



INDIAN INSTITUTE OF MANAGEMENT CALCUTTA

WORKING PAPER SERIES

WPS No. 702/ July 2012

A multi-criteria approach for railway project portfolio fund allocation

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Abstract: In an emerging economy, transport planners have a difficult task of allocating scarce and costly capital amongst the available shelf of railway projects to effectively meet

Bihar	44	38	33
Assam	90	31	40

Source: calculated from data obtained from various sources [2], [3] and [4]

In this paper we use the TOPSIS-Global criteria approach methodology, along with

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a MODM technique used to rank a finite set of pre-determined alternatives [9]. In this process, the decision makers are asked to specify the

(a)

••• BL₆?E₇?

Subject to the constraints:

$$\frac{\partial L}{\partial \lambda} = \lambda (L - \lambda) = 0 \quad (1)$$

$$\frac{\partial L}{\partial \mu} = \mu (L - \mu) = 0 \quad (2)$$

$$\frac{\partial L}{\partial \nu} = \nu (L - \nu) = 0 \quad (3)$$

$$\frac{\partial L}{\partial \alpha} = \alpha (L - \alpha) = 0 \quad (4)$$

$$\frac{\partial L}{\partial \beta} = \beta (L - \beta) = 0 \quad (5)$$

We thus solve the multi-objective problem, by formulating a single objective function maximize , with two constraints (in addition to the constraints (1) to (11) listed above):

$$(12)$$

$$(13)$$

The optimal fund to be allocated annually and time required for completion and construction (in years) of each project is obtained, as listed in Table 8.

TABLE 8 Optimal fund allocation and completion time

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
optimal annual fund allocation (Rs.crores)	88	195	200	107	185	123
time required for completion (years)	3.4	6.4	4.5	5.6	10.3	6.5

The time required for completion (in years) obtained using the above methodology, for different objective weight combinations and different total funds available for allocation each year amongst all the projects is given in Table 9. The net cash flow indicates the total earnings over the 30-year planning horizon minus costs of the projects; thus net cash flow will be low whenever commissioning of high revenue earning projects (such as Project 3) are delayed.

TABLE 9 Completion time and Net cash flows for different scenarios

Weights		Proj 1	Proj 2	Proj 3	Proj 4	Proj 5	Proj 6	Net cash Flow
total funds available for allocation each year=Rs.600 crores	w1=0.25;w2=0.25;w3=0.25;w4=0.25;	5.9	9.9	7.6	9.3	13.1	8.4	5560
	w1=0.3;w2=0.2;w3=0.4;w4=0.1;	6.0	12.0	8.6	9.6	11.3	7.3	5279
	w1=0.1;w2=0.1;w3=0.4;w4=0.5;	9.3	8.7	7.2	14.6	12.2	7.9	4805
	w1=0.8;w2=0.1;w3=0.05;w4=0.05;	4.4	10.3	6.5	7.5	16.6	10.1	5859
	w1=0.05;w2=0.8;w3=0.05;w4=0.1;	5.4	10.2	8.5	7.7	13.2	8.6	5587
	w1=0.05;w2=0.05;w3=0.8;w4=0.1;	11.3	18.7	17.4	23.1	7.3	4.7	1047
	w1=0.05;w2=0.05;w3=0.1;w4=0.8;	12.2	5.4	4.6	19.3	25.0	20.1	3393
total funds available for allocation each year=Rs.900 crores	w1=0.25;w2=0.25;w3=0.25;w4=0.25;	4.1	6.6	5.0	6.5	8.6	5.5	7362
	w1=0.3;w2=0.2;w3=0.4;w4=0.1;	4.1	8.0	5.8	6.6	7.5	4.8	7170
	w1=0.1;w2=0.1;w3=0.4;w4=0.5;	6.5	5.8	4.7	10.2	8.1	5.2	6810
	w1=0.8;w2=0.1;w3=0.05;w4=0.05;	3.0	6.9	4.4	5.0	10.9	6.7	7586
	w1=0.05;w2=0.8;w3=0.05;w4=0.1;	3.6	6.8	5.6	5.2	8.8	5.7	7410
	w1=0.05;w2=0.05;w3=0.8;w4=0.1;	8.9	11.7	9.3	13.9	5.1	3.3	4844
	w1=0.05;w2=0.05;w3=0.1;w4=0.8;	8.1	3.9	3.3	12.7	14.4	9.2	6257
total funds available for allocation each year=Rs.1200 crores	w1=0.25;w2=0.25;w3=0.25;w4=0.25;	3.2	4.9	3.8	5.0	6.4	4.1	8267
	w1=0.3;w2=0.2;w3=0.4;w4=0.1;	3.2	6.0	4.3	5.0	5.5	3.5	8116
	w1=0.1;w2=0.1;w3=0.4;w4=0.5;	5.1	4.3	3.5	8.0	6.1	3.9	7814
	w1=0.8;w2=0.1;w3=0.05;w4=0.05;	3.0	5.0	3.2	3.7	7.9	4.9	8407
	w1=0.05;w2=0.8;w3=0.05;w4=0.1;	3.0	4.9	4.1	3.9	6.6	4.3	8302
	w1=0.05;w2=0.05;w3=0.8;w4=0.1;	6.3	7.8	6.2	9.9	3.7	3.0	6726
	w1=0.05;w2=0.05;w3=0.1;w4=0.8;	5.4	3.0	3.0	8.5	8.8	5.7	7713
total funds available for allocation each year=Rs.1500 crores	w1=0.25;w2=0.25;w3=0.25;w4=0.25;	3.0	3.8	3.0	4.0	5.0	3.2	8769
	w1=0.3;w2=0.2;w3=0.4;w4=0.1;	3.0	4.7	3.4	3.9	4.2	3.0	8667
	w1=0.1;w2=0.1;w3=0.4;w4=0.5;	4.1	3.4	3.0	6.5	4.7	3.1	8427
	w1=0.8;w2=0.1;w3=0.05;w4=0.05;	3.0	3.7	3.0	3.0	5.8	3.5	8836
	w1=0.05;w2=0.8;w3=0.05;w4=0.1;	3.0	3.9	3.3	3.1	5.2	3.4	8795
	w1=0.05;w2=0.05;w3=0.8;w4=0.1;	4.4	5.3	4.3	6.9	3.0	3.0	7975
	w1=0.05;w2=0.05;w3=0.1;w4=0.8;	3.5	3.0	3.0	5.4	5.4	3.5	8612

It will be observed from the above table, that (a) for all instances with $w_1=0.8$ (maximization of revenue over 30-year planning horizon) the cash flow is maximum; (b) for all instances with $w_2=0.8$ (minimum completion time of all projects), the sum of completion time of all projects is minimum; (c) for all instances with $w_3=0.8$ (minimum completion time of north east projects), the sum of completion time of Projects 5 and 6 is minimum; (d) for all instances with $w_4=0.8$ (minimum completion time of port connectivity projects), the sum of completion time of Projects 2 and 3 is minimum. Further it may be noted that with the