WPS3829

FORECASTING INVESTMENT NEEDS IN SOUTH AFRICA'S ELECTRICITY AND TELECOMMUNICATIONS SECTORS

by

Željko Bogetić and Johannes W. Fedderke

Abstract: The paper uses a panel-data set for the period 1980-2002 to estimate demand for electricity and telecommunications services and project investment needs in South Africa through 2010 for two growth scenarios. Projections of average annual investment needs in electricity and telecommunications for the current growth scenario (3.6% per annum) are of the order of 0.2% and 0.75% of GDP, respectively. An alternative, accelerated growth scenario (6% per annum) implies approximate doubling of investment needs in these sectors.

JEL classification: H54, H, R, O, O57

World Bank Policy Research Working Paper 3829, February 2006

Authors: Bogetić is lead economist at the World Bank, Africa Region, Washington D.C. (E-mail: zbogetic@worldbank.org) and Fedderke is professor of economics at the University of Cape Town, School of Economics (E-mail: jfedderk@commerce.uct.ac.za).
Research assistance by Andrew Hill is gratefully acknowledged. The paper builds in large part on the earlier work by Bogetić and Fedderke (2005 a,b).

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Why forecast infrastructure needs?

There are at least four reasons for the need for more rigorous, empirical forecasting of infrastructure investment needs in South Africa at this time: (i) the strong international evidence on the links between infrastructure and growth and renewed emphasis of the development community on infrastructure in Sub-Saharan Africa, (ii) the broader links between infrastructure, equity and poverty in the Sub-Saharan African context, (iii) the South Africa specific evidence on infrastructure and growth and the significant decline in infrastructure investments in South Africa over the past two decades, and (iv) the on-going policy efforts to scale up infrastructure as a key element of the South African government's accelerated and shared growth strategy.

Infrastructure, growth, and the infrastructure deficit in Sub-Saharan Africa

Infrastructure investments have long been recognized in the development literature as an influential factor for economic growth and overall welfare (Aschauer 1989, World Bank 1994, Leipziger et al. 2003, Estache 2005). But recently, there has also emerged a growing sense that infrastructure provision has been inadequate relative to needs in many African and Latin American countries (Figure 1). Infrastructure deficits, in turn, have led to lower growth and private investments, deteriorating investment climate, and worse social indicators.[1]

* Bogetić is lead economist at the World Bank, Africa Region, Washington D.C. (E-mail: zbogetic@worldbank.org) and Fedderke is professor of economics at the University of Cape Town, School of Economics (E-mail: jfedderk@commerce.uct.ac.za). The paper builds on and extends the earlier related work by Bogetić and Fedderke (2005 a,b). Helpful discussions with Ioannis Kessides, Anton Eberhard, Antonio Estache, Paul Collier, Alan Gelb, Ritva Reinikka, Cecilia Briceno-Garmendia and Luiz Maurer, and research assistance by Andrew Hill are gratefully acknowledged.

[1] For example, Easterly and Serven (2004) show that about one-fifth of Latin American growth underperformance relative to East Asia was directly related to underinvestment in infrastructure. Also shown was that sub-Saharan Africa's poor growth performance was in part related to underinvestment in electricity and telecom infrastructure (Esfahani and Ramirez 2003). It is estimated that if Africa had enjoyed Korea's quantity and quality of infrastructure, it would have raised its annual growth per capita by about 1 percentage point (Eustache 2005). The recent World Development Report (World Bank 2004) on investment climate documents that about half of Sub-Saharan African entrepreneurs cite inadequate power supply as a major constraint to their growth, well ahead of some other constraints such as corruption. Also, Reinikka and Svensson (1999, 2002) find, using a firm-level data, that inadequate provision of public capital (especially infrastructure) reduces private investments.

Recognizing the infrastructure deficit in Sub-Saharan Africa, the international development community is putting increasing emphasis on infrastructure investments in the region. Specifically, to achieve the 7% economic growth rates needed to meet the MDG targets, Sub-Saharan Africa is estimated to require about 5% of GDP in annual infrastructure investments in the medium term, as well as another 4% of GDP to cover operation and maintenance requirements.

In absolute terms, these investment requirements amount to some US$20 billion per year, about twice as much as the region has historically been investing. The roads sector alone accounts for about 40% of the total need, with the energy and water sectors accounting for a further 20% each (World Bank 2005a).

This implies a need for more detailed, realistic assessments of individual country infrastructure requirements to inform public debate in the context of alternative growth scenarios, and will also help frame the policy discussion on infrastructure scale-up. This paper is an effort in that direction with an application to two of South Africa's major infrastructure sectors—at least one of which has come to be strongly associated with economic growth—electricity and telecom.

