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RAIL TRACK EXPANSION IN DEVELOPING COUNTRIES IN THE 1980S

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Abstract—Per capita income, country size, and economic growth are often seen as being major determinants of rail track expansion in developing countries. However, we could not empirically verify these explanations for rail expansion using recent World Bank data for a set of 35 developing countries. Instead, a factor analysis suggested multilateral loans to have been important. A discriminant analysis indicated only four variables are needed to predict a country's correct grouping into either a high and low rail expansion group. Regression analysis indicates that 1970s investment offset 1980s investment for the entire sample and the high expansion group. For the low expansion group, a factor capturing the quality of life appears to be the most important predictor of rail investment. © 1998 Elsevier Science Ltd. All rights reserved

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1. INTRODUCTION

To satisfy the need for basic services, to exploit new resources, and to stimulate agricultural and industrial productivity, a fully functional well-placed road and rail network is essential. Although infrastructure output is often measured in physical terms (e.g. electrical generating capacity), the hoped for outcome is the efficient movement of people and goods. Thus infrastructure's contribution depends not only on invested capital but also on the quality of service. Using the most recent World Bank data (1994), this paper explores the major factors which have affected rail track expansion in developing countries (DCs) during the 1980s and tries to identify the economic environment most conducive to rail track expansion.

2. METHODOLOGY

The literature on what determines infrastructure investment usually focuses on three factors. First investment in infrastructure—an expanded stock of social overhead capital—is often viewed as a efficient way to lower production costs and stimulate economic activity. Hirschman's (1958) unbalanced growth strategy is a variant of this position. New infrastructure investment opens up new opportunities for more private sector investment, especially by new investors who at the margin now find various investments profitable given the new infrastructure in place. A second view is that infrastructure is by and large passive and merely responds to economic market signals. For example, Glover and Simon (1975) and Frederiksen (1981) showed that increases in infrastructure investment in many DCs was a response, inter alia, to higher population density.

A third approach sees the country's budget as reflecting resource scarcity. Allocations to various infrastructure projects are explained by examining the competing claims of other types of

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expenditures such as public consumption or allocation to the military (Looney, 1993). A corollary to this approach assumes that various infrastructure claimants compete among themselves for necessary funding. Thus within a country, proponents for the expansion of railway systems compete directly with advocates for other projects such as highway expansion.

Our initial step was to identify the major patterns which characterize rail expansion in 35 DCs during the 1970–1990 period through factor analysis. A factor analysis assumes that a limited number of 'factors' can explain complex phenomena with a number of independent (uncorrelated) composite measures. Next, a discriminant analysis was conducted and the sample set of countries was divided into two groups—high and low rail track expansion. The objective was to see whether a specific environment, i.e. a set of economic variables, helped explain why countries experienced differences in rail tack expansion. Finally, a regression analysis was used to specify a model of rail track expansion in the 1980s for the sample of countries.

3. RESULTS

3.1. Factor and discriminant analysis

A factor analysis has three objectives (Frane and Hill, 1987, pp. 3–4): to study the correlation among a large number of variables by clustering the variables into factors so that the variables are highly correlated; to interpret each factor according to the variables in the factor group; and to summarize many variables by a few factors. For this paper we examined 29 variables from the *World Bank Report* (1994). Initially, the variables fell into seven categories: quality of life indices, debt assistance measures, size variables, economic performance in the 1970s and in the 1980s, infrastructure and economic infrastructure.[1] The results of the factor analysis (Table 1) indicate five factors:[2]

Factor 1: *Quality of life*: includes social indicators such as the infant mortality rate, life expectancy, adult literacy, per-capita Gross National Product (GNP), and concessional debt as a percentage of total external debt (which is fairly closely correlated with the level of underdevelopment).

Factor 2: *Growth in the 1970s*: includes major measures as aggregate and sectoral expansion during the 1970–1980 period. Also electricity production in the 1970s and electrical generating capacity from 1970 to 1980 are correlated with this factor. Interestingly, the expansion of paved roads was associated more with the level of underdevelopment rather than growth in the 1970s or 1980s.

Factor 3: *Growth in the 1980s*: as with Factor 2, closely correlated with various measures of aggregate and sectoral growth during the period.

