778 (-4.65)	-1.403 (-3.43)	0.89	1.22
100,000	Underground	24.220 (4.97)	0.341 (1.205)	-1.635 (-5.08)	-1.013 (10.931)	0.92	1.19
90,000	Underground	22.586 (2.14)	0.225 (7.83)	-1.793 (-1.85)	-0.821 (-2.182)	0.90	1.40
50,000	Underground	19.785 (3.16)	0.275 (6.14)	-1.893 (-2.11)	-1.411 (-2.12)	0.85	1.39
25,000	Underground	14.626 (2.20)	0.471 (3.01)	-1780 (-4.20)	-1.060 (5.22)	0.82	1.60
240,000	Open Pit	21.153 (1.31)	0.448 (3.68)	-2.694 (-6.224)	-1.313 (-2.94)	0.89	1.04

Tax Revenues

Effective taxation rates (including minerals and income taxes) constituted 73.5% of net profits, and in addition, the government of Zambia earned 51% of the remainder as its share of dividends. The government's share of profits thus was 87.0%. This constituted 70% of total government revenues from the mining industry during 1970-75. Customs duties, income taxes on wages and corporations supplying inputs to the industry supplied the remaining 30%.

Results

The simulated results were based on the following assumptions:

a) The value of θ was 0.70, the share of profit taxes in total government revenues. This tends to underestimate the contribution of domestic input payments to development.

b) The tax rate (at 86.8%) was considered fixed. Different simulations were carried out for different values of k and θ.

c) An upper production limit was set. This was assumed to be determined by the nature of deposits so that if $q_t^* > \bar{q}_t$ then $q_t^* = \bar{q}_t$ where $\bar{q}_t$ is the maximum capacity for each mine. Total industry capacity was estimated at 817,000 metric tons per year. The sequence with which the ores were to be exploited was determined by geological conditions and are outlined in corporate reports already referred to.

d) The difference between profit maximizing and returned value maximizing outputs was considered significant if it equalled or exceeded 25,000 tons, the capacity of the smallest mine.

e) The rate of discount was set at 8 percent.

Some indicative results are shown in Figure 1. Year 0 was 1975, and initial reserves were estimated at about 820 million tons of ore with an average copper content of 3.71%. With k_o=0.45, θ=0.70 (i.e. Case 2) and the prices constant at $1,200 a ton profit maximization would result in operation at full capacity for 12 years (18 years under returned value maximization).[11] There would be a significant difference in optimal output by the 14th year, but the size of this discrepancy would at first increase, then decrease over time. This is due to k being a constant when costs are increasing. Changing the value of k alone does not significantly change the results. The lower the value of θ the greater the discrepancy. When θ was set at 0.6 returned value maximization resulted

[11]Some mines would cut back their operations, but the reduced output would be made up by other mines. Two of the smaller mines have high costs due to water problems. Their excess refining capacity would be used to process ore from other mines, thus removing the latter's refining capacity constraint.

in 22 years of operation at full capacity but the difference was significant at the same time (14th year). If maximum output levels were to be determined only by the level of investment then the differences in optimal output would depend on the distribution of ore reserves by grade; the sharper the declines in grade the greater the difference.

Conclusion

The paper has shown the conflict between a profit maximizing level of output and the objective of retaining as much of the value of output as possible in an exporting country where a substantial amount of the inputs have to be imported. The response of optimal output to changes in the domestic share of costs depends on the nature of the cost function and the weight attached to goverment revenues.