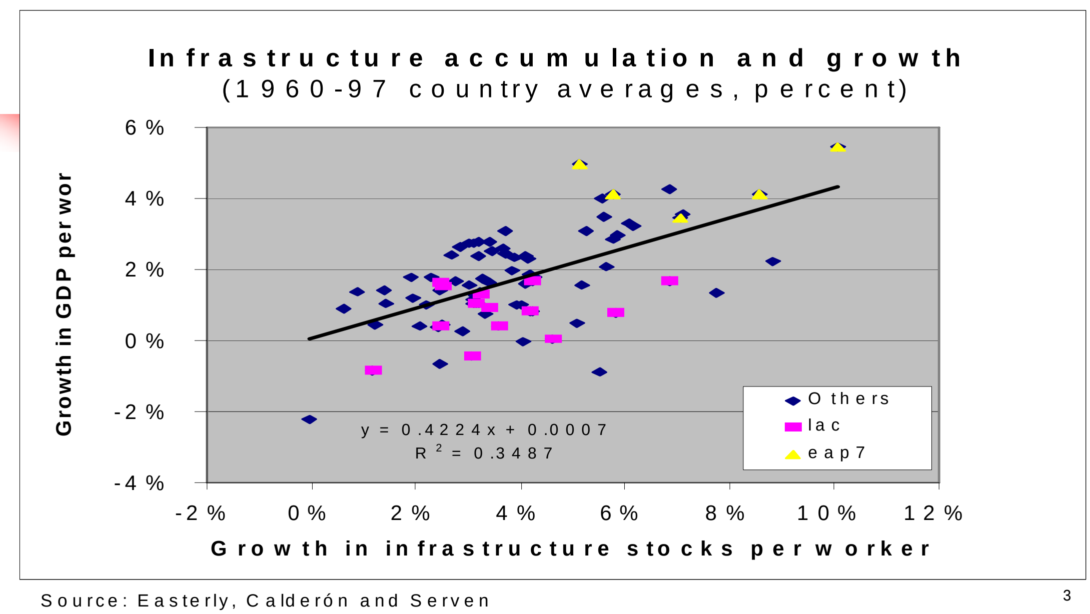

Figure 1: Infrastructure and Growth

The strong links between infrastructure, welfare and equity

Infrastructure provision is important not only for growth, but also for equity and poverty reduction (World Bank 2005b, c). In the Sub-Saharan African context, infrastructure directly and strongly affects human welfare and equity across community and income groups. Urban and rural households in Sub-Saharan Africa—South Africa included---experience widely different access to basic infrastructure services and lowest household

income groups often have no or extremely limited access to electricity, improved water and sanitation, or basic telephone services. (Figures 2-3).

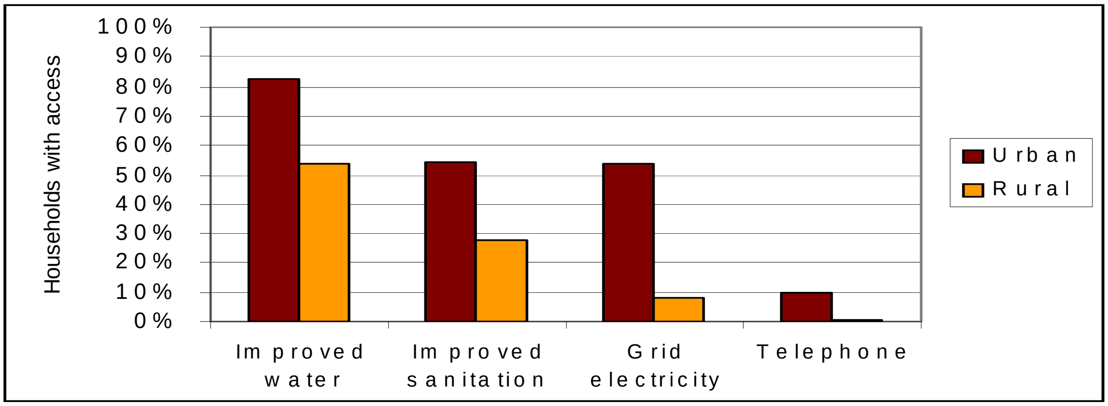

Figure 2: Different Access of Urban and Rural Households in Sub-Saharan Africa. Source: Estache (2005).

