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Factors Affecting the Expansion of Telephone Lines in Developing Countries with Special Reference to Pakistan and the Asia Pacific Region

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Using the Asia Pacific region as a frame of reference, the purpose of this paper is to examine the factors underlying the expansion of telecoms systems in Pakistan. The results from factor and discriminant analysis suggest that much of the main telephone line growth in the 1980s can be explained by a limited number of factors. Most important appears to be economic performance in the previous decade. Apparently this growth creates pressures that can be alleviated only through expanded infrastructure, including main telephone lines. The growth in main telephone lines also appears to occur more or less simultaneously with that of electricity generating capacity and paved roads. Linkages with expanded railroad tracks and irrigated acreage are much weaker.

I. Introduction

The characteristics common to telecoms development in every Asia Pacific country are diversity and growth, coupled with continuous change and reform. Asia Pacific is the world's fastest growing region with a large and unsatisfied demand for telecoms networks and services, ranging from the most basic to the sophisticated. Some 148m lines are planned across the region by 2000 at an average cost of US $1500 a line (Crane, 1995).

While every country plans substantial telephone line growth, the markets of the Asia Pacific region have been characterized as falling into three broad divisions (Crane, 1995).

The first consists of the developed nations, principally Australia, Hong Kong, Singapore and Japan. These countries do not need external investment to create new infrastructure. They are chiefly concerned with privatizing state-owned monopolies and introducing new competition to improve efficiency and reduce prices.

The second division includes countries such as Korea, Taiwan, Malaysia and Thailand, which have already instituted reforms and whose telecoms provision is to some extent matched by their economic activity. What they need is not finance from abroad so much as expertise to help develop their networks and then use them properly. Some have ambitions – in multimedia, for example – which are not justified by their economic development.

Third are the developing economies of China, India, Indonesia, the Philippines and Pakistan, where the telecoms infrastructure is not sufficiently developed to sustain the growth of industrial activity.

This characterization implies that Pakistan's telephone system has lagged somewhat behind the country's recent economic expansion and because of this is increasingly constraining that expansion. The purpose of this paper is to examine this proposition from a quantitative perspective. Specifically, we wish to assess the factors underlying the expansion of the telecoms system in Pakistan. Focusing on the growth in main telephone lines during the period 1975–1990 (the period for which comparable World Bank data are available) in general, and the growth of main telephone lines in particular. Has the recent growth in telephone lines in Pakistan lagged behind that of the economy? Do the factors responsible for the expansion in telephone lines differ considerably from those at work in other developing countries? In short, has Pakistan's recent experience been unique or rather is it typical of that found in developing countries as a whole? The answers to these questions are used to draw several policy implications.

II. Methodology

The literature on infrastructure stresses several different themes. On the one hand it is often felt that infrastructural investment tends to precede economic activity. In this mechanism an expanded stock of social overhead capital lowers the cost of directly productive activity, thus stimulating a wave of investment. Another strain of thought contends that infrastructure is largely passive, responding to the needs created by recent or current economic expansion. A final approach stresses the budgetary process and tradeoffs in allocation between current and capital expenditures. This view attempts to explain allocations to infrastructure in the light of competing claims made by other types of infrastructure and/or allocations to such public consumption categories as the military.

The first step in our analysis of factors affecting Pakistan's telecommunications was to identify which of the main patterns characterize developing countries over the 1970–90 period. For this purpose several factor analyses were undertaken. The basic assumption of factor analysis is that a limited number or underlying dimensions (factors) can be used to explain complex phenomena. The resulting data reduction produces a limited number of independent (uncorrelated) composite measures. In the current example, measures such as economic growth and investment in the 1970s and 1980s, external debt, defence expenditures, electric

generating capacity, agricultural growth, expansion in paved roads and irrigation systems and population growth were used to identify the main linkages with the expansion in telephone lines during the 1980–1990 period.

Formally, as an initial step in exploratory data analysis, factor analysis has three objectives (Frane and Hill, 1987): to study the correlations of a large number of variables by clustering the variables into factors such that variables within each factor are highly correlated; to interpret each factor according to the variables belonging to it; and to summarize many variables by a few factors.

The usual factor analysis model expresses each variable as a function of the factors common to several variables and a factor unique to the variable:

$$z_j = a_{j1}F_1 + a_{j2}F_2 + \ldots + a_{jm}F_m + U_j$$

Where z_j = the jth standardized variable
m = the number of factors common to all the variables
U_j = the factor unique to variable z_j
a_{ji} = factor loadings

The number of factors, m, should be small and the contribution of the unique factors should also be small. The individual factor loadings, a_{ji}, for each variable should be either very large or very small so that each variable is associated with a minimal number of factors.

To the extent that this factor analysis model is appropriate for the problem at hand, the objectives stated above can be achieved. Variables with high loadings on a factor tend to be highly correlated with each other and variables that do not have the same loading patterns tend to be less highly correlated. Each factor is interpreted according to the magnitudes of the loadings associated with it.

Perhaps more importantly here, the original variables can be replaced by the factors with little loss of information. Each case (firm) receives a score for each factor; these factor scores can be computed as:

$$F_i = b_{i1}z_1 + b_{i2}z_2 + \ldots + b_{ip}z_p$$

where b_{ij} are the factor-score coefficients. Factor scores are in turn used in the discriminant analysis that follows. In general these factor scores have less error and are, therefore, more reliable measures than the original variables. The scores express the degree to which each case possesses the quality or property that the factor describes. The factor scores have a mean of zero and standard deviation of one.

Operationally the computations of factors and factor scores for each industry were performed using a principal components procedure.[1] Subsequently these

1. **A description of this technique and the computational methods used is given in BMDP Statistical Software, BMDP Statistical Software Manual: 1990 Version, Volume 1** (Berkeley: University of California Press, 1990), pp. 311–337. The actual computations were made using SPSS version 5.0 with the BMDP results providing a double check accuracy.

factor scores were used as (relatively) uncorrelated independent variables in a regression analysis of main telephone line expansion in the 1980s. A discriminant analysis was also performed to determine whether high or low growth main telephone line countries shared a common environment.

