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Regional Distribution of Road Funds: An Empirical Procedure for Western Australia

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Abstract:

Empirical evidence suggests that infrastructure investments - in particular road infrastructure investment, can effectively, and permanently, induce forces of development in regions. Therefore a key task underlying the development of regional policies is to invest in infrastructure in all regions so that no regions are improved at the expense of the others. In strategic planning terms this means balancing efficiency and equity objectives in the regional distribution of funds. This paper proposes a methodology that combines the advantages of top-down optimisation analysis and bottom-up needs analysis to balance efficiency and equity objectives at regional level. The proposed procedure provides the optimum social, economic, safety and environmental gains to each region while maintaining equity in the distribution of road investments. Using data collected for Western Australia, the application of the procedure has been illustrated and compared with methods that are currently available to road authorities for regional allocation of funds. Refinements and extensions to the procedure are suggested

Disclaimer: The views expressed in this paper are those of the authors, and do not necessarily represent those of Main Roads Western Australia

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Introduction

Empirical findings have shown the existence of a significant relationship between infrastructure investment and regional development (Nijkamp and Blaas, 1994:p117, Weisbrod and Beckwith, 1992) Studies examining this relationship -specifically in the context of road infrastructure have drawn similar conclusions (cf Botham, 1980) These findings have important policy implications for regional infrastructure investment For example, in developing regional investment policies, state road authorities can opt for either an *efficiency oriented development policy* or an *equity oriented development policy* The former helps to maximise overall state economic growth by maximising investment in regions where the investment is most efficient The latter on the other hand can help to spread out development Adoption of the latter results in the loss of efficiency thereby reducing the aggregate economic development potential of the state Studies by McKenzie (1991), Kinhill (1990) and Clark (1985) show evidence supporting the need for a balance in economic efficiency and regional equity Consequently, State road authorities charged with promoting both efficiency and equity face a public policy dilemma when attempting to accommodate these contrasting policy objectives

The primary aim of this paper is to propose a procedure for regional distribution of road funds to simultaneously meet efficiency and equity objectives The next section provides a review of some of the traditionally used procedures in Australasia for regional distribution of road funds The proposed procedure is in the third section In that, the application of this procedure for regional allocation of funds is described and is illustrated using Western Australian data Advantages of the proposed procedure, refinements and extensions to it are suggested in the last section

Regional Distribution of Funds: A Survey of Procedures

Many procedures are available for regional distribution of road funds Often the procedure chosen depends largely on the outcomes expected from regional road networks by road providers, regional communities and other stakeholders The four procedures listed and reviewed below are traditionally used for distributing road funds

1 Historical expenditure trends
2 Benefit-cost ratio of projects
3 Expert opinion/political & community views
4 Gross Regional Product/economic activity

Historical expenditure trends

Regional road investments are determined by assuming that the past trends in regional road investment will continue in the future A main weakness of this procedure is that it does not explicitly account for:

- changes in policies affecting future road infrastructure demands of regions;
- significant changes in a region's population or economic activity; and
- perceptions of regional communities about road infrastructure investment impacts

Benefit-cost ratio of projects

Benefit-cost ratio (BCR) or the traffic related benefits per dollar of the project cost can be regarded as a measure of the microeconomic efficiency of road projects In this procedure, regional distribution of project funds are determined by arranging BCRs of projects for all regions in the descending order and selecting all projects above a given budget constraint (cf BTCE, 1995) The selected projects are then sorted out by region and the costs are aggregated for each region to find the regional share of funds Some of the main criticisms of this procedure are:

- economic efficiency is only one objective of road investment; and
- microeconomic benefits considered in this procedure are directly related to traffic volume and hence regions with low traffic volumes tend to be disadvantaged

Expert opinion/political & community views

Eliciting opinions and views of community leaders -including politicians is often practiced in apportioning infrastructure investment funds between regions The procedure is often criticised because:

- it is highly subjective;
- disputes arise when attempting to balance funds between different regions; and
- economic inefficiencies in investment can arise