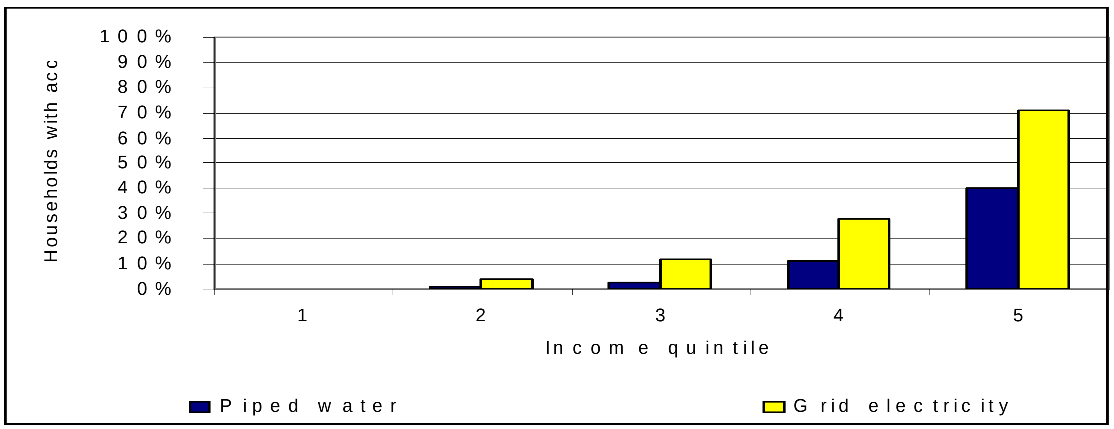

Figure 3: Access Across Income Quintiles in Sub-Saharan Africa. Source: Estache (2005).

Infrastructure, growth, and decline of infrastructure investments in South Africa

In South Africa, infrastructure has also been found to affect growth (see, for example, Fedderke, Perkins and Luiz 2005) with electricity having the largest and most robust impact on aggregate growth. Investment in infrastructure does appear to lead economic growth in South Africa, both directly and indirectly by raising the marginal productivity of capital; there is also weak evidence of feedback from output to infrastructure.

Since the 1970s, however, there has been a clear, long-term decline in infrastructure investment and capital stock, becoming an area of potential policy concern. Investment per capita fell from 1976 to 2002 (1995 prices) by 72%. As a percent of GDP, investment fell from 8.1% of GDP to only 2.4% of GDP, below the international benchmark of

approximately three to six percentage points identified by Kessides (1993: ix). Despite major efforts to extend electricity and telephone services to previously under-serviced areas, particularly since 1994, international, comparative benchmarking of South Africa's infrastructure shows considerable room for further improvement if South Africa is to catch up with the infrastructure performance of the upper-middle income group of countries (Bogetić and Fedderke 2005b).

Infrastructure scale-up in South Africa

The South African government has recognized the need to scale up infrastructure investments and major investment plans have been prepared. The 2005 budget and the 2005 Medium Term Budget Policy Statement, in particular, provide for significant expansion of investment in infrastructure, at central government, local government and public enterprise levels (e.g., ESKOM) as well as in collaboration with the private sector (PPIs). National Treasury projects that total infrastructure expenditures (at all levels mentioned above) will be gradually scaled up from 5.2% of GDP in 2004/05 to 6.7% in 2008/09, doubling these expenditures in nominal terms, from R 72 billion to R 135 billion in the same period (National Treasury, 2005 b, p. 36).

It is, therefore, within this broad context of renewed international interest in the links between infrastructure, growth and equity, the decline in infrastructure investments in South Africa over the past two decades, and the ongoing efforts of the South African government and the policy debate to scale up infrastructure in the period ahead, that we hope to provide a contribution in this paper by (i) applying an innovative, general empirical framework for estimating investment demand in electricity and telephony using panel data analysis, and (ii) projecting physical investment demand and associated dollar investment requirements in the period through 2010.

