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Abstract

Since the early 1970s, it has been realized that rapid economic development in developing countries leads to an acute inequality in income distribution. To prevent massive dissatisfaction among their citizens, developing countries were urged to achieve economic growth (particularly industrial growth) with distribution of income as their development goal. A good way of promoting growth and dispersal of industrial activities is the establishment of industrial estates in the locations where such activities are desired. This paper formulates the problem of optimal development of industrial estates, with the incorporation of specified minimum levels of development in poverty (priority) sites as distributive targets, as encountered by a Malaysian state government.

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PLANNING FOR INDUSTRIAL ESTATE DEVELOPMENT IN A DEVELOPING ECONOMY†

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Since the early 1970s, it has been realized that rapid economic development in developing countries leads to an acute inequality in income distribution. To prevent massive dissatisfaction among their citizens, developing countries were urged to achieve economic growth (particularly industrial growth) with distribution of income as their development goal. A good way of promoting growth and dispersal of industrial activities is the establishment of industrial estates in the locations where such activities are desired. This paper formulates the problem of optimal development of industrial estates, with the incorporation of specified minimum levels of development in poverty (priority) sites as distributive targets, as encountered by a Malaysian state government. The linear programming problem so formulated is then shown to be equivalent to a transportation problem, enabling it to be solved and parametically analyzed efficiently. Computational results, obtained using real-life data, show that the subsidy incurred in fulfilling the distributive targets is small compared to the total revenue generated. This justifies the imposition of the distributive targets on the development process. Further, the optimal policy was found to involve decisions to be taken in the initial years of the planning horizon that are fairly insensitive to variation in demand and cost parameters, thereby demonstrating the relative 'goodness' of the optimal policy for industrial estate development in the state.
(PLANNING; LAND DEVELOPMENT; LINEAR PROGRAMMING—APPLICATIONS)

1. Introduction

Since the early 1950s, it has been widely recognized that to alleviate the problems of poverty and mass unemployment encountered in developing countries, industrialization should play a key role in the economic growth of these nations [5]. The types of industries deemed most suitable for promotion in these countries are the small and medium-scale industries. These industries are generally less capital intensive than large-scale industries [11] and hence are more spread out in terms of ownership. Establishment of small and medium-scale industries could thus lead to a more equitable distribution of income [3]. Studies on development of small-scale industries have concluded that an effective means of promoting the growth and dispersal of small and medium-scale industries is the provision of proper sites for the establishment of these enterprises (e.g. [9]). These sites should preferably be located in an industrial estate [2], [9], which is defined as "a tract of land which is subdivided and developed according to a comprehensive plan for use of a community of industrial enterprises" [2, p. 1].

In common with the current economic philosophy of development, the strategy of Malaysian economic development is one of growth with distribution [8]. A major

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strategy for effecting the desired pattern of development is the promotion of new industries (particularly small-scale ones) in the less-developed regions. In the context of this strategy, State Economic Development Corporations (SEDCs) were established by the various Malaysian states to stimulate industrialization through the development of industrial estates in the respective states. The industrial estates to be established by these SEDCs are envisaged to be in the form of improved tracts of land, with access roads and utility services; however, no buildings are to be provided. Industrial land so developed are leased out (usually for 99 years) to interested entrepreneurs for an initial premium of between *M*\$0.35 to \$3.00 per square foot,[1] and an annual assessment tax of between \$200 to \$1,000 per acre. The lower rates are for industrial land developed in the rural areas, while the higher rates are for such land developed in the urban areas. Depending on the initial land conditions, cost of industrial land development in Malaysia varies between \$2.00 to \$10.00 per square foot. This means that industrial land developed in the rural areas are generally leased out to entrepreneurs at a public subsidy, so that the goal of industrial dispersal may be achieved. Given the large amount of subsidies involved, it is clear that some form of planning for the orderly development of industrial estates is required.

In the next section we present the industrial estate planning problem as encountered by a state SEDC. In §3 this problem is mathematically formulated as a constrained transportation problem. The problem is then converted into a pure transportation problem which enables it to be solved and parametically analyzed very efficiently. Finally, in §4 we discuss the computational results obtained by solving and parametically analyzing the problem using a commercial network code.

