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National Roads Requirements

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INTRODUCTION

Although significant advances have been made in the theory and practice of appraisal of roads projects, little is known about the determination of the overall requirements of roads for a country as a whole. Planners are often on the look out of a criteria for the same. The development plans of Pakistan and India, particularly the Nagpur and Bombay road plans of the latter, [Ministry of Shipping and Transport (1984)] are an indication of the same. Comparisons of road length per unit of area or population are commonly made between regions, countries, etc. to highlight the availability or deficiency of roads. Rarely mention is made of location and geographical factors and resource constraints which are more relevant for the purpose.

This paper intends to identify factors affecting requirements of roads in a country and to determine the form and strength of relationships of those variables to overall requirements of roads, with a view to assist the authorities in the formulation of policy for the development of roads in the country.

FACTORS AFFECTING REQUIREMENTS OF ROADS

The factors affecting requirements of roads in a country are many, varied and complex. The main ones are briefly reviewed in the following paragraphs.

Area

The first and foremost factor affecting requirements of roads in a country is the size of the country and type of its area. However, requirements vary according to types of area within and between countries. For example, hilly, desert, undeveloped, densely or sparsely populated areas, would have different requirements.

Roads are intended to serve the area and in doing so they consume space. A balance in allocation of space to roads and other uses is important particularly for small densely populated countries like England and Japan. In such countries area provides the ultimate limit upto which space can be devoted to roads. A maximum

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Author's Note: The views expressed in this paper are mine and not of the organisation. I am grateful to the two discussants (Dr Ashfaque H. Khan and Dr M. Aslam) whose comments have improved the paper. The addition of weighted least squares in Table 3 is due to them. The remaining deficiencies are mine.

of 4 kilometres of roads per square kilometre of area have been reported in Belgium (Table 1). Opposition of local people to construction of new roads in many European countries is an indication of constraints of area. However, for large sparsely populated countries, area is not a constraint.

Table 1

Road Length, Area, Pop. and GDP of Selected Countries

SN	Country	Area 000 sq km	Population Million	GDP Mill $	Per Cap GDP	Road Length K	Road Length Per sq km	Road Length Per 000 Pop.	Road Length Per Mill $
0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	Uganda	197.0	17.4	3819	220	28332	0.14	1.63	7.42
2.	Kenya	582.6	24.4	9016	370	54584	0.09	2.24	6.05
3.	Pakistan	796.1	113.7	43201	380	111237	0.14	0.98	2.57
4.	Sri Lanka	65.6	17.0	7991	470	20693	0.32	1.22	2.59
5.	Yemen	200.0	11.6	5806	500	37454	0.19	3.23	6.45
	Sub-total 1	1841.3	184.0	69833	379	252300	0.14	1.37	3.61
6.	Indonesia	1919.4	181.6	101685	560	219009	0.11	1.21	2.15
7.	Egypt	1000.0	31.4	18829	600	32836	0.03	1.05	1.74
8.	Philippines	300.0	61.4	44791	730	157448	0.52	2.57	3.52
9.	Syria	185.0	12.6	12427	990	28937	0.16	2.31	2.33
10.	Thailand	514.2	55.8	79237	1420	77609	0.15	1.39	0.98
11.	Turkey	780.6	56.3	91725	1630	320611	0.41	5.70	3.50
12.	Romania	237.5	23.2	38128	1640	72816	0.31	3.13	1.91
13.	Poland	312.7	38.0	64542	1700	360629	1.15	9.50	5.59
	Sub-total 2	5249.4	460.2	451365	981	1269895	0.24	2.76	2.81
14.	Malaysia	131.6	17.6	41072	2340	40094	0.30	2.28	0.98
15.	Iraq	434.9	18.9	47285	2500	44490	0.10	2.35	0.94
16.	South Africa	1123.2	35.9	90503	2520	182968	0.16	5.09	2.02
17.	Venezuela	916.4	19.7	50529	2560	100571	0.11	5.10	1.99
18.	Brazil	8512.0	150.2	402528	2680	1673733	0.20	11.14	4.16
19.	Yugoslavia	255.8	23.8	72828	3060	119608	0.47	5.03	1.64
20.	Korea	99.2	42.8	231061	5400	55778	0.56	1.30	0.24
21.	Greece	132.0	10.0	60288	6000	34492	0.26	3.43	0.57
	Sub-total 3	11605.1	319.0	996094	3123	2251734	0.19	7.06	2.26
22.	Belgium	30.5	10.0	154647	15440	128319	4.20	12.81	0.83
23.	Great Britain	230.0	57.5	923752	16070	352292	1.53	6.13	0.38
24.	Italy	301.3	57.6	970358	16850	301846	1.00	5.24	0.31
25.	Australia	7682.3	17.0	290445	17080	852986	0.11	50.16	2.94
26.	Netherlands	41.2	14.9	258754	17330	115305	2.80	7.72	0.45
27.	France	551.0	56.5	1099704	19480	805070	1.46	14.26	0.73
28.	Canada	9922.3	26.5	542804	20450	844386	0.09	31.81	1.56
29.	USA	9363.4	250.9	5445441	21700	6233308	0.67	24.84	1.14
30.	Germany	248.7	77.3	1757234	22730	493590	1.98	6.38	0.28
31.	Japan	377.8	123.5	3140681	25430	1104282	2.92	8.94	0.35
	Sub-total 4	28748.5	691.8	14583821	21082	11231384	0.39	16.24	0.77
	Grand Total	47444.3	1654.9	16101113	9729	15005313	0.32	9.07	0.93