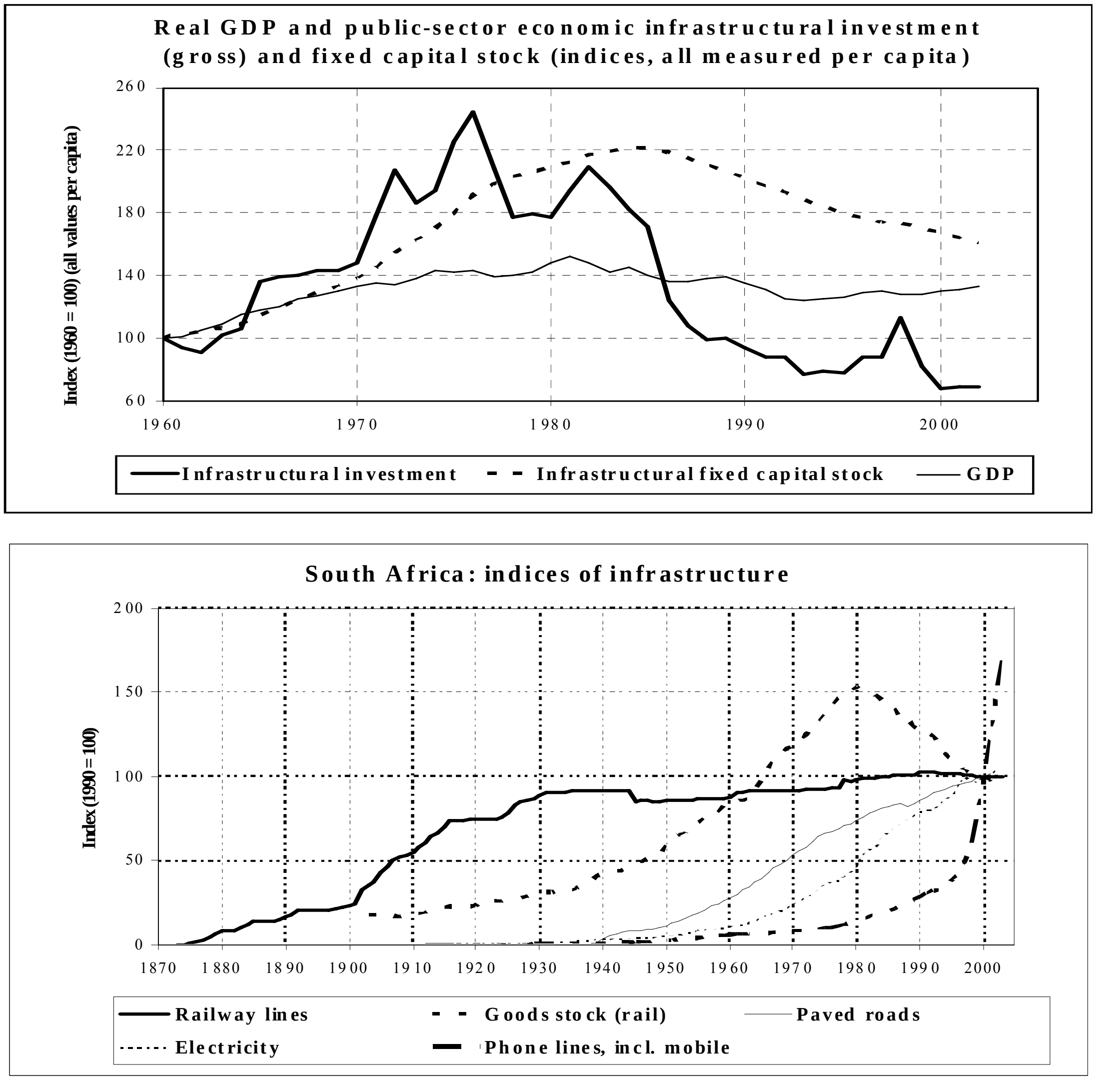

Figure 4: Historical Evolution of Infrastructure in South Africa. Source: Fedderke, Perkins and Luiz (2005).

Organization of the Paper

The paper has three related objectives. First, following previous studies of infrastructure investment needs, we use a panel of 52 countries to estimate robust functions of “demand” for electricity production and telephone lines (both fixed and cellular). We innovate by employing dynamic, heterogeneous panel estimation techniques that have not previously been employed in this context. Second, using these estimates, we forecast future infrastructure demand in both electricity generation and telecommunications for two alternative growth scenarios (“current” and “accelerated” scenarios). This serves to help assess and build on the current South African public policy effort to create conditions for accelerated and shared growth, inter alia, by eliminating infrastructure

bottlenecks. Third, using appropriate available measures of cost, we forecast the investment flows required in order to meet projected infrastructure needs in South Africa in electricity and telecommunications.

Earlier Studies of Infrastructure Needs

Several recent studies have either estimated infrastructure needs in developing countries or attempted to determine factors that influence an optimal level of public expenditure on infrastucture. Fay (2001) and Fay and Yepes (2003), for example, develop a methodology designed to identify the physical needs in infrastructural stocks. The basis of the methodology is the interaction of a demand for infrastructure, based on utility maximizing consumers, such that:

$$I_j^C = f\left(Y_j, q_I\right) \tag{1}$$

where I_j^C denotes the consumption of infrastructure by individual j, Y_j denotes j′s income, and q_I the price of infrastructure. Profit maximization on the production side of the economy provides the standard first order condition:

$$\frac{\delta Y_i}{\delta I_i^P} = \frac{q_I}{w_i} \tag{2}$$

where Y_i denotes the i′th firm's output, w_i the i′th firm's output price, and I_i^P the production use of infrastructure.

This framework leads Fay (2001) and Fay and Yepes (2003) to the formulation of a reduced form demand for infrastructure in per capita format:

$$\frac{I}{P} = F\left(\frac{Y}{P}, \frac{q_I}{w}, Y_{ag}, Y_{ind}, A\right) \tag{3}$$

where P denotes population, Y_{ag} and Y_{ind} the output of the agricultural and industrial sectors respectively,[2] and A denotes technology.

In their estimation, Fay (2001) and Fay and Yepes (2003) employ fixed effects estimation, in which fixed effects are to control for the unobservable aggregate infrastructure price, (q_I/w) , and technology dimensions. They apply this methodology to Latin America, as well as a wider set of countries.