2. The Industrial Estate Planning Problem

The problem considered in this paper is the problem encountered by the SEDC of Selangor (a Malaysian state with a 1975 population of slightly over one million) in planning for the optimal development of industrial estates within the state. The state corporation has to meet the targeted (given) demand for industrial land over a planning horizon. Industrial land can be developed in any of the 17 sites which have been earmarked in the state for industrial development. In each site there is, however, an upper limit on the amount of public land available for industrial land development. It is assumed that the schedule of leasing charges, for land developed in the various sites, is designed such that the less advantageous sites are compensated with respect to the more advantageous sites (e.g., in terms of transportation costs), and an entrepreneur is indifferent between the various sites because of the differentials in the leasing charges. Selangor, the Malaysian state considered here, is a relatively compact state with a good transportation network. The types of industries envisaged to be attracted to the industrial estates are mainly small-scale industries (e.g. manufacture of consumer items). Hence, this assumption is realistic. Hence the demand for industrial land in the state, in any particular year, can be fulfilled by leasing out developed land from any of the sites.

Eleven of the sites (those in the rural areas) are earmarked as priority areas. For each priority site, there is a specified minimum size of industrial land which must be developed by a target year, so that the goal of equitable distribution of economic

[1] The monetary unit used in this paper is the Malaysian \$. As at the end of 1979, the conversion rate is US\$1 = *M*\$2.20.

activity may be achieved. Industrial land development is generally done by contractors (selected by the state authority) on a cost-per-acre basis; hence the cost of industrial land development is assumed linear. Leasing charges for developed land are also linear, and are location-specific. Land developed in any year need not be allocated to meet the demand at that particular year; it can also be held as 'inventory' for demand in some future years. The problem facing the state corporation is to determine a schedule of industrial land development over the various sites, such that the total discounted development cost, less the discounted revenue generated from the leasing of the land over the lease period, is minimized.

3. Mathematical Formulation of the Problem

We commence the formulation process by defining $J = \{1, 2, \ldots m\}$ as the set of sites earmarked for development of industrial estate. Let J be arranged such that $J_p = \{1, 2, \ldots k\}$, $k \leqslant m$, is the set of priority sites where the targeted minimum levels of industrial land development must be met. Define $K = \{1, 2, \ldots T\}$, where T is the terminal year of the planning horizon, and let $K' = K \cup \{T + 1\}$. For development planning in Malaysia, 1990 is the generally accepted terminal planning year. Further, let d_t represent the estimated demand for industrial land in year t.

With respect to each site $i \in J$ we define the following variables:

$a_i =$ the maximum amount of public land available for industrial development in site i.

$r_{it} =$ the discounted revenue collectable (over the lease period) per unit area of industrial land leased out at site i in year t, for $t \in K$.

$c_{it} =$ the unit cost (estimated from past contracted prices) of developing industrial land at site i in year t, for $t \in K$.

$b_i(\tau_i) =$ the targeted (known) minimum size of industrial land that must be developed and leased out in priority site i by the targeted (known) year τ_i. Let $K_i = \{1, 2, \ldots \tau_i\} \subseteq K$ for $i \in J_p$. K_i is the planning subperiod during which the targeted minimum level of industrial development for priority site i must be achieved.

$y_{it} =$ the amount of developed industrial land leased out from site i at year t to meet the demand for industrial land, for $t \in K$. We must have $y_{it} \geqslant 0$.

Let

$$e_{it} = \min_{1 \leqslant s \leqslant t} \left[c_{is} - r_{it} \right] \quad \text{for } i \in J, t \in K. \tag{1}$$

The coefficient e_{it} denotes the net discounted cost of developing a unit of land at site i and leased out in year t, where the s^* that minimizes (1) is the year that the land is developed. It should be noted that if in computing a particular e_{it}, it is found $s^* < t$, this implies that a unit of land to be leased out in site i at year t should be developed at the period s^* prior to t and held as 'inventory' until the period t.

For each period t, to balance the leasing of and demand for industrial land we have

$$\sum_{i \in J} y_{it} = d_t \quad \text{for } t \in K. \tag{2}$$

Further for each site i, we have to satisfy the constraints of limited land availability, i.e.

$$\sum_{t \in K} y_{it} + y_{i,T+1} = a_i \quad \text{for } i \in J. \tag{3}$$

where $y_{i,T+1} \geqslant 0$ is the defined slack variable for site i, with cost coefficient $e_{i,T+1} = 0$.