Gross Regional Product/economic activity

This procedure assumes that road infrastructure significantly contributes to regional economic activity Accordingly, road funds are allocated proportional to an indicator of region's macroeconomic activity (eg gross regional product) The results of this procedure are misleading when a region's economic activity bears no significant relationship with its road infrastructure needs Fly-in fly-out diamond producing regions that contribute significantly to GRP rely more on air transport than roads Therefore, gross regional products of such regions are a poor indicator of road needs

Needs based regional distribution

"Equity" as referred to in this paper is an issue of distributive justice It concerns what is fair and recognises claims in the context of enhancing the general welfare (Rawls, 1971) by creating opportunities to meet needs as desired by groups of individuals or regional communities Findings of McKenzie (1991), Kinhill (1990), Clark (1985) and others clearly suggest that there is a need for enhancing equity through direct means such as road investment

The term "efficiency" as referred to in this paper is not the conventional economic efficiency -that is the dollars gained per dollar invested Rather, means cost effectiveness of delivering economic, safety, social and environmental gains from road investment

The importance of addressing efficiency and equity issues when making road investments is widely recognised (cf McKenzie, 1991; Kinhill, 1990). An "increasingly important technique of resource allocation for both efficiency and equity objectives is that of needs based planning" (Maher and Burke, 1991:p248). The purpose of this section is to discuss *two markedly different needs based planning methods* for regional distribution of road funds

The first method for needs based planning is discussed in the first sub-section below While this procedure helps to improve efficiency and equity of regional road investment more than any of the procedures reviewed in the previous section, its primary function however is the "global optimisation of gains" (GOG) It does not attempt to optimise gains at regional level

The "top-down, bottom-up" model which is proposed in this paper is the second needs based planning approach Unlike the first method, its aim is "joint optimisation of regional gains" (JORG) and is discussed in the second sub-section

Global Optimisation of Gains (GOG)

The procedure for GOG involves the following two steps:

- project assessment; and
- selection of projects within a budget

Project assessment: Involves assessment of all projects individually for their ability to cost effectively meet the needs of, or improve the gains to, regional communities Multicriteria analysis (MCA) has been used for this purpose Planning literature suggests that multi-objective decision models such as MCA are increasingly being used in assessing projects for needs based planning (cf Maher and Burke, 1991; Anderson and Settle, 1977) -because such models are capable of helping to make decisions involving trade-offs between competing objectives

MCA technique involves these sequential steps:

- Identifying criteria (*usually with community input*) to assess economic, social and environmental impacts of projects on regional communities
- Eliciting preferences of regional communities (*using community attitude surveys*) for the criteria and expressing these preferences as "criteria weights"
- Assessing each project (*usually with community input*) against each of the criteria to assign a value to reflect a project's relative contribution against the criteria This value is called "criteria score"
- Estimating the value of an index to represent overall gains from the project 'i' (G_i) This index is estimated by taking the sum of the products of criteria weights and their corresponding criteria scores (*ie, sum of the weighted criteria scores*)

Details of this technique are in De Silva, Peters and Bailey (1993) and De Silva and Tatam (1996)

Selection of projects within a budget Under the GOG method, an investment program can be developed by combining mutually exclusive projects that yield the highest value for money (VFM) within a budget The process of selecting a combination of projects or a program involves:

- pooling projects that are proposed for all regions;
- ranking projects in the descending order of VFM –that is, descending order of G_i/I_i, where I_i is cost of project 'i'
- selecting all projects that exhaust a given budget of $F million –that is $F \approx \sum I_i$; and
- sorting the selected projects by region and aggregating the costs for each region to find the regional share of funds

In this study, a total of 139 projects for four regions R1, R2, R3 and R4 have been used for generating investment programs for 7 budgets –ranging from $200M to $500M