Population

Population is the second main factor affecting requirements of roads. It is the user of roads. The more the number of users, the higher the demand for transport and requirements of roads. The effect of population is influenced by geography of the area which would determine the location of human settlements and economic activities. A country where population and economic activities are concentrated in a small number of large cities would have different requirements of roads than a country with a widely scattered population in a large number of small villages. The population is also relevant as it is directly involved in passenger transport and indirectly generates goods traffic by production and consumption of goods and services.

National Income

Of more significant importance is the type and extent of economic activity and the level of development. At low levels of development, the areas will have self-sustained economies generating little demand for transport and for roads. At higher levels of development, there will be larger production, greater specialisation and higher demand for transport and requirements of roads. The production is of diverse nature and types. However, national income of a country can be taken as an index of economic activities and level of production and a proxy for requirements of roads.

National income is also important for providing resources for the construction and maintenance of roads. It has therefore more influence on requirements than anything else.

Other Factors

There are numerous other factors affecting requirements of roads like ownership and utilisation of vehicles, etc. However, many such factors would have a close correlation with national income, population and area. Their inclusion would complicate the analysis. However, lack of data on such factors also precludes their consideration here.

Types of Relationships

Given the factors affecting requirements of roads, the next question is the type of relationships. These can be negative or positive, i.e. the requirements of roads can increase or decrease with increase or decrease in a given factor. Area and population would definitely be positively related. However, economic activities can have both positive and negative effects depending upon their nature. For example, concentration of industry at one place and distribution of products at distant places would have more demand for transport and for roads than if the industry is geographically spread out and needs of the areas are met locally. However, on the

whole, the overall increase or decrease in economic activities would have a strong positive effect on the requirements for roads.

Besides being negative or positive, the relationships can be of linear or non-linear form, that is, the requirements for roads can increase or decrease by a constant or variable amount, in response to changes in other factors. In the latter case the distribution can be of square, quadratic, log or more complex form.

Empirical Analysis

The form and strength of relationships of road length to area, population and national income can be determined empirically by cross-country analysis.

DATA SOURCES AND LIMITATIONS

The information concerning area, population, gross national product and length of roads in 91 countries of the world is given in Table 1. Information concerning area and road length has been taken from the Year Book of the International Road Federation (1989) which contains information for 92 countries out of which information for 91 countries has been made use of. The information for the remaining one country was discarded for being too scanty. The information pertains to December 1988, that is the last year for which information is available in published form.

Information on population and national income has been obtained from the World Development Report of the International Bank for Reconstruction and Development, 1991 [The World Bank (1991)]. It relates to the year 1989. The difference of one year in reference period is not likely to affect results which are intended to provide broad indicators.