An alternative approach to establishing an appropriate level of infrastructural expenditure is provided by Randolph, Bogetić and Hefley (1996). Conditional mean infrastructural

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[2] These are admittedly somewhat ad hoc proxies to address the aggregation issues that arise from developing industry demand from firm level demand functions.

expenditure in their model is determined by a wide range of regressors, including the existing stock of infrastructure, population density, the urbanization rate, the urban-rural balance, the labor force participation rate, per capita GDP, the internal and external balances, size of the foreign sector, terms of trade shifts, debt obligations, the level of institutional development, level and mix of foreign funding, and the degree of anti-poverty commitment on the part of government.

In our approach, we broadly follow the Fay (2001) and Faye and Yepes (2003) specification, taking into account recent work of Estache (2005) and the World Bank (2005a) that includes estimates of investment needs in the entire Sub-Saharan African region. The methodological innovation is the use of a panel of 52 low- and middle-income countries employing dynamic heterogeneous panel estimation methods in order to arrive at robust estimates of "demand" for infrastructure in electricity and telephony as a first step towards forecasting investment needs in South Africa.

The Econometric Approach to Estimating Demand for Infrastructure

The general approach

We adopted a three-stage, general econometric approach in estimating the demand for electricity and telephony, and for projecting the dollar investment needs in electricity and telephony for South Africa through 2010.

In the *first stage* of the research, we perform a panel data analysis on 52 countries for the period 1980-2002 from the World Bank World Development Indicators database to estimate two separate demand equations, for electricity and total telephone lines (fixed and cellular). The estimator employed in this context distinguishes between long-run equilibrium and short-run dynamics, and allows for panel group (country) heterogeneity in the dynamics of adjustment to long run equilibrium. In doing so, we avoid the danger of bias and inconsistency in estimation under the assumption of group homogeneity. The result is a set of more accurate parameter estimates, underlying the remainder of the forecasting exercise.

Then, in the *second stage*, we use the estimated demand equations to project the electricity and telephone demand until 2010 using consensus forecast of per capita growth for South Africa and the shares of manufacturing, agriculture, and services. This provides projections of the physical stocks and flows of electricity and telephone lines.

In the *third and final stage*, we use appropriate unit prices and the projected physical demand for electricity and telephone lines to arrive at the average dollar value of investment needs per year under the current growth scenario (average annual growth of 3.6% per year) and the alternative, government-targeted accelerated growth scenario of 6% per year. The resulting estimates provide average annual investment requirements in electricity and telecom up to 2010 for two alternative growth scenarios.

The panel analysis

The estimator is provided by the Pooled Mean Group Estimator Methodology provided by Pesaran, Shin and Smith (1999). Thus we base our panel analysis on the unrestricted error correction ARDL *(p,q)* representation:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta_i^{'} x_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^{'} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it,} \tag{4}$$

i = 1,2, ..., N, stand for the cross-section units, and t = 1,2, ..., T, indicate time periods. Here y_{it} is a scalar dependent variable, x_{it} (k x 1) is the vector of (weakly exogenous) regressors for group i,μ_i represent the fixed effects, ϕ_i is a scalar coefficient on the lagged dependent variable, β_i is the k x 1 vector of coefficients on explanatory variables, λ_{ij}'s are scalar coefficients on lagged first-differences of dependent variables, and δ_{ij}'s are k x 1 coefficient vectors on first-differences of explanatory variables and their lagged values. We assume that the disturbances ε_{it} 's are independently distributed across i and t, with zero means and variances $\sigma_i^2 > 0$. We also make the assumption that σ_i<0 for all i and thus there exists a long-run relationship between y_{it} and x_{it} :

$$y_{it} = \theta_i^{'} x_{it} + \eta_{it}, i = 1,2,\ldots, N, t = 1,2,\ldots, T, \tag{5}$$

where $\theta_i = -\beta_i^{'} / \phi_i$ is the k x 1 vector of the long-run coefficient, and η_{it}*'s* are stationary with possibly non-zero means (including fixed effects). Then, equation (4) can be written as:

$$\Delta y_{it} = \phi_t \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^{'} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it,} \tag{6}$$

where $\eta_{i,t-1}$ is the error correction term given by (5), and thus ϕ_i is the error correction coefficient measuring the speed of adjustment towards the long-run equilibrium.

We consider the Pooled Mean Group (PMG) estimator advanced by Pesaran, Shin and Smith (1999), which allows the intercepts, short-run coefficients and error variances to differ freely across groups, but the long-run coefficients are constrained to be the same; that is $\theta_i = \theta, i = 1,2,\ldots, N$. The common long-run coefficients and the group-specific short-run coefficients are then computed by the pooled maximum likelihood (PML) estimation. Denoting the PML estimators by $\tilde{\phi}_i, \tilde{\beta}_i, \tilde{\lambda}_{ij}, \tilde{\delta}_{ij} and \theta.$, we obtain the PMG estimators by $\hat{\phi}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\phi}_i}{N}$, $\hat{\beta}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\beta}_i}{N}$, $\hat{\lambda}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\lambda}_{ij}}{N}, j = 1,\ldots, p-1,$

$\hat{\delta}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\delta}_{ij}}{N}$, $j = 1,\ldots,q-1,$, and $\hat{\theta}_{PMG} = \tilde{\theta}$. This highlights both the pooling implied by the homogeneity restrictions on the long-run coefficients and the averaging across groups used to obtain means of the estimated error-correction coefficients and other short-run parameters.