The conservation equation obtained by taking the difference between the summation of (3) over the i indices and the summation of (2) over the t indices is

$$\sum_{i \in J} y_{i,T+1} = \sum_{i \in J} a_i - \sum_{t \in K} d_t = d_{T+1}. \tag{2a}$$

It should be noted that for feasibility of the problem d_{T+1} must be nonnegative.

In each priority site $i \in J_p$, we need to impose the minimum required level of development by year τ_i as lower bound constraints:

$$\sum_{t \in K_i} y_{it} \geqslant b_i(\tau_i), \qquad i \in J_p. \tag{4}$$

For completeness of the constraint set we have the nonnegativity requirements.

$$y_{it} \geqslant 0 \quad \text{for } i \in J, t \in K'. \tag{5}$$

The objective function of the problem (P) is the minimization of the discounted net cost incurred which is

$$\text{Min} \sum_{i \in J} \sum_{t \in K'} e_{it} y_{it}. \tag{6}$$

The problem P of minimizing (6) over constraint set (2)–(5) and (2a) is a constrained transportation problem [6], where the constraint set (2)–(3), (2a) and (5) is a bipartite transportation network with J as the set of m source nodes each with availability a_i. The set K' is the set of $T+1$ sink nodes with each with demand d_t. Each constraint of (4) is a lower bound on a subset of arcs (i.e. y_{it} for $t \in K_i$) leading out of a source node i. Constrained transportation problem of this nature has been studied by Wagner [10] and Manne [4, p. 382]. Using a method similar to [4, p. 382], the constrained transportation problem P can be converted into a pure transportation problem P′ by the addition of k source notes to the bipartite network representing constraint set (2)–(3), (2a) and (5), each new node being associated with $i \in J_p$. Let these additional nodes be labeled $m+1, \ldots, m+k$ where the node $m+l$, with availability $b_l(\tau_l)$, is associated with the $i = l$ for $i \in J_p$. Let $J' = J \cup \{m+1, \ldots, m+k\}$. The availability of the node $i \in \{1, \ldots, k\}$ in the enlarged $J' \times K'$ transportation network is now modified to $a_i - b_i(\tau_i)$. The cost coefficients, $\hat{e}_{it}$ for $i \in J'$, $t \in K'$, for this enlarged network is derived as follows: $\hat{e}_{it} = e_{it}$ for $i \in J$, $t \in K'$, and $\hat{e}_{m+i,t} = e_{it}$ for $i \in J_p$, $t \in K_i$; and $\hat{e}_{it} = M$ (a very large positive number) elsewhere. Let the 'shipment' variables of this enlarged network be z_{it} for $i \in J'$ and $t \in K'$. The enlarged pure transportation problem P' can now be stated as:

$$\min \sum_{i \in J'} \sum_{t \in K'} \hat{e}_{it} z_{it}, \tag{7}$$

$$\sum_{i \in J'} z_{it} = d_t \quad \text{for } t \in K', \tag{8}$$

$$\sum_{t \in K'} z_{it} = \hat{a}_i \quad \text{for } i \in J', \tag{9}$$

$$z_{it} \geqslant 0 \quad \text{for } i \in J', t \in K', \tag{10}$$

where $\hat{a}_i = a_i - b_i(\tau_i)$ for $i \in J_p$, $\hat{a}_i = a_i$ for $i \in J - J_p$, and $\hat{a} = b_i(\tau_i)$ for $i \in \{m+1, \ldots, m+k\}$.

The relationship between an optimal solution to the enlarged problem P', say z_{it}^*, and an optimal solution to the original problem P, say y_{it}^*, is given by:

$$y_{it}^* = z_{it}^* + z_{m+i,t}^* \quad \text{for } i \in J_p, t \in K' \tag{11}$$

and

$$y_{it}^* = z_{it}^* \quad \text{for } i \in J - J_p, t \in K'. \tag{12}$$

Since the conversion procedure is similar to [4, p. 382], the proof of the equivalence between problem P and problem P′ need not be given here. For the problem P (with $m = 17$, $k = 11$ and $T = 15$) considered in this paper, the equivalent transportation problem P′ has only 28 source nodes and 16 sink nodes. This is a very small transportation problem and can be solved very efficiently by the primal transportation algorithm [1] or the primal-dual transportation algorithm (e.g. see [4]). In the next section we shall discuss the application of this equivalent transportation problem to solving and analyzing the actual problem at hand.