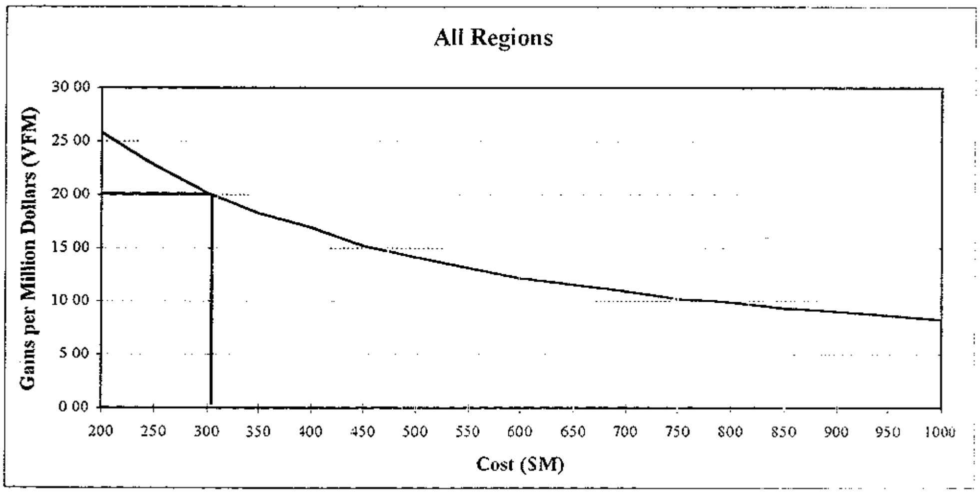

Figure 1 Relationship between VFM and the level of funding

Figure 2 shows the VFM function for a range of budgets The smoothness of this VFM function suggests that for each budget, the combined program for the regions has provided the maximum possible gains per million dollars (VFM)

Table 1 Actual distribution of funds ($M) and the gains under GOG method

Total Funds	Distribution of Funds				Corresponding VFM for Each Region				VFM for All Regions
	Region R1	Region R2	Region R3	Region R4	Region R1	Region R2	Region R3	Region R4	
200 00	56 30	70.50	33 80	36 00	29 51	24 71	31 22	17 03	25 80
250.00	61.70	93.50	39.30	50.90	27.81	21.14	28.27	15.27	22.74
300.00	**61.70**	**101.90**	**66.40**	**66.80**	**27.81**	**20.06**	**19.97**	**13.36**	**20.14**
350.00	72 00	101 90	66 40	102 70	24 66	20 06	19 97	10 94	18 28
400.00	82 10	101 90	77 00	126.80	22 29	20 74	17 98	9 89	16 98
450 00	82.10	116.50	89 00	156 50	22 29	18 15	16 13	8 79	15 21
500.00	82.10	116.50	89.00	203.50	22.29	18.15	16.13	7.65	14.12

Joint optimisation of regional gains (JORG)

The method of Joint Optimisation of Regional Gains (JORG) proposed here aims to meet the needs of regional communities while balancing economic efficiency and regional equity. As noted by the Australian National Audit Office (ANAO), complex goals similar to this can best be achieved in two broad stages - a *'top-down'* optimisation analysis followed by a *'bottom-up'* needs analysis ANAO has recommended the adoption of this two-stage approach to the Department of Transport and Communications (DOTAC) when making decisions about network construction and planning (ANAO, 1993:p63) A simple diagram of this approach is in Figure 2

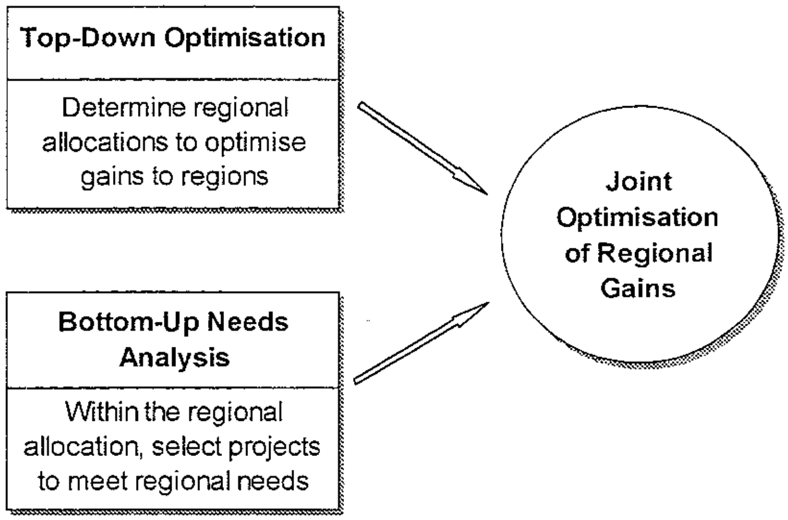

Figure 2 A model for Joint Optimisation of Regional Gains

Top-down optimisation analysis: Top-down "optimisation aims to provide an overall framework for allocating funds between clearly recognisable groups of individuals, areas or regions to best meet their needs It should flow from the objectives and strategies (ANAO, 1993:p62) of the road authority.