III. Results

The first factor analysis[2] (omitting the expansion in telephone main lines) found five main trends (factors) in the data set (Table 1):

1. *External Debt.* This dimension consisted of the debt service to export ratio together with multilateral debt as a proportion of total external debt. Interestingly the growth in defence expenditures in the 1980s was correlated with this factor, suggesting that perhaps some multilateral aid allowed countries to expand their defence expenditures.
2. *Growth in the 1970s.* This factor was made up of the three main measures of economic expansion – GDP growth, the growth in investment and expansion in the agricultural sector. Significantly, several measures of infrastructure investment in the 1980s, paved roads and electric generating capacity, were correlated with this factor.
3. *Growth in the 1980s.* This factor consisted of four measures of economic expansion during the 1980–91 period: GDP growth, investment, agriculture and government consumption.
4. *Population and Irrigation.* The expansion in irrigated land and population growth during both periods, 1970–80 and 1980–90(91), represent this independent dimension.
5. *Public Expenditures.* The final factor represents various public expenditures in the 1970s; government consumption, military expenditures and the expansion in paved roads.

From these patterns it appears that infrastructure has tended to follow or be associated with current economic expansion, rather than initiate a follow-on process of economic growth. The country factor scores for each dimension (Table 2) suggest that Pakistan scores especially highly on Factor 3, growth in the 1980s. The country's growth in the 1980s with expanded infrastructure investment in the 1980s was also above average.

Including the expansion in telephone main lines in the 1980s in the factor analysis (Table 3) reinforced Factor 3 – growth in the 1970s followed by expanded infrastructure in the 1980s. In this regard telephone lines appear to be associated

2. The main source of data was the recent complication of infrastructure statistics compiled by the World Bank. This data set was supplemented with figures on defence expenditures supplied by the United States Arms Control and Disarmament Agency. The data set consists of 144 countries, 116 of which were classified as developing and hence included in the analysis. However due to missing observations, the average sample size for analysis was around 56 countries.

Table 1 Developing Countries: Basic Factor Patterns (standardized regression coefficients)

	Factor 1 Debt	Factor 2 Growth 1970s	Factor 3 Growth 1980s	Factor 4 Population/ Irrigation	Factor 5 Public Expendit
MULTDE80	0.88084*	0.02763	–0.12864	0.03337	–0.12938
MULTDE91	0.82704*	–0.13531	–0.05808	0.10988	–0.13976
MEG8191	0.71006*	0.24946	0.09760	–0.08766	–0.09829
DSE80	–0.70105*	0.17418	–0.06904	–0.10598	–0.12872
DSE91	–0.63704*	–0.05463	–0.31362	0.19526	–0.12431
GDPG7080	–0.13132	0.84591*	0.19658	–0.04814	0.22802
AGG7080	–0.04457	0.73393*	–0.25457	0.17595	–0.27862
GDIG7080	–0.03685	0.58763*	–0.06984	–0.36412	0.54412
PR8090	0.24811	0.57740*	0.31950	0.22052	–0.03698
EGC8090	0.02495	0.53044*	0.13820	–0.13308	–0.06285
EGC7080	–0.09094	0.49727*	–0.03849	0.03846	0.46385
GDPG8091	0.05415	0.22862	0.86689*	–0.12345	0.11556
GDIG8091	0.31324	–0.03114	0.77606*	–0.14271	–0.16460
AGG8091	–0.37508	0.03121	0.58042*	0.13104	0.01314
GCG8091	0.31371	0.34566	0.55936*	0.31416	–0.13043
ILA8090	–0.13169	0.13416	0.13174	0.70098*	–0.08186
POPG8091	0.15744	–0.07752	–0.41801	0.67155*	0.10819
ILA7080	0.01662	–0.12465	0.00230	0.59718*	–0.02465
POPG7080	0.05540	0.28492	–0.54288	0.56988*	0.25208
GCG7080	–0.23473	0.19116	0.07772	–0.00945	0.72703*
MEG7079	0.03089	–0.19408	–0.00585	0.31577	0.65099*
PR7080	0.14634	–0.15770	–0.24157	–0.25912	0.60463*

Data Sources: World Bank (various issues); United States Arms Control and Disarmament Agency (various issues).

Labels: GDPG7080 = GDP Growth, 1970–80; GDPG8091 = GDP Growth, 1980–91; GDIG7080 = Growth in Investment, 1970–80; GDIG8091 = Growth in Investment, 1980–91; GCG7080 = Growth in Government Consumption, 1970–80; GCG8091 = Growth in Government Consumption, 1980–91; PR7080 = Growth in Paved Roads, 1970–80; PR8090 = Growth in Paved Roads, 1980–90; EGC7080 = Growth in Electricity Generating Capacity, 1970–80; EGC8090 = Growth in Electricity Generating Capacity, 1980–90; MEG7079 = Growth in Military Expenditures, 1970–79; MEG8191 = Growth Military Expenditures 1981–91; DSE80 = Debt Service % of Exports, 1980; DSE91 = Debt Service % of Exports, 1991; MULTDE80 = Multilateral Debt % of Total Debt, 1980; MULTDE91 = Multilateral Debt % of Total Debt, 1991; POPG7080 = Growth in Population, 1970–80; POPG8091 = Growth in Population, 1980–91; ILA7080 = Growth in Irrigated Land, 1970–80; ILA8090 = Growth in Irrigated Land, 1980–90; AGG7080 = Growth of Agriculture, 1970–80; AGG8091 = Growth of Agriculture, 1980–91.

with prior growth and the simultaneous expansion of paved roads and electric generating capacity. Pakistan's factor score in this third factor increased significantly (Table 4) with the inclusion of telephone lines. Again this suggests that Pakistan's overall infrastructure performance during the 1980s was quite high (1.673) relative to that of most other developing countries.