We briefly discuss one important modeling issue. The PMGE is legitimate only where long run parameters are homogeneous across groups. Tests of homogeneity of error variances and/or short- or long-run slope coefficients can be easily carried out using Log-Likelihood Ratio tests, since the PMG and dynamic fixed effects (DFE) estimators are restricted versions of (possibly heterogeneous) individual group equations. However, we note that the finite sample performance of such tests is generally unknown and thus unreliable. An alternative would be to use Hausman (1978) type tests. The mean group (MG) estimator[3] provides consistent estimates of the mean of the long-run coefficients, though these will be inefficient if slope homogeneity holds. For example, under long-run slope homogeneity the PMG estimators are consistent and efficient. Therefore, the effect of both long-run and short-run heterogeneity on the means of the coefficients can be determined by the Hausman test (hereafter *h* test) applied to the difference between MG and PMG or DFE estimators. It is this approach that is adopted in the present study.

As long as sector-homogeneity is assured, the PMG estimator offers efficiency gains over the MG estimator, while granting the possibility of dynamic heterogeneity across sectors unlike the DFE estimator. In the presence of long run homogeneity, therefore, our preference is for the use of the PMG estimator.

Finally, it is worth pointing out that a crucial advantage of the estimation approach of the present paper is that dynamics are explicitly modeled.

The data

The summary statistics for the fully balanced (1,472 observations for each variable), 52-country panel data for the period 1980-2002 from the World Bank World Development Indicators database are provided in Table 1. The list of countries is provided in Appendix A.

The dependent variables are (i) electricity production per capita (in kwh) (elepropc), and (ii) total telephone lines (fixed lines and cellular phone subscribers) per 1,000 population (telpc). The independent variables are: GDP per capita in PPP terms (constant US$, 2000) (gdppc), shares of agriculture (yag), manufacturing (yman) and services (yserv) in real GDP, and a dummy variable for a structural break arising from the emergence of the cellular lines (in 1996).

Demand for electricity production and telephone lines were estimated separately for each infrastructure service. Table 1 shows means, standard deviations, and other summary

[3] See Pesaran and Smith (1995).

statistics for each variable. The sample mean for the dependent variable electricity production per capita is 2,639 kwh per capita, and for the telephone lines per capita it is 195. For the purpose of estimation, per capita infrastructure and income measures were transformed into natural logarithmic form.

Table 1: Summary Statistics of the Panel Data, 1980-2002, 52 low- and middle-income countries

	gdppc	yag	yman	yserv	eleconpc	elepropc	telpc
mean	8336.2	15.2	17.6	53.1	2343.6	2638.6	195.4
median	4788.9	12.9	17.1	53.2	784.6	955.3	57.8
max	57740.8	62.6	40.5	87.5	24858.4	31086.2	1857.4
min	644.4	0.1	3.5	17.2	11.4	1.9	0.4
stddev	8641.5	11.7	6.7	11.3	3920.4	4364.8	297.0
skewness	1.6	1.1	0.4	-0.2	3.1	3.4	2.3
kurtosis	2.5	1.3	0.1	0.2	11.3	13.6	5.8
observations	1472	1472	1472	1472	1472	1472	1472

Source: World Development Indicators data base, World Bank (www.worldbank.org).

Results

We base our prediction of the required stocks and flows of infrastructure on an estimated long-run demand using a 52-country panel. The list of countries in the panel is listed in Appendix A. Justification for the use of international data is in the spirit of providing a benchmark against comparable country experiences. Advantage of the PMGE methodology is that the implicit assumption of homogeneity across the panel is explicitly tested for. The panel of countries was also limited to low- and middle-income countries, in order not to bias estimated infrastructure demand upward through the inclusion of high-income countries.

We estimated the following empirical specification of equation (3):

$$\ln\left(\frac{I}{P}\right)_{i,t} = \alpha + \beta_y \ln YPC_{i,t} + \sum_{k=1}^{3} \beta_k YS_{i,t} + \delta Z_{i,t} + \varepsilon_{i,t} \qquad (7)$$

where I denotes the relevant infrastructural measure (electricity, total telephone lines),[4] P population, YPC per capita real GDP, YS sectoral shares in GDP, where we consider agriculture (YAG), manufacturing (YMAN), and services (YSERV), and Z denotes a vector of additional explanatory variables.