According to the distributional equity concept of Theil (1967), the objective of equity between regions is achieved when the ratio of the share of gains to the share of costs for a region is equal to the corresponding ratios for the other regions

So, in the case study presented in this paper, one of our aims is to achieve equity by equating the regional VFM across all regions under a given budget In modelling terms, this means finding the optimum VFM which is equal across all regions when subject to a budget constraint (F) for all regions Equation 1 summarises this statement

$$\text{Maximise} \quad \Sigma G_{ij} / \Sigma I_{ij} \quad \text{subject to F} \qquad (1)$$

Where, ΣG_{ij} and ΣI_{ij} are the gains and the corresponding level of road investment respectively in each region "j" (where j ranges from 1 to 4) $\Sigma G_{ij}/\Sigma I_{ij}$ is VFM of the program (of projects) for a region F refers to a given funding constraint so that.

$$\Sigma I_{ij} = F \qquad (2)$$

Mathematical optimisation techniques such as linear programming can be used for solving equation 1. In this study, linear programming has been chosen as it helps to achieve a desired objective while explicitly accounting for funding and other constraints

Relationship between G_{ij} and I_{ij}

A primary source of information that is needed for setting up Equation 1 in a linear programming model is the functional relationship between G_{ij} and I_{ij}

Therefore, before solving Equation 1, region-specific functional relationships between G_{ij} and I_{ij} are established

The functional relationship between I_i and G_i can be modelled as follows:

$$I_{ij} = f(G_{ij}, D_j) \qquad (3)$$

where, D_j are binary dummy variables to account for regional differences in the relationship between I_{ij} and G_{ij} (cf Koutsoyiannis, 1973) To compare how different the influence of G_{ij} for a given region on I_{ij} as compared to G_{ij} from other regions, set D_j to 1 for all observations of that region and D_j to zero for observations of other regions

The model in Equation 3 has been estimated using pooled data for regions R1, R2, R3 and R4 (see Equation 4)

$$\text{Log } I_{ij} = \underset{}{0\ 1066} + \underset{(32.2890)}{0008\ G_{ij}} - \underset{(13\ 9013)}{0\ 5528\ D_1} - \underset{(15\ 7225)}{0\ 6066\ D_2} - \underset{(7\ 1086)}{0\ 2862\ D_3} \qquad (4)$$

where, D_1, D_2 and D_3 are dummy variables for regions R1, R2, R3. The absolute values in parenthesis are the t-statistic of the model-coefficients and R^2 is 0 9074

Only three dummy variables have been used in the modelling of inter-regional differences The region without the dummy variable acts as the reference region for comparison with other regions (cf Wood and Fildes, 1976)

The signs of the estimated regression coefficients accord with *a priori* expectations The estimated regression explains over 90 percent of the variability in the data used The regression coefficients are significant at 1 percent level of probability (see the t-statistic in parenthesis)

Equation 4 has been used for predicting the technical relationship between road investment and the gains from road investment for R1, R2, R3 and R4 as follows:

$\text{Log } I_{i1} =$	0.1066	$+\,0008\ G_{i1}$	$-\,0.5528\ D_1$	*(for region R_1)*	(5)
$\text{Log } I_{i2} =$	0.1066	$+\,0008\ G_{i2}$	$-\,0.6066\ D_2$	*(for region R_2)*	(6)
$\text{Log } I_{i3} =$	0.1066	$+\,0008\ G_{i3}$	$-\,0.2862\ D_3$	*(for region R_3)*	(7)
$\text{Log } I_{i4} =$	0.1066	$+\,0008\ G_{i4}$		*(for region R_4)*	(8)

The dummy variables in equations 5 to 7 have been assigned a value of 1 A dummy variable has not been included for region R4

Results of linear programming: The solution to the optimisation problem in Equation 1 are presented in Table 2 It shows that the optimum allocation of funds to each of the four regions under different funding levels (similar to those shown in Table 1) to best satisfy the needs of the communities there This table can be used as a 'look-up table' to develop investment programs for the four regions The bottom-up procedure that is used for developing investment programs is explained next