Table 2 Country Factor Scores

	Factor 1 Debt	Factor 2 Growth 1970s	Factor 3 Growth 1980s	Factor 4 Population/ Irrigation	Factor 5 Public Expenditure
Pakistan	**0.60353**	**0.62077**	**1.02275**	**0.48572**	**–0.56673**
Algeria	–2.02859	1.03300	–0.41271	0.83959	–0.12883
Argentina	–1.73539	–0.96234	–1.32321	–1.74157	–1.15788
Brazil	–1.85370	1.13546	0.43760	0.51321	–0.77842
Cameroon	0.22285	0.87903	–0.53762	1.02525	–0.34734
Chile	–1.01729	–0.96202	0.50858	–1.35644	–1.67866
Colombia	0.26061	0.23576	–0.01469	–0.48883	–0.97903
Congo	–0.30534	0.28843	–0.30510	1.29964	–0.17896
Costa Rica	–0.21127	0.48623	0.49797	1.05968	–0.26225
Ecuador	–1.17010	0.90119	–0.25988	–0.38540	1.07190
El Salvador	0.78424	–0.38908	–0.38578	0.03948	–0.23461
Ethiopia	1.78660	–0.68131	–0.72817	–0.16625	0.31255
Ghana	0.66129	–1.61607	–0.02246	–0.77913	–1.50245
Guatemala	0.69202	0.40673	–0.95778	–0.41317	–0.71804
Honduras	0.80336	0.10019	–0.50744	0.23558	0.37019
India	0.60043	–0.28639	0.79109	–0.38114	–0.66400
Indonesia	–0.39635	1.26663	1.11312	–0.18298	0.83381
Ivory Coast	–0.67790	0.69390	–2.34630	1.22234	1.75440
Kenya	0.20620	0.20880	–0.20749	1.63720	1.05592
Korea, South	0.14647	1.12316	2.19224	–1.49935	1.17852
Madagascar	–0.14229	–1.83755	–0.19465	0.65791	–0.56165
Mali	1.06710	0.33296	0.70829	0.50268	–1.12512
Mauritania	0.34527	–1.63552	–1.13234	–1.58005	3.49863
Mauritius	0.21841	–0.91869	2.02405	–1.87466	0.45362
Mexico	–0.98704	0.62051	–0.92376	–0.96912	–0.55680
Morocco	–0.92053	–0.33169	1.24639	0.05719	1.25471
Nigeria	–0.84690	–0.42063	–0.69851	–0.72588	0.86825
Panama	0.19803	–0.40355	–0.62182	–0.68505	–0.53545
Paraguay	0.51642	2.53158	–0.54490	–0.58307	–0.54868
Philippines	–0.44056	0.01912	–0.75891	–0.50717	0.06539
Rwanda	2.89707	1.21106	–1.95389	–0.57351	–0.48826
Senegal	0.17555	–1.01395	0.02612	0.10088	–0.49108
Thailand	–0.18911	0.85599	1.58460	0.05236	0.55141
Togo	0.49300	–0.77396	0.12907	0.21374	1.05559
Tunisia	0.02521	0.53695	0.35319	0.27880	–0.00379
Turkey	–0.32355	0.51142	0.41371	–0.72927	–0.41600
Upper Volta	1.84394	–0.35499	1.38545	1.44438	0.04650
Zambia	–1.19103	–1.71544	–0.53866	1.79621	–1.04746
Zimbabwe	–0.11066	–1.69570	0.94184	2.16019	0.60011

Note: Based on analysis presented in Table 1.

Table 3 Developing Countries: Factor Patterns With Telephone Line Expansion in the 1980s (standardized regression coefficients)

	Factor 1 Debt	Factor 2 Growth 1970s	Factor 3 Growth 1980s	Factor 4 Population/ Irrigation	Factor 5 Public Expendit
MULTDE80	0.88575*	0.04210	–0.14846	0.02804	–0.07818
MULTDE91	0.84070*	–0.18184	–0.00366	0.10992	–0.04038
MEG8191	0.70380*	0.24371	0.13652	–0.07875	–0.06007
DSE80	–0.66599*	0.16728	–0.07355	–0.07554	–0.09083
DSE91	–0.56137*	–0.14257	–0.09568	0.33108	0.03776
GDPG7080	–0.15947	0.87409*	0.12408	–0.04371	0.09537
AGG7080	0.02587	0.66398*	–0.08765	0.33757	–0.24639
GDIG7080	–0.05516	0.64707*	–0.17213	–0.26838	0.47546
PR8090	0.18033	0.61836*	0.27485	0.12173	–0.16599
EGC7080	–0.15094	0.56612*	–0.10641	0.03838	0.38157
TEL8090	**0.11236**	**0.53124***	**0.41514**	**–0.24545**	**0.27052**
EGC8090	0.04727	0.49173*	0.18766	–0.06850	–0.05355
GDPG8091	0.01636	0.26218	0.84812*	–0.31378	0.08899
GDIG8091	0.26021	–0.00946	0.72120*	–0.37112	–0.16503
AGG8091	–0.39481	–0.03545	0.67636*	0.02916	0.07256
GCG8091	0.27971	0.31647	0.63197*	0.19357	–0.20053
POPG8091	0.20092	–0.19551	–0.07606	0.82562*	0.21348
POPG7080	0.13598	0.19943	–0.21867	0.79955*	0.31356
ILA8090	–0.30993	0.17354	0.07785	0.58129*	–0.25369
ILA7080	–0.09990	–0.05867	–0.14763	0.43706*	–0.26706
GCG7080	–0.26588	0.21284	0.08876	0.02478	0.68516*
MEG7079	–0.01849	–0.12618	0.07877	0.27119	0.65684*
PR7080	0.16589	–0.04975	–0.26059	–0.18911	0.61475*

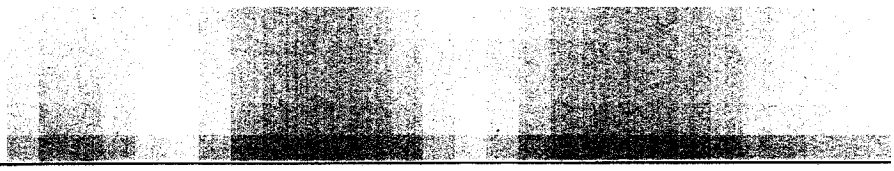
Data Sources: World Bank (various issues); United States Arms Control and Disarmament Agency (various issues).