Table 2 reports estimation results for the two long-run relationships. Results confirm adjustment to equilibrium (see the ECM-parameters, which correspond to the δ - parameters of equation 4), though unsurprisingly for infrastructure the adjustment to equilibrium is relatively slow, particularly in the case of telephones. The Hausman tests (denoted h-tests) confirm the legitimacy of the PMG estimator by failing to reject the homogeneity restriction on the long-run coefficients across our panel of 52 countries. The log likelihood statistics suggest a relatively high level of fit.

[4] Total telephone lines = fixed + mobile telephone lines.

Table 2: Estimates of Long-Run Demand for Electricity and Telephony

Dependent Variable: I/P		
	1	2
	$\frac{Electricity}{Population}$	$\frac{Telephones}{Population}$
ARDL:	PMGE AIC(2)	2,1,1,1,1
lnYPC	1.428* (0.022)	1.198* (0.310)
YAG	-0.007* (0.001)	-0.035* (0.015)
YMAN	0.011* (0.002)	-0.055* (0.010)
YSERV		0.079* (0.010)
D96		1.059* (0.080)
ECM	-0.28* (0.05)	-0.04* (0.01)
h-test	3.10 [0.38]	8.89 [0.11]
RLL	1979.22	1422.89
ULL	2401.12	1821.27
LR: χ^2	843.79*	796.77*

Note: Figures in round parentheses denote standard errors. Figures in square parentheses denote probability levels. * denotes rejection of the null at the 5% level of significance.

Both estimations return an income elasticity that lies above unity. In the case of electricity demand, the elasticity of 1.4 is comparable to other international findings. For instance, the World Development Report (1994) reports electricity income elasticities varying between 1.6 and 1.7, while Fay (2001) reports power elasticity for Latin America of approximately 1.1. The telephone elasticity of approximately 1.2 is again comparable to other international evidence, with the World Development Report (1994) again reporting a 1.6 to 1.7 elasticity range for telephones, while Fay's (2001) Latin American elasticity is approximately 1.0. Given that the WDR (1994) data sample did not extend beyond the late 1980's, our estimated elasticities are thus relatively close to the study using more recent data (Fay's data sample extends to 1995).

The share of agriculture reports a negative and statistically significant association with the two per capita infrastructure measures. While Fay (2001) reports positive coefficients on YAG for Latin America, the broader panel of Fay and Yepes (2003) reports results consistent with ours. Given that a declining share of agriculture in GDP is associated with industrialization and urbanization, with a rising share of economic activity and of households more intensive in electricity and telephone use, the negative coefficient is plausible.

The share of manufacturing in output is positively related to per capita electricity, but negatively related to per capita telephone use. Given the relative energy intensity of manufacturing, the electricity result is intuitively plausible. One possible reason for the negative coefficient for the telephone per capita estimation, may be the existence of a threshold effect in the association - with demand initially rising rapidly in manufacturing activity, but at a sharply decreasing rate.[5] The net effect may thus be a plateau of demand by manufacturing.

For the telephone specification, we added both the share of services in output, and controlled for a structural break in telephone provision in 1996. The first augmentation of the specification is justified on the grounds that service sectors are likely intensive in the use of telephones, while the 1996 structural break corresponds to the introduction of mobile phone technology, which is reflected in a marked change in the rate of increase in telephone lines in most of the countries included in our panel.[6]

The service sector share in GDP has the predicted positive impact on per capita telephone use, while the structural change also proves significant implying a permanent acceleration in the growth rate in per capita telephony of 1% per annum.

Forecasting Investment Flows in South Africa—Electricity and Telephony

The current growth scenario

The panel estimates presented above form the basis for our forecast of electricity and telephony demand for South Africa under two growth scenarios, a current growth scenario assuming average annual growth of 3.6% through 2010, and a significantly accelerated growth scenario assuming a 6% annual growth in the same period.[7] In this section, we first discuss the implications of the current growth scenario.

We project the physical measures of electricity and telephone infrastructure (left hand side of equation 9) in the period 2003 by using projected explanatory variables (i.e., growth and sector shares on the right-hand side of equation 9) in the estimated equation. Next we obtain U.S. dollar values of required investment flows in the two sectors by using appropriate unit costs. For electricity, we used the average projected long-run marginal cost of power generation (National Integrated Resource Plan 2002) for the period 2005-2010. Due to some uncertainty about the precise projected unit cost of electricity generation, we used lower bound estimate of the average long run marginal cost for the period 2005-2010 (US$2.1 cents) and an upper bound estimate (US$3.7) based on the LRMC at the end of the projection period. For telecom, we used the best practice international unit cost (see Table 3)

[5] The essential intuition here is straightforward: manufacturing activity may require a relatively fixed number of lines per establishment, making the association with the level of value added strongly non-linear.
[6] Note that previous studies did not include time periods subject to the structural change.
[7] Note that the forecast employs South Africa specific dynamics in addition to the long-run coefficients reported above. The full specification is available from the authors on request.