Data Ranges

The range, mean and standard deviations of variables given in Table 2 below indicate that dispersion of information is quite large. For example, area varies from 600 to more than 22 million square kilometres and population from 0.1 to more than 288 million. Similarly per capita income varies from $80 to more than $32,000. Standard deviations are two to three times the mean values.

Table 2

Range, Mean and Standard Deviations of Variables

Description	Area 000 Sq. Km	Pop. Million	GNP Mill. $	Rd Length Km
Minimum	0.6	0.1	228	1137
Maximum	22403.0	288.7	5445441	6233308
Average	1065.3	28.5	232036	214466
Std. Dev.	2899.3	48.3	733580	699672

REGRESSION ANALYSIS

The available data appears quite suitable for over a wide range as they provide easy and clear indication of the existence or non-existence of correlations and make the results applicable to a large number of countries. However, large variations can lead to the problem of heteroscedasticity wherein errors increase with size and lose their independence. The problem can be overcome by transforming the data into some different units, by taking logs or assigning weights to variables, as suggested by Gujrati (1988) and others.

In view of the above, the road length in different countries was regressed on area, population and GNP in simple and log forms by following the least squares method. The data was then tested for heteroscedasticity and it was found that errors are positively related to GNP. The variables, when divided by squares of GNP and regressed by method of ordinary least squares with zero intercept, improved the results.

The results of the regression analysis are shown in Table 3 at the end. It

Table 3

Regression Analysis

Ind. Variable	Const	Se	Area 000 Skm		Popul 000		GNP Mill $		*R* Sq
			Coef	Se	Coef	Se	Coef	Se	
OLS/LINEAR*									
Area	64910	575442	140.39	20.81					0.338
Pop	–81648	493706			10.382	1.072			0.513
GNP	18396	328121					0.845	0.047	0.785
Area Pop	–76036	492236	31.96	25.81	8.992	1.550			0.521
GNP Area	–2069	317774	35.77	13.63			0.769	0.054	0.801
Pop GNP	–9937	325567			1.663	1.073	0.763	0.071	0.791
Area Pop GNP	–3599	319580	34.87	16.76	0.120	1.288	0.765	0.069	0.801
OLS–LOGe**									
Area	7.424	1.195	0.618	0.064					0.509
Pop	8.650	1.024			0.880	0.070			0.640
GNP	4.417	1.001					0.628	0.048	0.656
Area Pop	7.679	0.936	0.287	0.067	0.640	0.085			0.703
GNP Area	3.489	0.628	0.424	0.036			0.494	0.032	0.866
Pop GNP	5.674	0.822			0.509	0.077	0.383	0.054	0.771
Area Pop GNP	3.959	0.618	0.370	0.045	0.143	0073	0.442	0.041	0.872
WLS***									
Area	0	0.005	19.354	2.733					0.280
Pop	0	0.003			2.600	0.125			0.806
GNP	0	0.003					7.749	0.351	0.825
Area Pop	0	0.002	9.921	1.114	2.279	0.098			0.897
Pop GNP	0	0.001			1.452	0.088	4.585	0.261	0.957
Area GNP	0	0.002	–5.871	1.915			8.884	0.499	0.842
Area Pop GNP	0	0.001	0.851	1.097	1.482	0.096	4.355	0.395	0.957

* $Y = a + b1X1 .... + e.$

** Log $Y = a + b1\ Ln(X1) ... + e.$

*** $Y/gnp\text{^}2 = b1(X1/gnp\text{^}2) + b2(X2/gnp\text{^}2) ... + e.$

would be seen that there are three groups of regression equations. All have been solved by method of ordinary least squares using variables in linear, log and weighted forms. The last group of equations provides weighted least squares coefficients. The 'Y' values calculated by these coefficients would have to be multiplied by their original weights (squares of GNP) to arrive at true values of 'Y' or actual road length.

A brief description of the advantages and disadvantages of the three types of equations would be in order here. The linear equations have the advantage of being simple and easy to solve. However, they indicate elasticities at the mean and values of coefficients depend on units of measurement.