Labels: TEL8090 = Growth in telephone lines, 1980–1990; GDPG7080 = GDP Growth, 1970–80; GDPG8091 = GDP Growth, 1980–91; GDIG7080 = Growth in Investment, 1970–80; GDIG8091 = Growth in Investment, 1980–91; GCG7080 = Growth in Government Consumption, 1970–80; GCG8091 = Growth in Government Consumption, 1980–91; PR7080 = Growth in Paved Roads, 1970–80; PR8090 = Growth in Paved Roads, 1980–90; EGC7080 = Growth in Electricity Generating Capacity, 1970–80; EGC8090 = Growth in Electricity Generating Capacity, 1980–90; MEG7079 = Growth in Military Expenditures, 1970–79; MEG8191 = Growth Military Expenditures, 1981–91; DSE80 = Debt Service % of Exports, 1980; DSE91 = Debt Service % of Exports, 1991; MULTDE80 = Multilateral Debt % of Total Debt, 1980; MULTDE91 = Multilateral Debt % of Total Debt, 1991; POPG7080 = Growth in Population, 1970–80; POPG8091 = Growth in Population, 1980–91; ILA7080 = Growth in Irrigated Land, 1970–80; ILA8090 = Growth in Irrigated Land, 1980–90; AGG7080 = Growth of Agriculture, 1970–80; AGG8091 = Growth of Agriculture, 1980–91.

Table 4 Country Factor Scores With Telephone Line Expansion in the 1980s

Country	Factor 1 Debt	Factor 2 Growth 1970s	Factor 3 Growth 1980s	Factor 4 Population/ Irrigation	Factor 5 Public Expendit
Pakistan	**0.77012**	**0.34015**	**1.67348**	**0.50794**	**–0.30017**
Algeria	–1.85561	0.60656	0.47783	1.29572	0.44574
Argentina	–1.68334	–0.85592	–1.97715	–1.56576	–0.91625
Brazil	–1.93320	1.21491	–0.12459	0.18349	–1.35217
Cameroon	0.13864	0.96777	–0.65125	1.04914	–0.87728
Chile	–0.84267	–1.04968	0.44632	–1.44174	–1.13222
Colombia	0.36946	0.10741	0.03562	–0.34722	–0.79998
Congo	–0.34279	0.31048	–0.32091	1.17989	–0.61656
Costa Rica	–0.33089	0.57439	0.13346	0.71643	–0.92019
Ecuador	–1.14613	0.77452	–0.25586	–0.11289	1.11795
El Salvador	0.71023	–0.04136	–1.23029	–0.30120	–0.98796
Ethiopia	1.89275	–0.66244	–0.50523	0.01791	0.54011
Ghana	0.81828	–1.98437	0.05849	–0.58533	–1.14205
Guatemala	0.83113	0.24434	–0.87210	–0.01959	–0.59294
Honduras	1.01898	–0.01673	0.14144	0.53170	0.83288
India	0.71955	–0.40585	0.89855	–0.43946	–0.49653
Indonesia	–0.46974	1.32509	0.97993	–0.30083	0.55868
Ivory Coast	–0.72546	0.83742	–2.13405	1.67353	1.52993
Kenya	0.35899	–0.05857	0.81588	1.90028	1.37020
Korea, South	0.02677	1.54267	1.55564	–2.01227	0.76462
Madagascar	–0.05427	–1.87095	0.00520	0.54652	–0.44213
Mali	1.06634	0.37309	0.49378	0.17754	–1.54939
Mauritania	0.24156	–0.93504	–1.57471	–1.41221	3.41718
Mauritius	0.13634	–0.61419	1.18017	–2.43518	0.18287
Mexico	–0.90871	0.57301	–1.16568	–0.66420	–0.46890
Morocco	–0.87929	–0.42610	1.47164	–0.11077	1.39690
Nigeria	–0.83770	–0.54396	–0.79313	–0.36310	0.93030
Panama	0.18648	–0.35972	–0.98657	–0.57456	–0.69873
Paraguay	0.62760	2.13033	–0.34301	0.06820	–0.48593
Philippines	–0.47146	–0.05287	–1.06194	–0.25898	–0.08710
Rwanda	3.22325	1.06379	–1.22484	0.28759	0.08657
Senegal	0.36842	–1.08944	0.42379	0.10077	–0.11848
Thailand	–0.22521	1.05136	1.55998	–0.32304	0.32222
Togo	0.51662	–0.84819	0.32982	0.28238	1.05563
Tunisia	0.00521	0.66216	0.25567	0.10364	–0.22036
Turkey	–0.13825	0.68407	0.80973	–0.75502	0.11963
Zambia	–1.02542	–1.73274	0.12270	1.60928	–0.68572
Zimbabwe	–0.15659	–1.83540	1.35218	1.79142	0.21964

Note: Based on analysis presented in Table 3.



In fact, of the sample countries, Pakistan had the highest score for this particular dimension.

The final factor analysis (Table 5) included the expansion in telephone main lines during the 1975–80 period (1970–74 figures are not available). To maintain the same relative number of infrastructure variables, paved roads were omitted from this analysis. Again telephones along with electric generating capacity loaded quite heavily on past economic growth (now Factor 1).

In sum, the picture that emerges from this exploratory factor analysis is one in which infrastructure responds to the needs created by prior growth. The main types of infrastructure appear to expand simultaneously, with no major tradeoffs occurring. Also, there do not appear to be a major pattern of budgetary conflict between infrastructure and allocations to defence.

The next step in the analysis was look at telephone main line expansion from a somewhat different perspective. Here we were interested in determining whether countries with rapid expansion in telephone main lines during the 1980s shared a common set of characteristics that set them apart from countries with below average rates of main line growth.

For this purpose a discriminant analysis[3] was used to determine whether a limited number of the variables used in the proceeding factor analysis could be used in predicting whether a particular country's expansion in main lines placed it in a high or low group. For our purposes here the two groups of countries were defined on whether their main telephone lines expanded above (high group) or below (low group) the sample mean of 8.05% for the 1980–90 period.