Factor 4: *Economic size*: comprises a country's geographic area, population and (GDP). A supplemental analysis found that rail traffic (kilometers per GDP) was correlated with this factor—larger countries in terms of factor 4 have higher levels of traffic.

Factor 5: *Rail track expansion*: considers expansion in the 1970s and 1980s. Although rail track expansion is often correlated with quality of life, economic growth and size we found no similar correlation. Instead, the factor analysis suggests that 1970s expansion led to less pressure for expansion in the 1980s (and vice versa), and that loans from multilateral sources were used to fund rail expansion in the 1980s.

The factor analysis shows that recent rail track expansion seems to be insensitive to economic factors such as economic growth, per capita income, or country size—factors which we and others had assumed to be the major determinants of rail expansion. In other words, the usual explanations for rail track expansion in developing countries could not be empirically verified using the newly published World Bank data.

[1]See Appendix for list of variables and definitions.
[2]Factor scores for each country are available from the authors upon request.

Table 1. Factor analysis, standardized regression coefficients

Variable	Factor 1 Quality of Life	Factor 2 Growth in the 1970s	Factor 3 Growth in the 1980s	Factor 4 Size	Factor 5 Railroad expansion
IM92	**0.895**	−0.108	−1.145	0.042	0.052
LE92	**−0.863**	0.217	0.189	0.015	0.152
LITT90	**0.829**	0.076	−0.051	0.053	0.059
CDED92	**0.826**	−0.136	0.217	−0.276	0.176
GNPPER92	**−0.817**	0.055	0.185	−0.117	−0.025
CDED80	**0.773**	−0.056	0.416	0.173	0.143
PR7080	0.279	−0.139	−0.160	0.153	−0.252
GDPG7080	−0.210	**0.913**	0.060	−0.037	−0.087
IG7080	−0.246	**0.808**	0.007	−0.050	−0.214
GDIG7080	−0.066	**0.795**	−0.136	0.164	−0.052
EP7080	−0.069	**0.756**	0.216	0.059	0.157
SG7080	0.244	**0.715**	0.111	−0.066	0.080
EGC7080	−0.111	**0.617**	−0.058	−0.000	−0.085
EGC8090	−0.012	0.445	0.331	0.209	−0.091
AGG7080	−0.260	0.434	0.064	0.019	0.089
GDPG8092	−0.095	0.114	**0.895**	0.248	−0.040
GDIG8092	−0.021	−0.192	**0.869**	−0.048	0.282
SG8092	−0.071	0.075	**0.849**	0.255	−0.039
IG8092	0.111	0.100	**0.776**	0.222	−0.144
EP8090	−0.128	0.446	**0.530**	0.366	−0.372
PR8090	0.317	0.414	0.468	−0.201	−0.017
AGG8092	−0.285	0.083	0.394	0.144	0.196
AREA92	0.084	0.044	0.142	**0.873**	−0.059
POP92	0.138	−0.016	0.226	**0.841**	0.108
GDP92	−0.147	0.085	0.432	**0.814**	−0.055
RT8090	−0.120	−0.031	−0.012	0.105	**0.762**
RT7080	−0.106	0.213	0.325	−0.026	**−0.616**
MDED80	0.498	0.115	0.261	−0.117	**0.610**
MDED92	0.493	0.110	0.268	−0.334	**0.523**

See Appendix for listing of variables and data sources. Factors calculated using varimax factor rotation. See SPSS, 1993.

As a next step, a discriminant analysis was conducted to identify the economic variables which help explain above average rail expansion (a Factor 5 score greater than zero) and below average rail expansion. In other words, can a country's membership in either group be predicted by a certain set of economic characteristics. Interestingly, only four variables[3] were found to be statistically significant in differentiating countries into above average rail expansion and below average expansion groups. The four variables were 1980s growth in electricity production, 1970s agricultural expansion, 1980s gross capital formation, and the country area (in km^2). The area, gross capital formation and agricultural growth terms were about equally important in splitting the countries into two groups. The strongest variable was 1980s electricity production, and the negative sign suggested that countries traded off railway expansion for high rates of electricity growth in electricity. The accuracy of predicting correct group placement was as follows:

	Actual	Predicted
Group I (below average expansion)	19	18
Group II (above average expansion)	16	14
Total	35	32

Thus using only four variables, we can predict proper grouping approximately 91% of the time (32 cases out of 35).[4] The factor and discriminant analyses complement each other in that rail track expansion seems to have been the result of a much smaller number of variables than usually assumed, at least for the last 20 yr. However, we can successfully predict rail track investment using only a few independent variables.