Table 2 Funding ($M) distribution generated by the optimisation model

Total Funds	Region R1	Region R2	Region R3	Region R4
200.00	56.42	58.13	47.70	37.75
250.00	70.02	72.04	59.77	48.16
300.00	**83.59**	**85.91**	**71.86**	**58.65**
350.00	97.13	99.73	83.96	69.18
400.00	110.64	113.53	96.07	79.76
450.00	124.13	127.30	108.19	90.38
500.00	137.61	141.04	120.31	101.04

Bottom-up "needs analysis

Bottom-up "needs analysis" entails assessment of the capacity of existing infrastructure and determining when and where investments should occur to meet the broader investment objectives of the community and the stakeholders of each region Assuming that the projects proposed for each region consider the capacity of existing road infrastructure, our task is to select projects to meet the broader community and stakeholder objectives in each region This is done by ranking projects in the descending order of VFM and selecting only those projects that exhaust the funds allocated to that region

Supposing the total funds available for the 4 regions for road investment is $300M for a five year period, then according to Table 2, the maximum amount of fund available for Region R1 would be $83.59M For R2, R3 and R4, the maximums would be $85.91M, $71.86M and $58.65M respectively These figures in other words are the budget cut-off points for those regions They are highlighted in Table 2

The information in Table 2 has been used for selecting projects for each region The project selection process outlined here has some similarities to the process that has been used in GOG method. The difference is, projects are selected out of regional lists instead of a pool of projects for all regions.

Tables 3 to 6 provide regional lists of projects arranged in the descending order of VFM. According to the information in Table 2, region R1, can have as many projects as can be included within a budget of $83.59M. As projects are "lumpy" or indivisible, only projects worth $82.10M can be chosen within the regional budget constraint of $83.59M. Using a similar approach, projects for the other 3 regions have also been selected. The regional distribution of a total budget of $300M is highlighted in Tables 3 to 6. Table 7 summarises the results for a number of budget constraints.

Table 3 Details of projects for R1

Project	Cum. Inv. ($M)	Cum. Gains	VFM
R1-26	0.20	53.7	268.5
R1-4	0.70	118.1	128.8
R1-30	1.20	171.2	106.2
R1-10	1.90	235.6	92.0
R1-9	2.60	300.0	92.0
R1-33	3.50	352.0	57.8
R1-11	4.70	416.4	53.7
R1-7	5.90	480.8	53.7
R1-8	7.10	545.2	53.7
R1-16	8.20	602.4	52.0
R1-20	9.40	658.8	47.0
R1-18	10.70	715.9	43.9
R1-12	12.30	780.3	40.3
R1-5	13.90	844.7	40.3
R1-6	15.50	909.1	40.3
R1-29	16.90	962.7	38.3
R1-13	18.80	1026.2	33.4
R1-21	20.80	1082.6	28.2
R1-31	22.70	1135.3	27.7
R1-17	24.80	1192.5	27.2
R1-32	27.00	1245.0	23.9
R1-2	30.20	1309.6	20.2
R1-14	33.90	1370.9	16.6
R1-28	37.40	1424.6	15.3
R1-1	41.80	1489.6	14.8
R1-3	47.00	1554.0	12.4
R1-27	51.50	1607.7	11.9
R1-25	56.30	1661.5	11.2
R1-23	61.70	1715.9	10.1
R1-15	72.00	1775.5	5.8
R1-22	**82.10**	1830.3	5.4
R1-24	105.30	1884.4	2.3