An examination of the variable means by group (Table 6) suggests that:

- The high group (group 2) appears to have stronger overall rates of growth in both the 1970 and 1980s. This pattern also characterizes infrastructure growth such as paved roads and, to a lesser extent electric generating capacity (in the 1970s).
- This group also has a higher proportion of its debt accounted for by multilateral loans.
- On the other hand its rates of population growth and expanded irrigation are less than the rates experienced in the low group.

On a statistical basis, however, only four variables were significant in profiling the two groups of countries (Table 7) namely: GDP growth in the 1980s; the share of multilateral debt in external debt, 1991; the debt service to export ratio in 1991; and the growth in investment in the 1970s. These four variable were capable of correctly classifying 81% of the countries as experiencing high (25 out of 30) or low (22 out of 28) main telephone line growth in the 1980s.

Pakistan seems to fit the normal profile of a high growth country, with the model classifying it with a probability of 99.6% (Table 8) as being in that group.

3. Cf. the discussion in **SPSS for Windows Professional Statistics Release 6.0** (Chicago: SPSS 1993), chapter 1 for a discussion of the computational methods used.

Table 5 Developing Countries: Basic Factor Patterns With Telephone Line Expansion, 1975–1990 (standardized regression coefficients)

	Factor 1 Growth 1970s Infrastructure	Factor 2 Debt	Factor 3 Growth 1980s	Factor 4 Population/ Public expend	Factor 5 Irrigation expansion
GDPG7080	0.81521*	–0.16296	0.17819	0.16859	–0.08255
GDIG7080	0.78448*	0.02803	0.03072	0.06068	–0.11097
TEL7580	**0.77709***	**–0.06140**	**0.20764**	**–0.20768**	**0.31387**
AGG7080	0.73017*	0.00020	–0.26508	0.06718	0.11337
TEL8090	**0.55405***	**–0.01662**	**0.17664**	**–0.01180**	**–0.38268**
EGC8090	0.54595*	0.07437	0.15506	–0.08149	–0.04584
EGC7080	0.50767*	–0.14955	–0.03535	0.39746	–0.17183
MULTDE80	0.04702	0.85112*	–0.26712	–0.11524	–0.03203
MULTDE91	–0.10520	0.82330*	–0.12796	–0.15362	0.05983
MEG8191	0.18407	0.75622*	0.05896	0.11577	–0.40421
DSE80	0.24140	–0.72132*	–0.27863	–0.22686	–0.02385
DSE91	–0.00285	–0.58683*	–0.32443	0.03326	0.08702
GDPG8091	0.18621	0.04844	0.90988*	–0.11779	–0.16030
GDIG8091	–0.11987	0.16073	0.70553*	–0.41423	–0.19038
GCG8091	0.26240	0.28893	0.66569*	–0.03793	0.19184
AGG8091	0.07047	–0.26679	0.657998	0.04127	0.02484
POPG7080	0.36920	0.17918	–0.32387	0.69930*	0.28247
POPG8091	0.01453	0.26108	–0.24601	0.66594*	0.33787
MEG7079	–0.23127	–0.11249	–0.05036	0.65540*	0.05410
GCG7080	0.30000	–0.27341	0.22010	0.55496*	–0.29833
ILA8090	0.12655	–0.34422	0.06776	0.13050	0.74390*
ILA7080	–0.16488	0.00897	–0.07441	0.09961	0.72968*

Data Sources: World Bank (various issues); United States Arms Control and Disarmament Agency (various issues).

Labels: TEL7580 = Growth in telephone lines, 1975–80; TEL8090 = Growth in telephone lines, 1980–1990; GDPG7080 = GDP Growth, 1970–80; GDPG8091 = GDP Growth, 1980–91; GDIG7080 = Growth in Investment, 1970–80; GDIG8091 = Growth in Investment, 1980–91; GCG7080 = Growth in Government Consumption, 1970–80; GCG8091 = Growth in Government Consumption, 1980–91; EGC7080 = Growth in Electricity Generating Capacity, 1970–80; EGC8090 = Growth in Electricity Generating Capacity, 1980–90; MEG7079 = Growth in Military Expenditures 1970–79; MEG8191 = Growth Military Expenditures 1981–91; DSE80 = Debt Service % of Exports, 1980; DSE91 = Debt Service % of Exports, 1991; MULTDE80 = Multilateral Debt % of Total Debt, 1980; MULTDE91 = Multilateral Debt % of Total Debt, 1991; POPG7080 = Growth in Population 1970–80; POPG8091 = Growth in Population, 1980–91; ILA7080 = Growth in Irrigated Land, 1970–80; ILA8090 = Growth in Irrigated Land, 1980–90; AGG7080 = Growth of Agriculture, 1970–80; AGG8091 = Growth of Agriculture, 1980–91.

Table 6 Group means High and Low Telephone Line Growth (1980–90) Countries

Telephone line growth group	GDPG7080	GDPG8091	GDIG7080	GDIG8091
1	4.55000	1.62000	5.06000	–1.55000
2	5.40000	4.40000	8.75000	3.27222
Total	4.95263	2.93684	6.80789	0.73421
	GCG7080	GCG8091	PR7080	PR8090
1	6.62500	1.30500	5.73250	2.84950
2	7.76111	3.80556	9.82333	3.39889
Total	7.16316	2.48947	7.67026	3.10974
	EGC7080	EGC8090	MEG7079	MEG8191
1	8.41700	4.29600	6.31813	–1.10873
2	8.97500	8.30167	8.30345	2.93174
Total	8.68132	6.19342	7.25855	0.80518
	DSE80	DSE91	MULTDE80	MULTDE91
1	20.01000	24.75000	13.85500	25.10000
2	20.15555	25.93333	16.40000	30.43333
Total	20.07895	25.31053	15.06053	27.62631
	POPG7080	POPG8091	ILA7080	ILA8090
1	2.70500	2.73500	5.83400	2.67650
2	2.58333	2.42222	2.47556	1.73000
Total	2.64737	2.58684	4.24316	2.22816
	AGG7080	AGG8091	Factor 1	Factor 2
1	2.39500	2.00500	–0.18835	–0.23660
2	3.13333	3.13333	0.10684	0.28261
Total	2.74474	2.53947	–0.04852	0.00934
	Factor 3	Factor 4	Factor 5	
1	–0.39439	0.20588	–0.16391	
2	0.36124	–0.30900	0.17954	
Total	–0.03646	–0.03801	–0.00122	

Notes: See Table 1 for discriminating variable definitions. Mean growth for telephone line growth in the 1980–1990 period = 8.05%. Group 1 = low growth group – growth less than 8.05%; Group 2 = high growth group – growth greater than 8.05%. Factors 1 through Factor 5 are included as a basis of comparison. They were not used in the actual discriminant analysis.