[3]The factors plus all variables in the Appendix (except multilateral debt and rail growth terms) were included in the discriminant analysis.

[4]The Philippines was predicted to be in the "high" group; Paraguay and Panama were predicted to be in the "low" group. Although Thailand and Costa Rica were correctly grouped by the Discriminant procedure, the probabilities of correct placement were 0.521 and 0.515, respectively.

3.2. The regression analysis

Regression techniques were used to build a model to measure the significance and strength of various independent variables which might affect rail expansion. The estimated model was of the form:

$$\text{RT8090} = f(\text{RT7080, Factor 1, Factor 2, Factor 3, Factor 4, INFRA})$$

where RT8090 and RT7080 are 1970s and 1980s rail track expansion, respectively, and INFRA is a measure of other types of competing infrastructure. The expected sign of the estimated coefficients is positive for each factor, negative for RT7080 since earlier expansion might have met country needs, and negative for the INFRA to reflect competition from other projects.

Initially the regression equation was estimated for the entire sample [eqn (1)]:

$$\text{RT8090} = \underset{(0.64)}{0.26} - \underset{(-3.18)}{0.45}\ \text{RT7080}; \quad R^2 = .211 \tag{1}$$

where the t-statistic appears in parentheses.[5] The only variable that was statistically significant was RT7080—1970s rail track expansion—indicating that investment in the earlier decade had presumably met desired investment goals. Although the sign of the estimated coefficient was as expected, the model only explained 21% of the total variation in 1980s rail track expansion. As the above factor and discrimant analyses suggested, factors other than those traditionally looked at, appear to account for a large part of recent rail investment.

The model was then estimated for those countries with a 50% probability or more of being placed in the low rail track expansion group:[6]

$$\text{RT8090} = \underset{(0.85)}{0.10} + \underset{(2.28)}{1.59}\ \text{Factor 1}; \quad R^2 = 0.199 \tag{2}$$

These results suggest the general quality of life (Factor 1) and rail track expansion go hand in hand. Unlike the results for all countries, for this group of countries 1970s rail expansion had little effect on later investment.

On the other hand, the results for the high rail track expansion group [eqn (3)] mirror the results for the entire sample:

$$\text{RT8090} = \underset{(0.15)}{0.17} - \underset{(-2.54)}{0.53}\ \text{RT7080}; \quad R^2 = 0.279 \tag{3}$$

Rail track expansion in the 1980s was largely related to prior investments. Large capital expenditures in the 1970s prompted no follow-on investment which might reflect either the capital indivisibility inherent in rail investment, or quite possibly that countries had met investment goals *vis-à-vis* a capital stock adjustment model.

Finally we were interested to see if the determinants of rail expansion were different for the poorest of the low track expansion group. This group was limited to those countries with a probability of at least 65%:

$$\text{RT8090} = \underset{(0.04)}{1.34} + \underset{(2.76)}{1.45}\ \text{Factor 1} - \underset{(-2.46)}{0.26}\ \text{INFRA} \quad R^2 = 0.461 \tag{4}$$

The results suggest that for the poorest group, other infrastructure variables—in this case irrigation in the 1970s—became statistically significant. This result might reflect a capital constraint leading to a preference for investment in irrigation instead of rail expansion on the one hand, or

[5]Only the intercept and variables whose estimated coefficients are statistically different from zero at the 95% level or higher are reported.

[6]Since the probabilities of being in the low group were very close to 0.5 for Thailand and Costa Rica (see footnote 4 above), we included these two countries in the low track expansion group.

demand pressures for increased investment in agriculture (irrigation) and follow-on demand for other increases in infrastructure (such as roads) at the expense of rail expansion, on the other hand.