4. Analysis of Results

The basic data for the problem can be summarized as follows. The 1976 land development cost (c_{i1} in thousand $M\$$ per acre), 1976 present value of revenue (r_{i1} in thousand $M\$$ per acre) and land availability (a_i in acres) of the 17 sites are:

site (i)	1	2	3	4	5	6	7	8	9
c_{i1}	130.7	130.7	34.8	30.5	30.5	18.3	87.1	26.1	17.4
r_{i1}	28.3	28.3	45.3	45.3	28.3	28.3	28.3	28.3	28.3
a_i	250	350	32	532	350	60	74	30	45
site (i)	10	11	12	13	14	15	16	17	
c_{i1}	23.3	30.5	21.8	30.5	130.7	65.3	21.8	26.1	
r_{i1}	28.3	28.3	101.9	113.2	141.5	84.9	84.9	113.2	
a_i	30	102	25	164	1593	321	196	2133	

The eleven priority sites can be classified into two groups–the first group (sites $i = 1, \ldots, 5$) has 1985 as its τ_i and the second group (sites $i = 6, \ldots, 11$) has 1990 as its τ_i. The minimum required level of development ($b_i(\tau_i)$ in acres) for the eleven priority sites are site 1 (40 acres), site 2 (50 acres), site 3 (30 acres), sites 4–5 (50 acres each), and sites 6–11 (30 acres each). Further, the projected demand (d_t) for industrial land over the planning horizon are: 300 acres per year for 1976 to 1978, 350 acres per year for 1979 to 1980, 400 acres per year for 1981 to 1985 and 450 acres per year for 1986 to 1990.

Initially the problem was analyzed with the assumption of stationary costs and stationary revenue, and using a discount rate of 10% per year. The transportation model so set up was solved using a widely available PL/1 out-of-kilter network routine (the OCNF Procedure in [7]) on the IBM 370/138 computer using the PL/1 Optimiser Compiler. The basic problem was solved in about 3 sec. (excluding input and output) and gave an optimal objective function value of \$164.8 million (net revenue). In practice the projected demand for the initial years is likely to be accurate, while that for the later years are likely to be subjected to projection errors. We performed a parametic analysis of the optimal solution as a function of d_t by varying d_t as follows: $d_t' = d_t$ for $t = 1, \ldots, 5$, and $d_t' = (1 - \delta)\, d_t$ for $t = 6, \ldots, 15$, with δ varied between -0.15 to 0.10. This was carried out using the parametic subroutine available in the OCNF Procedure in steps of δ involving integer values of d_t'. Figure 1 (Policy 3) presents the objective function value as a function of δ. From the figure it can be seen that as δ is decreased from 0.10, the optimal objective function is an inverted 'V' function with respect to δ.

The distribution parameters, year τ_i and land size $b_i(\tau_i)$, are the two planning parameters within the control of the state agency. To examine the effects of imposing the required minimum levels of development in the priority sites upon the total revenue, we traced the objective function value by varying $b_i(\tau_i)$ as follows: $b_i'(\tau_i) = \beta b_i(\tau_i)$ for all $i \in J_p$ and β varied from 1.0 to 0.0. The plot for $\beta = 0.0$ (i.e. when there are no distributive targets) is presented as Policy 1 in Figure 1. Besides varying β, τ_i itself can be moved forward to accelerate the achievement of the targets. In Figure 1, we also plot policy 2 for $\beta = 0.5$ with $\tau_{\text{group 1}} = 1982$ and $\tau_{\text{gp2}} = 1987$. The vertical difference between policy 1 and each of the other policy cases (i.e. policy 2 or 3) represents the revenue lost (or subsidy required) for fulfilling the distributive targets. From the figure, it can be seen that the subsidy required for policy 3 (or policy 2) is a very small percentage of the total revenue (e.g. about 1.0% for $\delta \geqslant -0.025$), justifying the imposition of the distributive targets.