The log transformations, on the other hand, compress the scale so that relative differences of tenfold are reduced to twofold only and the heteroscedasticity element is suppressed. [Gujrati (1988), Ch. 11.6]. Besides, there is the added advantage that coefficients directly provide constant elasticities of 'Y' with respect to 'X' which give percentage change in 'Y' in response to percentage change in 'X' variables.

The weighted least squares, when they fit the data, reduce the error term and increase the degree of explanation without much affecting the coefficients. However, when they do not fit the data, the relationships may be spoiled.

It would be seen from Table 3 that in single variable equations, R_2 is higher for GNP than for population or area, in all forms. This means that road length in a country is more dependent on national income than on area or population. In combination of two variables, GNP and area provide more explanation than GNP and population or area and population in linear and log forms. In linear form, population would not even enter the regression model in step-wise analysis as it makes little improvement in the degree of explanation and adds to the error term. However, in weighted form, population is more important than area in any combination of two variables. The coefficient of area has negative sign with GNP.

For the three variables combined, R_2s are highest in all forms. Between the three sets of equations, R_2 is highest in weighted form (.957), followed by log form (.872) and linear form (.801).

In linear form, intercepts in five out of seven equations are negative. This is difficult to explain statistically. In log form, all signs are correct. As indicated before, coefficients in log transformation provide elasticities. Thus coefficients of the last equation in log form indicate the relative importance of the three independent variables. They show that a one percent increase in GNP, area or population would result in .44, .37 or .14 percent increase in road length respectively.

Contrary to the above findings, road length is commonly related to area in order to emphasise inadequacy of density or poor accessibility. It is rarely related to available resources or GNP which are more relevant in determining the length of roads in a country as shown by the cross-country analysis.

Effective Demand

It would not be out of place to mention here that in economics, demand for any good or service becomes effective when it is backed by power to purchase. Similarly, demand for roads would be effective only when resources are available for their construction and maintenance. The resources are directly dependent upon the magnitude of national income. From this angle, effective demand for roads in the poor countries would be much less than indicated by density in relation to area or population in developed countries.

Relative Burdens

Road length per 100 dollars of per capita income for countries divided into four income groups is shown in Table 4 below. It is evident therefrom that individuals of a poor countries are much more heavily burdened with construction and maintenance of roads than is the case for developed countries. Although poor countries have less than 1/8th road length per head, their per capita income is about 68 times less, so that they have about 8 times more road length to maintain for every unit of their per capita income. Considering the differences in per capita incomes, the real burden is far greater.

Table 4

Road Burden per Capita

GNP$ Range	No. of Obs.	Avg. P.C. GNP $	Road Length Metres	
			Per Capita	Per 100 $PC
1	2	3	4	5
Upto 500	22	303	1.83	.60
501–2000	22	1004	3.00	.30
2001–10000	23	5340	5.93	.11
10000+	24	20,584	15.59	.08
Total	91	8,135	7.52	.09

Source: Table 5.

It is thus quite clear that poor countries have over-burdened their resources by having more road length than they can afford. The chronic shortage of funds, delays in the implementation of projects, deterioration of existing roads due to lack of maintenance are indications of the fact that more roads are being provided than can be afforded and maintained. At low levels of income hardly sufficient to meet bare necessities of life, relatively larger expenditure on roads can cause more loss of welfare than the expected benefits of a road which are often exaggerated.

Developmental Effect of Roads

There are also misconceptions about the role of roads in the process of development. They are often considered to be a prerequisite for the development of other sectors of the economy. However, mere construction of roads would not cause any development in itself unless investments are also made on other necessary services like water, power, seed, fertilizers, machinery and equipment, etc. Therefore, what is needed is balanced development of all sectors of the economy and not emphasis on one or the other sector. If more resources are allocated to roads, less will be left for other sectors and there would be loss of output elsewhere. On the other hand, inadequate development of roads would create bottlenecks which would hamper production in other sectors and cause loss to the economy as a whole. A balanced development is the key to progress.