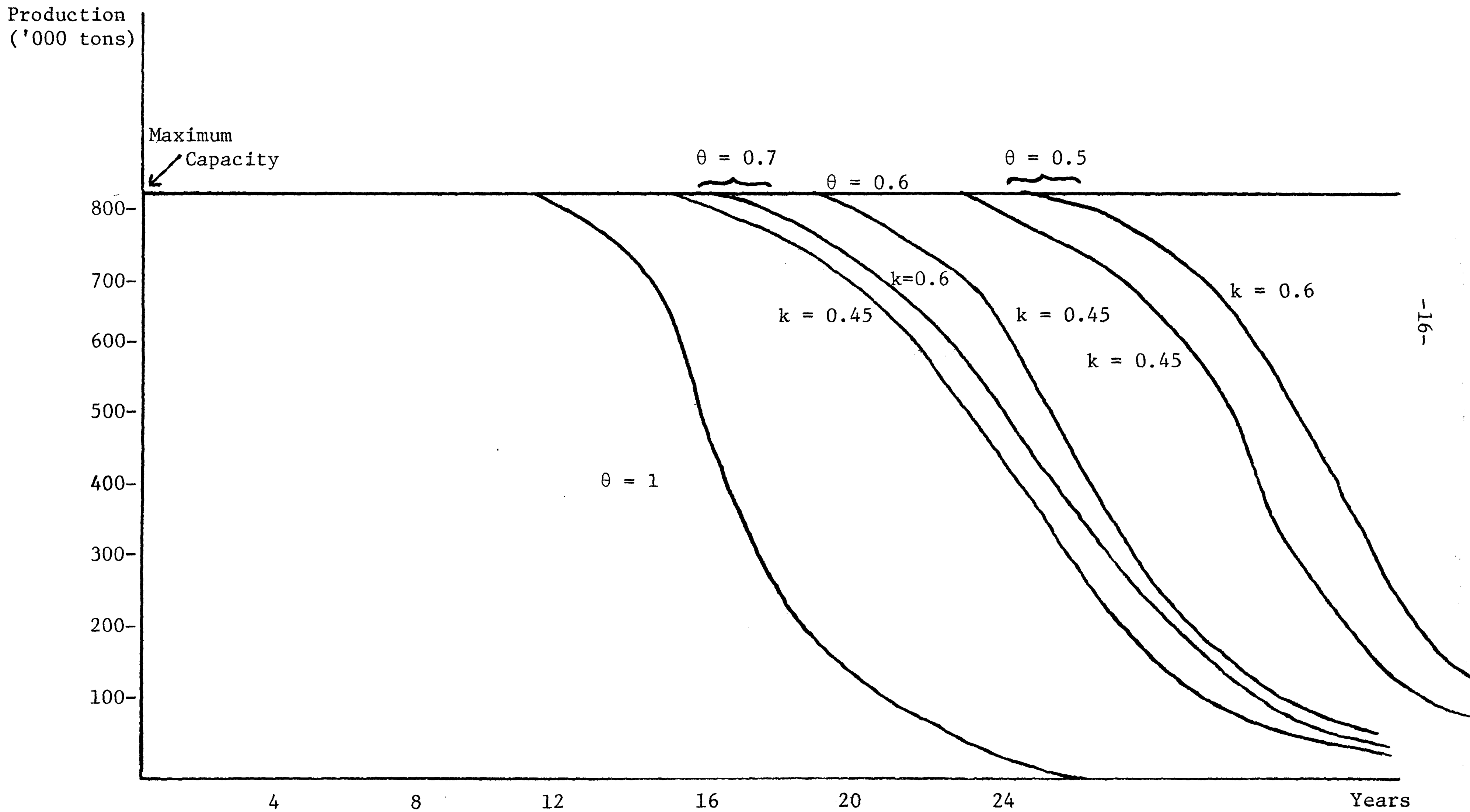
Profit maximization as well as maximization of the government's share of the net rent from the resource has been previously accepted as the major determinant of the level of investment, and hence optimal output. Net returned value has been considered a legitimate concern, but its other component (domestic input payments) has been relegated to the position of an externality which is determined by the level of output, rather than the other way around. This paper assumes that if maximization of returned value is a legitimate objective function of a government then it should be used to determine the level of output considered optimal. The analysis suggests that such a level of output will be different from the profit maximizing level, and there will be a different tilt in the production profile. The magnitude of the difference will depend on the composition of net returned value, which in turn is determined by prices and the behavior of costs. Differences in the rate of discount would also result in different levels of optimal output. A thorough discussion of the proper social rate of discount is outside the scope of this paper. However, the proper rate for a private foreign corporation could be the market rate of interest, whereas that of a government is determined largely by forces outside of the extractive industry under consideration. One of the most important of these forces could be the availability of capital, and the recent trend has been the expansion of private bank financing of government projects in developing countries at rates of interest pegged to market rates. This could be taken as an indication that the rates of discount for private foreign investors and governments in extractive industries of developing countries may be converging. The analysis in this paper suggests that even in the rates of discount were the same, levels of production considered optimal by the foreign investor and the host government would still be different.

The analysis also highlights the problems of management contracts. Government in developing countries usually lack the technological know-how to run such complex industries. Purchase of a controlling share, therefore, usually involves the signing of a management contract with a foreign firm. In a majority of the cases the contract is awarded to the minority partners. This paper suggests that it could be in the firm's interests to continuously introduce technology that required imported inputs. Not only are they usually more efficient that domestically produced inputs, they also serve to focus government interest on profits thus ensuring a high value of θ_t and the need for foreign technology (and management) in realizing these profits.

Training programs that raise the domestic share of factor inputs help create an atomosphere of good will between the host government and the foreign management firm. However, they sow the seeds for potential disagreement over appropriate production levels, especially in times of low prices and high costs. The host government would then be interested in output levels that are higher than what profit maximization would justify. That would tend to keep foreign exchange earnings and employment levels high, and the government could always recoup lost profit taxes by raising income taxes on domestic inputs.

Figure 1

PRODUCTION PROFILE UNDER RETURNED VALUE MAXIMIZATION



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