Finally a regression analysis was performed to determine the relative importance of the main factor dimensions (Table 1) in determining the expansion in main telephone lines during the 1980s. This analysis (Table 9) found two factors (Factor 2 and Factor 3) significant in this regard. The beta coefficients of 0.46 and 0.33 respectively suggest that Factor 2 (prior growth) is somewhat stronger in this regard than Factor 3 (current growth).

Again, Pakistan appears to fit the model quite well. During the 1980s that country's main telephone lines expanded at an average annual rate of 10.78%. The model predicted (Table 9) the rate would have been 10.22%, a difference of

Table 7 Discriminant Analysis of Telephone Line Growth, 1980–1990

Groups

TELF = 1 = countries with telephone line expansion during 1980–90 lower than the sample mean (8.05%).

TELF = 2 = countries with telephone line expansion during 1980–90 higher than the sample mean (8.05%).

Step	Entered	Wilks Lambda	Variable name
1	GDPG8091	0.59676	GDP Growth, 1980–91
2	MULTDE91	0.51799	Multilateral Debt % of Total Debt, 1991
3	DSE91	0.43456	Debt Service % of Exports, 1991
4	GDIG7080	0.34062	Growth in Investment, 1970–80

Standardized canonical discriminant function coefficients

GDPG8091	1.20457
GDIG7080	0.63319
DSE91	0.77799
MULTDE91	0.88841

Classification Results – Summary

		Predicted Group Membership	
Actual group	Cases	1	2
Group 1	30.0	25.0	5.0
		83.3%	16.7%
Group 2	28.0	6.0	22.0
		21.4%	78.6%

Percentage of "grouped" cases correctly classified: 81.03%

0.56%. On the whole however the model only accounts for around 30% of the observed variance in main telephone line expansion.

As with our initial analysis of high and low telephone line countries, a discriminant analysis was performed to determine whether countries above and below the regression line shared a common set of characteristics. Since the various measure of economic growth were incorporated in Factors 2 and 3 of the regression analysis, this analysis was confined largely to various measures of infrastructure and defence expenditures, areas of potential competition with telephone lines for scarce resources. Also, since telephone line growth has been so rapid in the mid-east and south Asia region following the oil boom of the 1970s and early 1980s (oil revenues and expatriate remittances) a regional variable MESA (2 for Middle East, south Asia countries and 1 for other parts of the world) was added to the analysis.

Again some patterns seem present (Table 10). Those countries which expanded their telephone main lines at rates faster than that predicted by the regression

Table 8 Developing Countries: Telephone Line Expansion Groupings

Country	Actual group	Discriminant function	Probability in low group	Probability in high group
Pakistan	**2.00**	**2.10302**	**0.00403**	**0.99597**
Algeria	2.00	2.30943	0.00231	0.99769
Argentina	1.00	–2.61122	0.99931	0.00069
Bangladesh	2.00	2.06740	0.00444	0.99556
Benin	2.00	0.6904	0.43416	0.56584
Bolivia	1.00	–0.89645	0.93245	0.06755
Botswana	2.00	6.29915	0.00000	1.00000
Brazil	1.00	–0.96320	0.94300	0.05700
CAR	1.00	–1.65480	0.99082	0.00918
Cameroon	1.00	–1.29803	0.97620	0.02380
Chile	2.00	0.11880	0.46788	0.53212
China Mainland	2.00	2.90695	0.00046	0.99954
Colombia	2.00	1.38957	0.02725	0.97275
Congo	1.00	–1.49464	0.98590	0.01410
Costa Rica	2.00	0.08585	0.49019	0.50981
Dominican Republic	1.00	–1.86040	0.99472	0.00528
Ecuador	1.00	–0.37390	0.76989	0.23011
Egypt	2.00	0.82177	0.11555	0.88445
El Salvador	1.00	–1.05172	0.95461	0.04539
Ethiopia	1.00	–1.36848	0.98026	0.01974
Gabon	1.00	–3.41194	0.99992	0.00008
Ghana	2.00	0.66428	0.16685	0.83315
Guatemala	1.00	–1.24610	0.97270	0.02730
Haiti	1.00	–0.35506	0.76071	0.23929
Honduras	2.00	1.82857	0.00844	0.99156
India	2.00	2.14148	0.00363	0.99637
Indonesia	2.00	2.64289	0.00093	0.99907
Iran	1.00	–3.02626	0.99978	0.00022
Ivory Coast	1.00	–1.53291	0.98727	0.01273
Jamaica	1.00	–2.44649	0.99892	0.00108
Kenya	2.00	1.49808	0.02044	0.97956
Korea, South	2.00	3.19766	0.00021	0.99979
Lesotho	2.00	5.17897	0.00000	1.00000
Madagascar	1.00	–0.95021	0.94108	0.05892
Malawi	2.00	2.58060	0.00111	0.99889
Malaysia	2.00	0.21816	0.40177	0.59823
Mali	1.00	–1.17085	0.96673	0.03327
Mauritania	1.00	–0.24591	0.70278	0.29722
Mauritius	2.00	2.15087	0.00354	0.99646
Mexico	1.00	–1.51975	0.98682	0.01318
Morocco	2.00	1.10152	0.05765	0.94235
Niger	1.00	–0.24179	0.70043	0.29957
Nigeria	1.00	–1.25776	0.97353	0.02647
Panama	1.00	–4.40869	0.99999	0.00001
Papua New Guinea	1.00	–1.42247	0.98290	0.01710
Paraguay	2.00	0.65463	0.17052	0.82948
Peru	1.00	–3.37190	0.99991	0.00009