Inflated Demand

The demand for roads is inflated for the simple reason that there is no direct pricing system. Therefore, everybody would like to have them till their utility becomes negative. If the expenditure on construction and maintenance of roads is the responsibility of the federal or provincial governments, local bodies do not feel any pinch on their resources and therefore exert all sorts of pressures to have more roads in the area. Some sort of local contribution and a situation where local bodies and users would have an option to have more fertilizers, electric power, water, education, dispensary or roads would perhaps provide better distribution of resources.

CONCLUSIONS

The obvious conclusion to be drawn is that availability of roads in any country depends more upon resources than on area or population. The general emphasis on density of roads per square kilometre of area is misplaced. Due to absence of any direct pricing or local contributions, there are pressures from all quarters for the supply of roads.

Succumbing to such pressures, poor countries have over-burdened their economies with the construction and maintenance of roads. Mere construction of roads would not cause any development unless complementary investments are also made. A balanced development of all sectors is essential. For initial development, minimum necessary roads should be part of the package of all essential inputs. Subsequent improvements should be based on savings in vehicle operating costs. Only in this way, a country can approach the optimum level of roads in a country.

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The World Bank (1991) World Development Report 1991. Washington. [Statistical Appendix Table 1.]

Comments on "National Roads Requirements"

The author has made a significant contribution to the economic literature by introducing new variables, in addition to the traditional approaches which failed to fulfil the desired objectives. The author has successfully introduced new variables like GDP, area and population etc., as basis to justify roads network which is more appropriate than that of only considering traditional variables like traffic and population only. Such a comprehensive approach has hardly been utilised in the past for such work. The outcomes of the paper could help in decision-making for important roads projects, in the public sector. By using the regression technique, the author has attempted to prove that the roads network is not as per national requirement and, thus, arbitrary decisions have led to overburdening the economy due to more than required roads which is a waste of resources because roads built on uneconomic grounds and the inadequacy of the public sector to maintain them has led to its deterioration and also due to insufficient provision of recurring expenditure have caused depletion of such infrastructure. Based on the given technique, the author has pointed out that road network is more than desired, as compared with the developed countries. These are important findings which have direct policy implications.

The comments presented below were conveyed to the author and they pertain to the original paper. The author may have, in the meanwhile, revised the paper and some of the comments may have been already incorporated. The author has criticised the Nagpur transport plan which was based on road mileage formula and was utilised to forecast the demand for roads in India. The formula was based on agriculture area, non-agriculture area, population, economic growth and other road networks like railways. However, this formula failed to predict adequately the demand for road networks. The author has criticised this approach and yet has used similar variables himself in his estimation which is hardly a better technique to provide any improvement. Besides, a road network is directly dependent on the growth of vehicles etc., which is ignored in his estimation. Thus, utilising new variables but leaving out the important basic indicators does not improve the methodology.

The author has discussed some data limitations, however, the methodology used for estimation is not explained in the paper. There is a need to point out the methodology and basis for its choice. The author has pooled the data for more than ninety countries which does not seem appropriate. Firstly, it is proposed that countries may be grouped on some rationale and then regression analysis may be done. Secondly, the author has utilised the OLS technique for pooled data which does not seem appropriate. It is proposed that for such estimation GLS may be a

better technique. Moreover, for such cross-sectional analysis there may be a problem of heteroscedasticity for which author may want to make sure that it has been taken care of.

While presenting the results, the author makes a very important point that LDCs are overburdened due to excess of roads. He makes this point while discussing roads to GNP/population ratios. However, his discussion contradicts his regression results which indicate that road networks are explained by the level of GNP. Moreover, while considering road networks, it is not the economic benefits which dominate such decisions but social benefits far exceed the economic ones. The provision of roads in a far-flung village may not be justified on the basis of output or economic rationale, but, it may be very well be justified due to social benefits. Thus, such considerations are also absent in the paper which need to be made a part of the discussion.

Notwithstanding the above, the paper is important due to the introduction of a comprehensive approach for such analysis which may be very helpful to decide road projects which have the lion's share in public sector investment. I think if the above proposed comments are incorporated, the paper will provide a sound foundation to explain the position taken by the author.

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