4. SUMMARY AND CONCLUSIONS

The recent publication of a large data base by the World Bank has afforded researchers with an opportunity to explore a number of interrelationships for the less developed countries. This paper has examined what factors have affected rail track expansion for a group of 34 developing countries.

We had expected to confirm that rail expansion was determined by the usually assumed set of responsible economic variables such as per capita income, economic growth and country size. However our analysis suggested only a few—and different—set of explanatory variables to be important. A factor analysis of 29 variables indicated that multilateral loans were a major factor in rail expansion supporting the idea that only with concessionary loans can countries invest in this type of infrastructure. Rail track expansion seemed to have little relationship to economic growth. A discriminant analysis supported this conclusion. We identified a set of four variables which, when used to placed countries into either a high or low rail track expansion group, was 91 per cent accurate. Lastly, a model of rail track expansion was specified and estimated by regression analysis. For the entire sample and also for countries with a greater than average factor score for rail expansion, it seems that only rail expansion in the 1970s was important (negatively) in predicting later expansion in the 1980s. For the other low expansion countries, rail expansion responds positively to the quality of life and for a sub-set of the low expansion group negatively to other (competing) infrastructure investments such as irrigation projects. This result may suggest either a capital constraint—rail and other projects cannot be done simultaneously—or competing demand pressures for more investment in agriculture projects which could then presumably lead downstream to more road investment (for example) to transport the increased crop outputs—at the expense of railway expansion.

Since our analysis suggested a different set of variables important for explaining track expansion than previously assumed, it is clear that further research is needed to clarify the determinants of rail expansion on the one hand, and then the benefits from this expansion. Researchers may find important differences among countries when looked at on an individual basis or by some other grouping such as level of development or geography.

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REFERENCES

Frane, J. W. and Hill, M. A. (1987) *Annotated Computer Output for Factor Analysis: A Supplement to the Write-up for Computer Program BMDP4M*. Technical Report #8. BMDP Statistical Software, Los Angeles, CA.

Frederiksen, P. C. (1981) Further evidence on the relationship between population density and infrastructure: the Philippines and electrification. *Economic Development and Cultural Change* **29**, 749–758.

Glover, D. and Simon, J. (1975) The effect of population density on infrastructure: the case of road building. *Economic Development and Cultural Change* **23**, 453–468.

Hirschman, A. O. (1958) *The Strategy of Economic Development*. New Haven, CT: Yale University Press.

Looney, R. E. (1993) The budgetary impact of defence expenditures in the middle east. *The Middle East Business and Economic Review* **5**, 38–49.

SPSS (1993) *SPSS for Windows Professional Statistics Release 6.0*. SPSS, Chicago, IL.

World Bank (1994) *World Development Report, 1994*. Oxford University Press Press, New York.

APPENDIX

List of variables

Quality of life indices		
IM92	Infant mortality rate (per 1000 live births) (1992)	
LE92	Life expectancy at birth, (years), (1992)	
LITT90	Adult literacy (%)	
GNPPER92	Per capita gross national product ($), (1992)	
Debt assistance measures,		
1980	1992	
CDED80	CDED92	Concessional debt as percentage of total external debt
MDED80	MDED92	Multilateral debt as a percentage of total external debt
Size variables		
GDP92	Gross domestic product, ($) (1992)	
AREA92	Area (thousands of sq. km) (1992)	
POP92	Population (millions) (mid-1992)	
Economic performance (average annual growth rate)		
1970–1980	1980–1992	
GDPG7080	GDPG8092	Gross domestic product
IG7080	IG8092	Industry
SG7080	SG8092	Services
AGG7080	AGG8092	Agriculture
GDIG7080	GDIG8092	Gross domestic investment
Infrastructure (average annual growth rate),		
1970–1980	1980–1990	
RT7080	RT8090	Railroad tracks
EGC7080	EGC8090	Electrical generating capacity
PR7080	PR8090	Paved roads
ILA7080	ILA8090	Irrigated land area
Economic/Infrastructure (millions of Kw-h),		
1970–1980	1980–1990	
EP7080	EP8090	Growth in electricity production

Source: World Bank, (1994).