Table 8 Cont'd

Country	Actual group	Discriminant function	Probability in low group	Probability in high group
Philippines	1.00	–1.35145	0.97935	0.02065
Portugal	1.00	–1.76265	0.99313	0.00687
Rwanda	2.00	1.22264	0.04219	0.95781
Senegal	1.00	–0.07801	0.59993	0.40007
Sri Lanka	2.00	1.08526	0.06009	0.93991
Tanzania	1.00	–0.26785	0.71505	0.28495
Thailand	2.00	1.69207	0.01218	0.98782
Togo	1.00	–0.18471	0.66698	0.33302
Trinidad	1.00	–6.15292	1.00000	0.00000
Tunisia	2.00	0.70179	0.15319	0.84681
Turkey	2.00	1.26562	0.03772	0.96228
Upper Volta	2.00	2.05590	0.00458	0.99542
Venezuela	1.00	–2.66898	0.99941	0.00059
Zambia	1.00	–2.33962	0.99856	0.00144
Zimbabwe	1.00	–1.32160	0.97764	0.02236

model tended to have higher military burdens (military expenditures, MEY as a share of GDP), much higher railroad (RT) expansion in the 1980s, more rapid expansion of paved roads in the 1970s, and lower rates of expansion in irrigated land.

Of these variables, however, only three: defence burden in the 1980s; energy production (EP) in the 1970s; and the regional variable (MESA) were statistically significant in classifying countries into the two predetermined groupings.

The standardized coefficients suggest that the military variable was the most important followed by energy production and finally the regional variable. These three variables correctly classified around 79% of the countries as being above or below the regression line.

Pakistan, again, seems to fit the model fairly well (Table 11), being classified with a 97.4% chance of having a rate of main telephone line expansion more rapid than that predicted by the regression model.

IV. Conclusions

The statistical work outlined above suggests that much of the main telephone line growth in the 1980s can be explained by a limited number of factors. Of these the most important appears to be economic performance in the previous decade. Apparently this growth creates pressures that can be alleviated only through expanded infrastructure, including main telephone lines. The growth in main telephone lines also appears to occur more or less simultaneously with that of electricity generating capacity and paved roads. Linkages with expanded railroad tracks and irrigated acreage are much weaker.

Table 9 Determinants of Telephone Line Expansion, 1980–1990

[0.46] [0.33]
*TEL*8090 = 8.20 + 1.47 *FAC* 2 + 1.08 *FAC* 3
(3.34)** (2.38)**

[ ] = beta coefficients; ( ) = *t* statistic

Multiple *R* = 0.57213; *R* Square = 0.32733; Adjusted *R* Square = 0.28889;
Standard error = 2.72477; *F* = 8.51574; Signif *F* = .0010; *df* = 35.0

Country	Actual	Predicted	Residual	Cook's Distances
Pakistan	**10.78**	**10.22540**	**0.55460**	**0.00106**
Algeria	9.82	9.28199	0.53801	0.00085
Argentina	5.09	5.34882	–0.25882	0.00035
Brazil	7.24	10.35304	–3.11304	0.03272
Cameroon	7.41	8.91937	–1.50937	0.00612
Chile	9.01	7.33048	1.67952	0.00858
Colombia	8.42	8.53443	–0.11443	0.00002
Congo	6.43	8.29815	–1.86815	0.00507
Costa Rica	5.98	9.45901	–3.47901	0.02363
Ecuador	8.01	9.25251	–1.24251	0.00374
El Salvador	5.17	7.20978	–2.03978	0.00676
Ethiopia	6.94	6.40764	0.53236	0.00073
Ghana	1.80	5.78967	–3.98967	0.08407
Guatemala	6.99	7.76705	–0.77705	0.00165
Honduras	10.75	7.80116	2.94884	0.01365
India	8.26	8.63437	–0.37437	0.00033
Indonesia	11.02	11.27748	–0.25748	0.00038
Ivory Coast	7.15	6.68963	0.46037	0.00271
Kenya	8.61	8.28607	0.32393	0.00014
Korea, South	14.85	12.23261	2.61739	0.09265
Madagascar	4.62	5.27618	–0.65618	0.00290
Mali	7.58	9.46000	–1.88000	0.00770
Mauritania	9.59	4.56054	5.02946	0.19462
Mauritius	9.77	9.03357	0.73643	0.00593
Mexico	7.59	8.11974	–0.52974	0.00083
Morocco	9.19	9.05987	0.13013	0.00007
Nigeria	4.76	6.82492	–2.06492	0.00902
Panama	5.48	6.93311	–1.45311	0.00413
Paraguay	8.55	11.35338	–2.80338	0.11231
Philippines	3.80	7.40939	–3.60939	0.02595
Rwanda	12.14	7.87821	4.26179	0.19828
Senegal	8.90	6.73193	2.16807	0.01277
Thailand	13.73	11.18063	2.54937	0.04387
Togo	6.13	7.19790	–1.06790	0.00243
Tunisia	10.48	9.37737	1.10263	0.00222
Turkey	18.14	9.40510	8.73490	0.14239
Zambia	7.91	5.08454	2.82546	0.05048
Zimbabwe	2.61	6.71496	–4.10496	0.13111

Table 10 Discriminant Analysis of Residuals

Groups
TELF = 1 = countries with telephone line expansion lower than that predicted by regression model.

TELF = 2 = countries with telephone line expansion greater than that predicted by regression model.

Group means

TELF	MEY7080	MEY8091	RT7080	RT8090	MESA
1	4.85198	2.31073	–0.07429	–0.00714	1.04762
2	6.46249	4.62933	–0.74333	1.49733	1.40000
Total	5.52303	3.27681	–0.35306	0.61972	1.19444

TELF	PR7080	PR8090	EGC7080	EGC8090
1	5.86762	3.10524	7.71714	6.69190
2	10.00600	3.10933	10.29467	5.78867
Total	7.59194	3.10694	8.79111	6.31556

TELF	EP7080	EP8090	ILA7080	ILA8090
1	7.70286	5.48190	5.42333	2.56667
2	11.79667	4.51733	3.11333	2.01067
Total	9.40861	5.08000	4.46083	2.33500

Step	Entered	Wilks Lambda	Variable Name
1	MEY8091	0.70488	Average Share of Military Expenditure
2	EP7080	0.62385	Growth in Electricity Production, 1970–80
3	MESA	0.54733	Middle East/South Asia Regional Variable

Standardized canonical discriminant function coefficients

MEY8091	0.63831
EP7080	0.56974
MESA	0.53711

Classification Results – Summary

		Predicted Group Membership	
Actual Group	Cases	1	2
Group 1	21.0	20.0	1.0
		95.2%	4.8%
Group 2	17.0	7.0	10.0
		41.2%	58.8%

Percent of "grouped" cases correctly classified: 78.95%

Note: Regression residuals are from the analysis in Table 9.