Table 4 Details of projects for R2

Project	Cum. Inv. ($M)	Cum. Gains	VFM
R2-7	0.20	61.6	308.0
R2-36	0.40	119.3	288.5
R2-17	0.80	178.1	147.0
R2-15	1.30	238.1	120.0
R2-11	1.80	290.4	104.6
R2-16	2.40	349.6	98.7
R2-18	3.40	407.4	57.8
R2-37	4.50	465.1	52.5
R2-14	5.80	525.7	46.6
R2-30	7.10	581.6	43.0
R2-5	8.60	643.6	41.3
R2-28	10.00	700.1	40.4
R2-10	11.60	757.3	35.8
R2-8	13.30	815.1	34.0
R2-12	15.60	878.2	27.4
R2-35	17.80	937.1	26.8
R2-31	20.00	993.0	25.4
R2-26	22.80	1049.7	20.3
R2-22	25.80	1107.0	19.1
R2-25	28.80	1163.8	18.9
R2-23	32.00	1221.0	17.9
R2-32	35.00	1273.4	17.5
R2-33	38.20	1325.8	16.4
R2-2	42.90	1394.0	14.5
R2-6	47.30	1455.8	14.0
R2-20	51.50	1513.3	13.7
R2-9	55.70	1570.8	13.7
R2-34	59.90	1622.4	12.3
R2-27	64.90	1679.1	11.3
R2-13	70.50	1742.1	11.3
R2-21	75.90	1799.4	10.6
R2-4	**82.20**	1863.6	10.2

Table 5 Details of projects for R3

Project	Cum. Inv. ($M)	Cum. Gains	VFM
R3-13	0.20	52.2	261.0
R3-26	0.60	110.4	145.5
R3-6	1.00	168.6	145.5
R3-28	1.60	222.8	90.3
R3-17	2.40	274.5	64.6
R3-32	3.50	325.8	46.6
R3-9	4.70	380.9	45.9
R3-19	5.90	432.2	42.8
R3-24	7.60	493.2	35.9
R3-14	9.10	545.3	34.7
R3-5	10.80	603.8	34.4
R3-23	12.80	665.0	30.6
R3-25	14.80	725.8	30.4
R3-10	16.60	779.0	29.6
R3-20	18.40	830.3	28.5
R3-18	20.90	881.9	20.6
R3-12	23.50	934.4	20.2
R3-7	28.40	992.0	11.8
R3-2	33.80	1055.4	11.7
R3-8	39.30	1111.0	10.1
R3-16	45.10	1162.8	8.9
R3-15	51.50	1214.6	8.1
R3-3	59.20	1274.1	7.7
R3-30	**66.40**	1325.8	7.2
R3-4	77.00	1384.5	5.5
R3-21	89.00	1435.3	4.2
R3-1	109.50	1502.9	3.3
R3-29	125.50	1554.8	3.2
R3-31	146.50	1606.5	2.5
R3-27	174.50	1661.6	2.0
R3-22	207.50	1723.9	1.9
R3-11	249.50	1776.7	1.3

Table 6 Details of projects for R4

Project	Cum. Inv. ($M)	Cum. Gains	VFM
R4-16	1.10	54.1	49.2
R4-29	2.30	107.2	44.3
R4-24	3.90	161.7	34.1
R4-34	7.00	217.0	17.8
R4-28	10.60	272.3	15.4
R4-35	14.40	327.0	14.4
R4-26	18.40	382.6	13.9
R4-7	22.70	440.4	13.4
R4-17	27.10	498.8	13.3
R4-14	31.70	558.4	13.0
R4-36	36.00	612.9	12.7
R4-32	40.70	665.0	11.1
R4-33	45.70	720.4	11.1
R4-22	50.90	777.0	10.9
R4-23	**58.30**	832.5	7.5
R4-12	66.80	892.4	7.0
R4-30	74.60	945.2	6.8
R4-1	84.10	1008.0	6.6
R4-10	93.70	1067.9	6.2
R4-3	102.70	1123.9	6.2
R4-8	115.00	1191.9	5.5
R4-2	126.80	1254.3	5.3
R4-37	141.10	1313.9	4.2
R4-5	156.50	1375.3	4.0
R4-11	171.60	1435.2	4.0
R4-4	187.70	1496.7	3.8
R4-15	203.50	1556.2	3.8
R4-20	219.60	1613.5	3.6
R4-13	237.60	1673.1	3.3
R4-18	258.90	1731.3	2.7
R4-27	279.20	1786.6	2.7
R4-6	303.10	1844.9	2.4

Comparison of GOG and JORG methods

As the JORG method attempts to equate aggregate VFM across all regions (see Figure 3), it can be expected to yield a more equitable distribution of road investments and investment benefits than the GOG method. The GOG method on the other hand attempts to achieve a global optimisation of gains from road investment. Under the GOG method, regional distribution of funds is merely a secondary product of a process attempting to maximise investment gains globally Nevertheless, it is important to note, that in the study presented in this paper, the maximum investment gains achieved under the GOG method is smaller than that achieved under the JORG method (see the last columns of Tables 2 and 7).

