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A MULTIOBJECTIVE MODEL FOR PLANNING THE EXPORTS OF DEVELOPING COUNTRIES

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ABSTRACT

This study presents a linear goal-programming model for planning exports in less developed countries. The model examines some economic factors such as: industrial structure, labor force, value added in exports, capital efficiency, imported inputs for exports, and investment planning, among others, that could affect exports. The application of the model is demonstrated using data from the Indian economy. The model presented in this study, is hoped, will have general appeal to planners in developing countries facing similar constraints.

INTRODUCTION

Developing countries facing the challenges of industrial development have over the past decades embarked on deliberate efforts to promote the development of their economy through import substituting industrialization. This measure which is constrained by its limited domestic market capacity have been found inadequate in generating sufficient employment for the vast domestic labor force. Consequent on this, many less developed nations have been pushed to contemplate complementary industrial development strategies of which the most appealing is export promotion strategy (Alade, 1983). Such development of

export-oriented sector in the less developed countries (LDCs), as noted by Spetter (1970) can help contribute to changing the branch structure of industry and the whole economic structure of LDCs. Thus, an export-oriented industrialization strategy is needed because of its dynamic effect which allows it to make use of both the advantages of foreign resources and markets as well as the untapped domestic labor force.

In most of the developing countries, the government exercises control on the local economy through centralized planning at the expense of market forces. Planning takes the form of multiobjective multisectoral modeling of optimization varieties to achieve a specific set of target goals predetermined by the central planners. Different forms of subsidies are used in order to stimulate private economic activities, which may help to achieve the government's target goals. These, in general, cause some shift of resources into sectors favorable to the economic plan, which in most cases is premised on both spatial and temporal allocation of resources.

Levary and Choi (1983) described an export-planning model based on a set of interrelated goals using the Republic of South Korea. This paper presents an export-planning model, using a similar scenario with that of Levary and Choi (1983) to examine export planning in India. A multiobjective programming model, which requires predetermined goals, is adopted for the analysis of the export-planning model. The use of predetermined goals in planning is a policy-oriented approach which requires coordinating decisions and reformulating policies to attain certain economic objectives in harmony with broader social goals. The economic planners determine the target goals based on forecasts of the future changes that might influence trade and growth of a country (Myint, 1968). The export planning model considered in this study includes some economic factors which may affect exports, capital efficiencies, import of raw material used for manufacturing goods for exports, investment plan, etc.

Export plan can also be based on projections of the future growth rate of exports and pattern of output. Projections are based on specific assumptions concerning the variables, which are likely to influence the output. A discussion and evaluation of forecast, target and projection used in development planning is given by Maizels (1968). Chenery and Taylor (1968) developed a methodology of projecting the typical commodity exports pattern on the basis of a worldwide cross-country analysis as a first step to deducing an efficient path of changing the export pattern. Export performance is directly related to the rate of economic growth (Krueger, 1980) and a few non-price factors combined under the title of product quality (Bela, 1979). These factors play a vital role in changing of world exports.

MULTIOBJECTIVE PLANNING METHODOLOGIES

The methodological framework of multiobjective planning model uses the goal programming technique, which is, developed to handle multicriteria situations within the general framework of linear programming. The model provides opportunities for situations in which the decision-maker needs to consider multiple criteria in arriving at the overall best decision. This planning technique has a special appeal, particularly, in the less developed countries (LDCs) where decision making in their economy is characterized by multiple and often-conflicting development objectives. As noted by Alade (1988), the need to make practical choice between balanced and unbalanced development in a federated state in the LDCs demonstrate how conflicting their planning objectives are since “federalism”, in itself, necessitates spatial development while economic development requires optimal allocation of resources. In addition to the goal programming model, which has widely been used in multicriteria objectives, the analytic hierarchy process (AHP) which permits the inclusion of subjective

factors in arriving at a recommended decision, has a practical appeal in developing countries planning models.