To test the effects of increases in development costs upon the total revenue, we simulated the first three policies of Figure 1 with the additional assumption of a 25% increase in development cost in every 3 years with the revenue remaining stationary. The results are presented as policies 4–6 in Figure 1. Several points emerged from a comparison of policies 1–3 and policies 4–6. Firstly, from the results it is evident that even under severe development cost increases, the overall revenue generated by the optimal development of industrial land still remains positive. Secondly, for the range

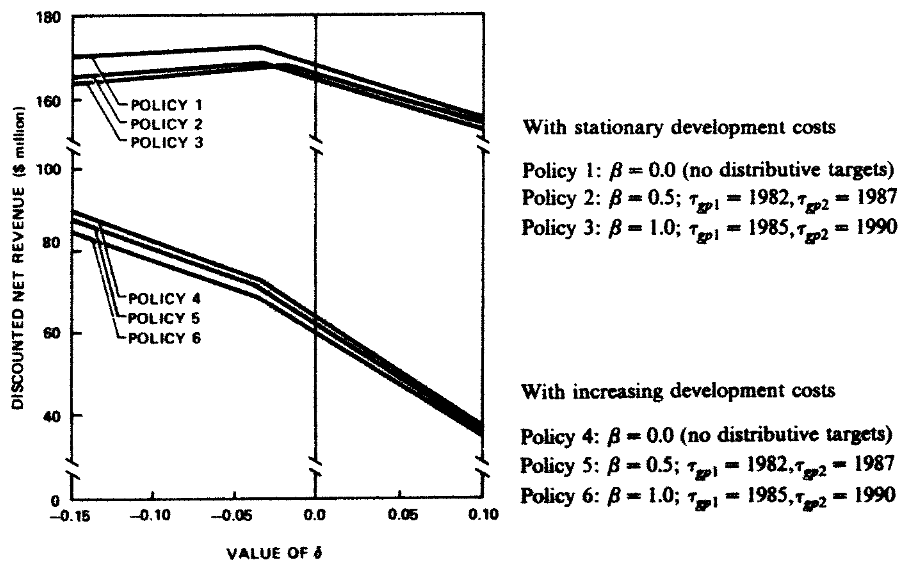

FIGURE 1. Revenue as a Function of δ.

of δ considered the total revenue, for each of policy cases 4–6, increases as δ is decreased. This implies that, under the condition of development cost increases, the total revenue the agency can expect to generate will actually increase if the projected demands are scaled down in years 6–15. Thirdly, with development cost increases, the optimal objective function value is much more sensitive to variation in demand. Fourthly, the subsidy required for fulfilling the distributive goals (i.e. the vertical difference between policy 4 and policy 5 or policy 6) remains minimal as a proportion of the total revenue generated. This point further enhances the justification for imposition of the distributive goals. Finally, an examination of the optimal solutions (for brevity these are not presented here) indicated that the decisions taken in the initial years remain the same as those taken with stationary costs—demonstrating the relative 'goodness' of the initial decisions under uncertain conditions.[2]

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References

1. BRADLEY, G. H., BROWN, G. G. AND GRAVES, G. W., "Design and Implementation of Large Scale Primal Transhipment Algorithms," *Management Sci.* Vol. 24, No. 1 (1977), pp. 1–34.
2. BREDO, W., *Industrial Estates: Tool for Industrialization*, Stanford Research Institute, Free Press, Glencoe, Ill., 1963.
3. CHENERY, H. *et al.*, *Redistribution with Growth*, Oxford Univ. Press, London, 1977.
4. DANTZIG, G. B., *Linear Programming and Extensions*, Princeton Univ. Press, Princeton, N. J., 1963.
5. ELLIS, H. S. (ed.), *Economic Development for Latin America*, MacMillan, London, 1961.
6. GLOVER, F., KLINGMAN, D. AND ROSS, G. T., "Finding Equivalent Transportation Formulations for Constrained Transportation Problems," *Naval Res. Logist. Quart.* Vol. 21, No. 2 (1974), pp. 247–254.
7. INTERNATIONAL BUSINESS MACHINE, *Program Library-Mathematics (PL-MATH) Program Description, Program No. 5734-XM3*, IBM Corp., White Plains, New York, 1971.
8. MALAYSIA, *Third Malaysia Plan 1976–1980*, Government Printers, Kuala Lumpur, 1976.
9. UNITED NATIONS, "Consultative Group Meetings on Industrial Estates and Industrial Areas," *Industrialization and Productivity*, No. 12 (1969), pp. 81–88.
10. WAGNER, H. M., "On a Class of Capacitated Transportation Problems," *Management Sci.*, Vol. 5, No. 3 (1959), pp. 304–318.
11. WORLD BANK, *Employment and Development of Small Enterprises: Sector Policy Paper*, World Bank, Washington, D.C. 1978.