Although the JORG method attempts to equate aggregate VFM across all regions, the empirical results shown in Table 7 show that the expected results have not been achieved (ie VFMs are not equal across all regions) While this can be attributed to the indivisibility of projects, it is however important to empirically test whether the JORG method generates a more equitable regional distribution of investments and investment gains than the GOG method

An empirical equity test of the two methods is in the next section

Table 7 Actual distribution of funds ($M) and gains under JORG method

Total Funds	Distribution of Funds				Corresponding VFM for Each Region				VFM for All Regions
	Region R1	Region R2	Region R3	Region R4	Region R1	Region R2	Region R3	Region R4	
200.00	56.30	55 70	45 10	36 00	29 51	28 20	25 78	17 03	25 93
250.00	61.70	70.50	59.20	45.70	27.81	24.71	21.52	15.76	23.30
300.00	**82.10**	**82.20**	**66.40**	**58.30**	**22.29**	**22.67**	**19.97**	**14.28**	**20.25**
350 00	82 10	93 50	77 00	66.80	22 29	21 14	17 98	13 36	19 05
400.00	105 30	101 90	89 00	74 60	17 90	20 06	16 13	12 67	17 02
450.00	105 30	116 50	89 00	84 10	17 90	18 15	16 13	11 99	16 31
500.00	105.30	133.50	109.50	93.70	17.90	16.27	13.73	11.40	14.99