The use of linear goal programming (LGP) models and other multiobjective planning techniques in developing countries have been well-documented (Alade, 1988; Bazaraa and Bouzale, 1981; Ehie and Benjamin, 1993; Soyibo and Lee, 1986; Leinbach and Cromley, 1983; Levary and Choi, 1983). The preemptive goal programming introduced by Ijiri (1965), following a pioneering study by Charnes and Cooper (1961), assigns ordinal rankings to the objective and then solves the resulting model iteratively by moving from the highest to the lowest priority structures (Ehie and Benjamin, 1993). The technology has witnessed further refinement and review over the years (Lee, 1972; Ignizio, 1976; Zanakis and Gupta, 1985).

THE MODEL

The model approaches the problem of determining the optimum mix of exports under a set of goals and constraints imposed on the exporting system. This is achieved by minimizing a weighted sum of deviations from the target goals. In order to develop a multiobjective goal function, each goal has to be assigned its due weight from decision-maker's point of view (Yotopoulos and Nugini, 1976).

The goals

The following targeted goals, in order of their importance, were established as follows:

(i) That the total value of exports should be greater than the lower target (T_l) but not exceeding the upper target (T_u).

(ii) The weighted value added in exports should attain at least a given target fraction (V), out of total exports value.

(iii) The weighted capital-output ratio (C) should at least reach the given lower target.

(iv) The weighted labor-output ratio (L) should at least reach the given lower target.

(v) The weighted export price index (P) should at least reach the given lower target.

(vi) Subsidies (S) for exports should be minimized.

(vii) The weighted import content ratio (I) of value of imported raw materials used to produce exporting goods to the total value of exports should not exceed the upper target.

These target goals will vary from country to country, depending on the adjustment of the model to fit different economic environments.

Variables/Symbols

The variables and symbols for the model are defined as follows:

X_i = value of exporting goods belonging to commodity i.

V(i) = value added in exports of goods.

C(i) = capital output ratio.

L(i) = labor output ratio.

I(i) = ratio of value of imported raw materials to total value of exports.

S(i) = subsidy per unit value of exporting goods.

P(i) = expected average export price index.

d_i^- = underachievement of goals or constraints in the ith equation.

d_i^+ = overachievement of goals or constraints in the ith equation.

Goal Constraints

The LGP model constraints with deviational variables are formulated as follows:

(i) Target goal on total exports is determined by trends established during previous years, as well as anticipated world demand, expected growth of domestic economy, expected share of world exports and expected available export surplus. The target goal constraint for the lower bound is defined below:

$$\sum_{i=1}^{n} X_i + d_1^- - d_1^+ = T_1 \qquad (1)$$

Since total value of exports not to exceed the upper target, positive deviation can be excluded from this constraint. The target goal for the upper bound is given as:

$$\sum_{i=1}^{n} X_i + d_2^- = T_u \qquad (2)$$

(ii) The weighted value added in exports should reach at least the target fraction out of total exports value. The related goal constraint is written as follows:

$$\sum_{i=1}^{n} V(i)\, X_i + d_3^- - d_3^+ = V \sum_{i=1}^{n} X_i \qquad (3)$$

(iii) The weight capital-output ratio should at least reach the given lower target. The constraint can be expressed as follows:

$$\sum_{i=1}^{n} C(i)\, X_i + d_4^- - d_4^+ = C \sum_{I=1}^{n} X_i \qquad (4)$$

(iv) The weighted labor output ratio should at least reach the given lower target because the country enjoys comparative advantage in labor intensive product and generation of employment is a policy priority. This goal constraint can be represented as follows:

$$\sum_{i=1}^{n} L(i)\, X_i + d_5^- - d_5^+ = L \sum_{i=1}^{n} X_i \qquad (5)$$

(v) The weighted export price index should at least reach the given lower target. This constraint can be expressed as follows:

$$\sum_{i=1}^{n} P(i)\, X_i + d_6^- - d_6^+ = P \sum_{i=1}^{n} X_i \qquad (6)$$

(vi) Since subsidies for exports should be minimized, a goal of zero subsidies is set and attempt is made to minimize the positive deviation from this goal. The constraint can be written as follows:

$$\sum_{i=1}^{n} S(i)\, X_i - d_7^+ = 0 \qquad (7)$$

(vii) The weighted ratio of value of imported raw materials used to produce exporting goods to the value of exports should not exceed the upper target. Mathematically, this can be written as:

$$\sum_{i=1}^{n} I(i)\, X_i + d_8^- - d_8^+ = I \sum_{i=1}^{n} X_i \qquad (8)$$

Exportable surplus production capacity (given in Rupees millions) of the industrial sector i (i = 1,2,...,n) places an upper bound (U_i) on the value of exporting goods from the industrial sector. Similarly, minimum committed world demand (given in Rupees millions) for goods from industrial sector i places a lower bound (M_i) on the volume of exporting goods from industrial sector i. The related system constraints are given as:

$$X_i \leq U_i \text{ for } i = 1,2,...,n \qquad (9)$$

$$X_i \geq M_i \text{ for } i = 1,2,...,n \qquad (10)$$

The last constraint is non-negativity of model variables:

$$X_i \geq 0 \text{ for } i = 1,2,..., n$$

$$\text{and } d_i^-, d_i^+ \geq \text{ for } i = 1,2,...,8 \qquad (11)$$

The objective function is a weighted sum of deviations from the target goals. Thus deviations are:

$$d_1^-, d_2^-, d_3^-, d_4^-, d_5^-, d_6^-, d_7^+, d_8^+$$

Assuming that each of the goal has its own priority level. This property can be stated as:

$P_k >> P_{k+1}$, where P_k is the higher priority level. The LGP model objective function is written as follows:

$$\text{Minimize } Z = P_1(d_1^- + d_2^-) + P_2 d_3^- + P_3 d_4^- + P_4 d_5^- + P_5 d_6^- + P_6 d_7^+ + P_7 d_8^+$$

CASE EXAMPLE

In terms of population and arable land, India ranks as the second largest country in the world. It has 16% of the world's population and 12% of the world's arable land. It is also the sixth largest economy with respect to gross domestic product (GDP).

Like many other developing countries, India has been involved in a series of development plans and strategies to promote industrial development in the economy. The common strategy in the 1960s was the import substituting industrialization (ISI) strategy that entails the protection of the domestic economy constraint behind high tariff and other quantitative measures like import quotas. However, because of the limited domestic market capacity in these countries, complied with severe foreign exchange and resource constraints, many of the

LDCs including India, adopted export promotion strategy. In addition, many of the countries have been involved in structural reforms.

The reforms undertaken in India since July 1991 have led to a strong revival of the growth of the economy, rapid increase in employment, reduction in poverty, and a boom in exports as well as a decline in inflation and growth of real GDP at factor cost, which had fallen to 0.8% in the crises year 1991-92, and recovered within a year to reach 5.1% in 1992-93. This represents one of the fastest economic recoveries from macroeconomic crises by international standards. As a result of this exceptional recovery, the average growth of 5.7% over the first four years of the eighth plan in India was higher than the plan target of 5.6% (see Reference 23).

The structural reform of the India economy, particularly of the external sector and the consequent achievements on the balance of payments, played a key role in the turnaround in the growth of GDP, employment and social indicators. India witnessed a strong three-year boom with annual export growth averaging 19% in 1993-94 and 1994-95 and then accelerating to 24% in the first nine months of 1995-96. Growth of foreign direct investment average 100% per annum over 1992-93 to 1994-95, and maintaining the same level over their first eight months of 1995-96. The country has been able to shift its debt burden around. The growth of external debt between March 31, 1991 and September 30, 1995 averaged US $2.2 billion per year compared to the much higher average annual increase of US $4.9 billion a year, between end March 1986 to end March 1991. Notwithstanding the phenomena growth witnessed in India economy in recent years, it will require strong commitment and continuing effort to widen the ambit of economic reform, and difficult decisions will have to be taken by both Government and the private sector to deal with the emerging challenges within India and worldwide.