While there are no doubt notable exceptions, generally there do not appear to be any major conflicts for resources between the various types of infrastructure. Also, the alleged budgetary conflict between expanded funding of infrastructure and the military was not found. If anything, military expenditures may stimulate additional efforts to expand telephone service.

Table 11 Developing Countries: Telephone Line Expansion Groupings

Country	Actual group	Discriminant function	Probability in low group	Probability in high group
Pakistan	**2.00**	**2.16736**	**0.02615**	**0.97385**
Algeria	2.00	1.60817	0.06817	0.93183
Argentina	1.00	–0.44749	0.74460	0.25540
Benin	1.00	–3.63548	0.99887	0.00113
Bolivia	1.00	–0.64801	0.80682	0.19318
Brazil	1.00	–0.79111	0.84370	0.15630
Burma	1.00	–0.33285	0.70360	0.29640
Burundi	1.00	–1.36963	0.93838	0.06162
CAR	1.00	–1.42226	0.94361	0.05639
Cameroon	1.00	–1.67320	0.96329	0.03671
Chad	1.00	–1.19820	0.91803	0.08197
Chile	1.00	–0.62037	0.79898	0.20102
China Mainland	2.00	0.69966	0.27161	0.72839
Colombia	1.00	–0.77175	0.83907	0.16093
Congo	1.00	–0.18432	0.64525	0.35475
Costa Rica	1.00	–1.38069	0.93952	0.06048
Dominican Republic	1.00	–0.87682	0.86291	0.13709
Ecuador	1.00	–0.14209	0.62774	0.37226
Egypt	2.00	3.33501	0.00330	0.99670
El Salvador	1.00	–0.06090	0.59315	0.40685
Ethiopia	2.00	3.35359	0.00319	0.99681
Gabon	2.00	0.78021	0.24400	0.75600
Ghana	1.00	–1.57160	0.95628	0.04372
Greece	2.00	0.67222	0.28145	0.71855
Guatemala	1.00	–1.06334	0.89790	0.10210
Guinea	1.00	–1.32291	0.93335	0.06665
Honduras	1.00	–0.26536	0.67777	0.32223
India	2.00	0.92726	0.19869	0.80131
Indonesia	1.00	–0.35400	0.71145	0.28855
Iran	2.00	2.57620	0.01274	0.98726
Ireland	1.00	–1.23597	0.92298	0.07702
Israel	2.00	6.04007	0.00003	0.99997
Ivory Coast	1.00	–0.48439	0.75698	0.24302
Jamaica	1.00	–1.70392	0.96519	0.03481
Jordan	2.00	6.83763	0.00001	0.99999
Kenya	1.00	–0.31352	0.69633	0.30367
Korea, South	2.00	0.98510	0.18270	0.81730
Madagascar	1.00	–1.14883	0.91111	0.08889
Malawi	1.00	–0.43236	0.73941	0.26059
Malaysia	2.00	0.21629	0.47005	0.52995
Mali	1.00	–0.90831	0.86945	0.13055
Mauritania	2.00	1.69861	0.05856	0.94144
Mauritius	1.00	–1.59037	0.95766	0.04234
Mexico	1.00	–1.31576	0.93255	0.06745
Morocco	2.00	2.28346	0.02134	0.97866
Mozambique	2.00	2.67667	0.01066	0.98934

Table 11 Cont'd

Country	Actual group	Discriminant function	Probability in low group	Probability in high group
Nepal	2.00	0.57868	0.31657	0.68343
Nicaragua	2.00	1.44963	0.08859	0.91141
Niger	1.00	–1.69843	0.96486	0.03514
Nigeria	1.00	–0.13777	0.62593	0.37407
Oman	2.00	9.73204	0.00000	1.00000
Panama	1.00	–1.44367	0.94562	0.05438
Papua New Guiena	2.00	0.40870	0.38584	0.61416
Paraguay	1.00	–0.22331	0.66109	0.33891
Peru	1.00	–0.23721	0.66665	0.33335
Philippines	1.00	–0.98144	0.88363	0.11637
Portugal	1.00	–0.46782	0.75147	0.24853
Rwanda	1.00	–1.04834	0.89540	0.10460
Saudi Arabia	2.00	9.52569	0.00000	1.00000
Senegal	1.00	–0.97364	0.88218	0.11782
Sierra Leone	1.00	–1.91640	0.97595	0.02405
Singapore	2.00	0.67831	0.27925	0.72075
Somalia	2.00	1.43711	0.09042	0.90958
Spain	1.00	–0.94462	0.87667	0.12333
Sri Lanka	2.00	0.80150	0.23703	0.76297
Sudan	1.00	0.02073	0.55741	0.44259
Syria	2.00	6.56618	0.00001	0.99999
Tanzania	1.00	–0.66789	0.81232	0.18768
Thailand	2.00	0.18928	0.48213	0.51787
Togo	1.00	–1.40916	0.94235	0.05765
Trinidad	1.00	–1.35600	0.93695	0.06305
Tunisia	2.00	1.70403	0.05803	0.94197
Turkey	2.00	1.82180	0.04751	0.95249
Uganda	1.00	–2.03547	0.98048	0.01952
Upper Volta	2.00	0.16688	0.49216	0.50784
Uruguay	1.00	–0.62603	0.80061	0.19939
Venezuela	1.00	–0.59698	0.79216	0.20784
Zambia	2.00	2.53195	0.01377	0.98623
Zimbabwe	1.00	–0.60457	0.79439	0.20561

Note: Based on analysis in Table 10.

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