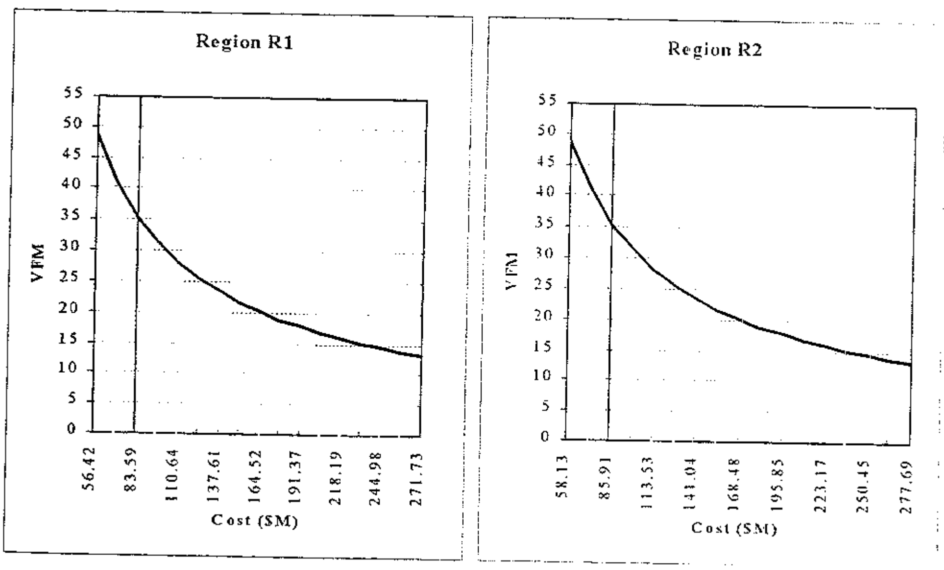

Figure 3.a VFM functions for the 1st and 2nd regions

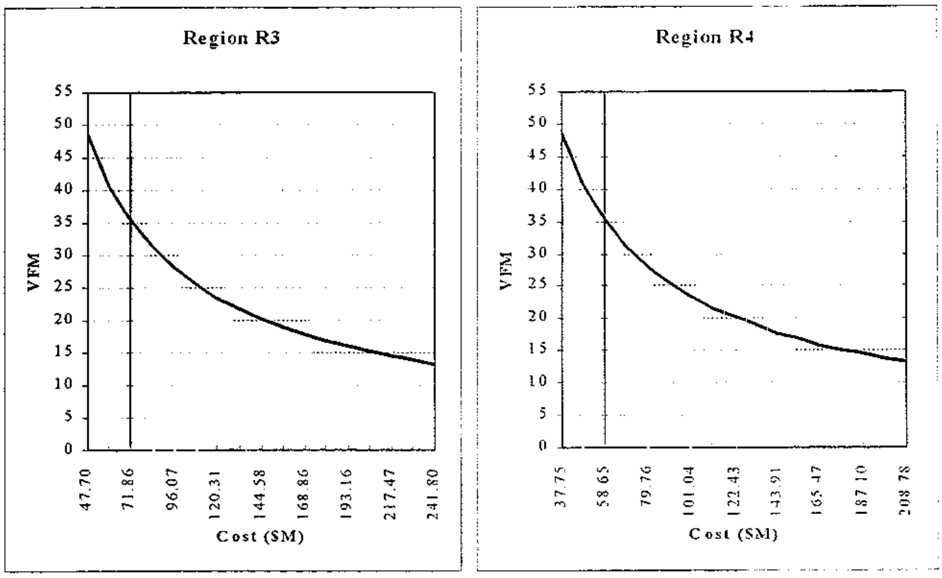

Figure 3.b VFM functions for the 2nd and 3rd regions

Theil's test of distributional equity

According to Theil's concept of distributional equity quoted earlier, equity between regions exists when the ratio of share of gains to the share of costs for a region is equal to the corresponding ratio for the other regions.

Assuming that Y_{R1}, Y_{R2}, Y_{R3}, and Y_{R4}, are the shares of road investment gains to regions R1, R2, R3 and R4 and X_{R1}, X_{R2}, X_{R3}, and X_{R4}, are the shares of road investment in those regions, Theil's equity index can be expressed as

$$I = \{Y_{R1} \log(Y_{R1}/X_{R1})\} + \{Y_{R2} \log(Y_{R2}/X_{R2})\} + \{Y_{R3} \log(Y_{R3}/X_{R3})\} + \{Y_{R4} \log(Y_{R4}/X_{R4})\} \quad (9)$$

Accordingly, if there is perfect equity in the distribution of road investments, then the share of aggregate benefits per dollar of funds to all regions will be the same and $\log(Y_{R1}/X_{R1})$, $\log(Y_{R2}/X_{R2})$, $\log(Y_{R3}/X_{R3})$ and $\log(Y_{R4}/X_{R4})$ will be zero (as $\log 1 = 0$). Therefore at perfect equity I will be zero

Table 8 shows the value of I under the two methods. The values of I for JORG are smaller than that for GOG Therefore it can be inferred that the use of the JORG method results in a more equitable distribution of investments and investment gains between regions than the GOG method

Table 8. Theil's index (T)

Total Funds	JORG Method	GOG Method
200	0 0071	0 0081
250	0 0091	0.0104
300	0 0057	0 0121
350	0 0070	0 0182
400	0 0052	0 0214
450	0 0049	0 0259
500	0.0056	0.0376

Conclusions

It is suggested "that infrastructure investments can effectively, and permanently, induce forces of development in regions, since they raise development potential" (cf Georgi, 1973:p52) Empirical studies in Australasia and elsewhere support Georgi's notion and in general the importance that policy makers attach to infrastructure related economic and social development of regions (cf. Queensland Transport, 1994; Michael, 1996; Vic Roads, 1990; MRWA, 1995; Small, Winston and Evans, 1989; Israel, 1992) Due to these and other reasons, it is often argued that the success of a package of transport/road policies for a State would depend on whether such packages include policies that *explicitly account for efficient and equitable economic and social development of regions* (PPC, 1990; AGPS, 1987) While a number of methods are available for regional distribution of road funds, only a few are capable of providing a balance in efficiency and equity objectives This paper proposes a methodology that combines the advantages of top-down optimisation techniques and bottom-up needs analysis to balance efficiency and equity objectives at regional level Using data for Western Australia, the paper shows that the proposed approach is better than the methods that are currently available to road authorities for regional distribution of funds -including some needs analysis methods

Refinements to the proposed method are planned –especially in establishing functional relationships between regional road investment and gains from such investment In this paper the method has been illustrated for regional allocation of funds –but it has applications in other areas Balancing funds between social, economic, environmental and other outcomes, is one area of application of the proposed method

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