To demonstrate the use of proposed LGP model, India has been chosen. It should be noted that the purpose of this modeling is to illustrate how exports can

Table 1

Summary of relevant data to the exports commodities (R Millions)

Commodity	V(i) %	C(i) %	L(i) %	P(i)	S(i) %	I(i) %	U(i)	M(i)
Cashew Kernels	24	0.32	5.62	191	0	24	4,900	2,500
Coffee & Substitute	33	0.50	2.33	128	0	2	3,900	2,250
Cereals & Rice	10	0.20	0.64	202	0	1	10,000	5,500
Spices	16	0.27	1.80	172	0	1	5,000	3,000
Tea & Mate	32	0.26	0.59	158	0	2	9,000	6,000
Processed Foods	29	0.49	1.00	197	8	15	14,000	2,750
Marine Products	17	0.16	0.41	165	17	7	27,000	5,000
Leather & Manufactures	27	0.36	0.80	210	18	18	44,000	12,000
Iron Ore	19	0.52	1.55	183	0	0	7,800	4,500
Engineering Goods	40	0.62	0.78	174	14	19	75,000	17,000
Fabrics & Textiles	25	0.50	1.35	163	14	14	64,000	10,000
Ready-made Garments	21	0.27	0.97	155	10	5	65,000	17,000
Jute Manufactures	35	0.36	2.06	149	6	4	4,500	2,200
Chemicals	24	0.61	0.36	157	11	23	54,000	12,500
Gems & Jewelry	26	0.41	0.47	184	0	70	90,000	26,000

Source: Various issues of Indian government publications (see Reference 23).

Notes: The variables and symbols used in the above table are defined as follows:

X_i = value of exporting goods belonging to commodity I V(i) = value added in exports of goods C(i) = capital output ratio L(i) = labor output ratio I(i) = ratio of value of imported raw materials to total value of exports S(i) = subsidy per unit value of exporting goods P(i) = expected average export price index.

be planned in a developing economy and not to actually plan India's exports. The data used in testing this model has been collected from various issues of Indian government publications (see Reference 23). The model requires information for commodity exports. For the model, it is assumed that the data for the industry (domestic and exports combined) are representative of the export-industrial sectors. This is a very important assumption to be weighted when planning is conceived on the basis of the results of the model.

Table 1 shows the summary of the input data required for the model. There is negligible data available on the export targets as per goal constraints of the model (i.e. V, C, L, P, and I). Nevertheless, attempt is made to determine the target goals keeping in view the economic framework in which exports take place. In Table 2, a summary of the data related to target goals is given.

Table 2

Summary of Data Related to Target Goals

Target Goals	Value
T_1	Rs. 240,000 million
T_u	Rs. 280,000 million
V	25%
C	0.52
L	0.75
P	171
I	15%

RESULTS

The resulting LGP model consists of the 15 real variables, 58 deviational variables, 38 constraints, 7 priorities, and an objective function presented in the Appendix. The solution of the problem was obtained by using the QSB+ software package (Chang, 1991) on a P5-120 Gateway 2000 PC. The solution was generated in less than 8 seconds and took 90 iterations of the modified simplex method on which the software is based. The summary of results is given in Table 3 and Table 4.

Table 3: Summary of Decision Variable Analysis

Variable	Amount
X_1	4,900
X_2	3,900
X_4	5,000
X_6	14,000
X_8	44,000
X_9	7,800
X_{10}	75,000
X_{11}	64,000
X_{12}	1,950
X_{13}	4,500
X_{14}	54,000
X_{15}	950

Table 4

Summary of Analysis of the Objective

Priority	Underachievement
P_1	0
P_2	0
P_3	0
P_4	0
P_5	0
P_6	34,710
P_7	5,896.50

The solution of the problem indicates that the first five goals had zero values and priority level 1-5 are completely achieved. The sixth goal related to export subsidy is underachieved by a value of 34,710 and the seventh goal which is related to the ratio of the value of imported raw materials to the value of exports is also underachieved by a value of 5,896.50 (see Table 4).

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Appendix

Both constraints and the objective function for the problem under consideration are listed below.

Constraints

1. $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + d_1^- - d_1^+ = 24{,}000$
2. $X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + d_2^- = 28{,}000$
3. $- 0.01 X_1 + 0.08 X_2 - 0.15 X_3 - 0.09 X_4 + 0.07 X_5 + 0.04 X_6 - 0.08 X_7 + 0.02 X_8 - 0.06 X_9 + 0.15 X_{10} - 0.04 X_{12} + 0.10 X_{13} - 0.01 X_{14} + 0.01 X_{15} + d_3^- - d_3^+ = 0$
4. $- 0.20 X_1 - 0.02 X_2 - 0.32 X_3 - 0.25 X_4 - 0.26 X_5 - 0.03 X_6 - 0.36 X_7 - 0.16 X_8 + 0.10 X_{10} - 0.02 X_{11} - 0.25 X_{12} - 0.16 X_{13} + 0.09 X_{14} - 0.11 X_{15} + d_4^- - d_4^+ = 0$
5. $4.87 X_1 + 1.58 X_2 - 0.11 X_3 + 1.05 X_4 - 0.16 X_5 + 0.25 X_6 - 0.34 X_7 + 0.05 X_8 + 0.80 X_9 + 0.03 X_{10} + 0.60 X_{11} + 0.23 X_{12} + 1.31 X_{13} - 0.39 X_{14} - 0.28 X_{15} + d_5^- - d_5^+ = 0$
6. $- 20 X_1 - 43 X_2 + 31 X_3 + X_4 - 13 X_5 + 26 X_6 - 6 X_7 + 39 X_8 + 12 X_9 + 3 X_{10} - 8 X_{11} - 16 X_{12} - 22 X_{13} - 14 X_{14} + 13 X_{15} + d_6^- - d_6^+ = 0$
7. $0.08 X_6 + 0.17 X_7 + 0.18 X_8 + 0.14 X_{10} + 0.14 X_{11} + 0.06 X_{13} + 0.11 X_{14} - d_7^+ = 0$

8. $0.09\ X_1 - 0.13\ X_2 - 0.14\ X_3 - 0.14\ X_4 - 0.13\ X_5 - 0.08\ X_7 + 0.03X_8 - 0.15\ X_9 + 0.04\ X_{10} - 0.01\ X_{11} - 0.10\ X_{12} - 0.11\ X_{13} + 0.08\ X_{14} + 0.55\ X_{15} + d_8^- - d_8^+ = 0$

9. $X_1 + d_9^- - d_9^+ = 2{,}500$

10. $X_1 + d_{10}^- = 4{,}900$

11. $X_2 + d_{11}^- - d_{11}^+ = 2{,}250$

12. $X_2 + d_{12}^- = 3{,}900$

13. $X_3 + d_{13}^- - d_{13}^+ = 5{,}500$

14. $X_3 + d_{14}^- = 10{,}000$

15. $X_4 + d_{15}^- - d_{15}^+ = 3{,}000$

16. $X_4 + d_{16}^- = 5{,}000$

17. $X_5 + d_{17}^- - d_{17}^+ = 6{,}000$

18. $X_5 + d_{18}^- = 9{,}000$

19. $X_6 + d_{19}^- - d_{19}^+ = 2{,}750$

20. $X_6 + d_{20}^- = 14{,}000$

21. $X_7 + d_{21}^- - d_{21}^+ = 5{,}000$

22. $X_7 + d_{22}^- = 27{,}000$

23. $X_8 + d_{23}^- - d_{23}^+ = 12{,}000$

24. $X_8 + d_{24}^- = 44{,}000$

25. $X_9 + d_{25}^- - d_{25}^+ = 4{,}500$

26. $X_9 + d_{26}^- = 7{,}800$

27. $X_{10} + d_{27}^- - d_{27}^+ = 17{,}000$

28. $X_{10} + d_{28}^{-} = 75{,}000$

29. $X_{11} + d_{29}^{-} - d_{29}^{+} = 10{,}000$

30. $X_{11} + d_{30}^{-} = 64{,}000$

31. $X_{12} + d_{31}^{-} - d_{31}^{+} = 17{,}000$

32. $X_{12} + d_{32}^{-} = 65{,}000$

33. $X_{13} + d_{33}^{-} - d_{33}^{+} = 2{,}200$

34. $X_{13} + d_{34}^{-} = 4{,}500$

35. $X_{14} + d_{35}^{-} - d_{35}^{+} = 12{,}500$

36. $X_{14} + d_{36}^{-} = 54{,}000$

37. $X_{15} + d_{37}^{-} - d_{37}^{+} = 26{,}000$

38. $X_{15} + d_{38}^{-} = 90{,}000$

Objective Function

Minimize $Z = P_1(d_1^{-} + d_2^{-}) + P_2d_3^{-} + P_3d_4^{-} + P_4d_5^{-} + P_5d_6^{-} + P_6d_7^{+}$

$+ P_7d_8^{+}$