Table 3: Unit Cost of Infrastructure in South Africa: Electricity and Telecom	
Sector	**Unit Costs**
Power:	
Lower Bound 1/	$0.021 per kwh
Upper Bound 2/	$0.037 per kwh
Telecom	$1,000 per telephone mainline
Notes 1/ Lower bound represents long run marginal cost of generation. Figure may be underestimate since it is based on projected demand growth that the present study suggests may be an underestimate.	
2/ Upper bound represents long run marginal cost of generation adjusted for average cost of generation. Upper bound = 1.8 x Lower Bound.	

Note: Source for Telecom Cost: Fay (2001); Source for Electricity Cost: National Integrated Resource Plan (2002).

Our forecasts indicate that the **electricity** production would grow from 4,815.47 kwh per capita in 2002 to 5,418.23 kwh par capita in 2005, reaching 6,453.19 kwh per capita in 2010. The average annual forecast growth rate for electricity production based on the estimated long-run relation during 2003-2010 is 3.7%. See Figure 5a.

For **telecom**, our model forecasts the growth in total telephone lines per 1000 of population from 410 in 2002 to 474 in 2005, and then 664 in 2010. The implied growth rate in the period 2003-2010 is 6.0%. For comparison, a similar exercise for Latin American upper middle-income countries resulted in telephone lines of 255 per 1000 of population (Fay 2001). See Figure 5b.

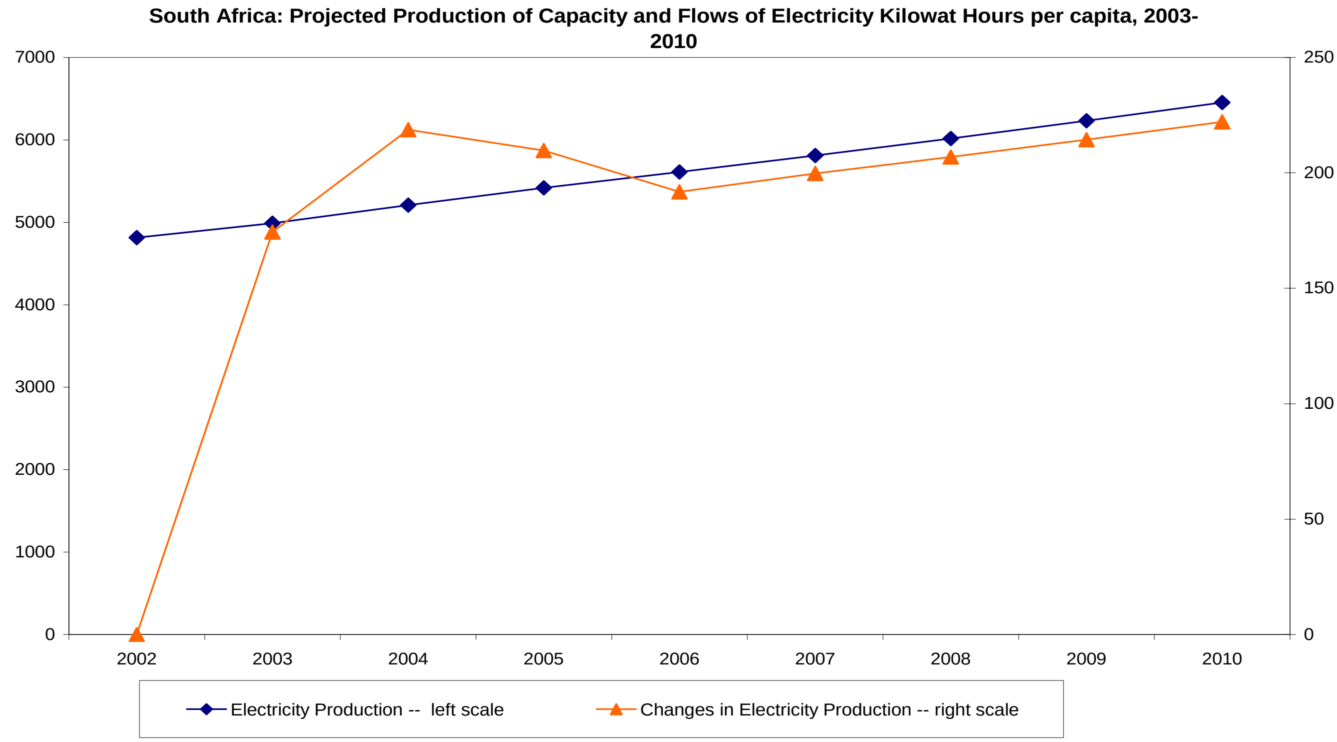

Figure 5a: 2003-2010 Forecast of Electricity Infrastructure Demand

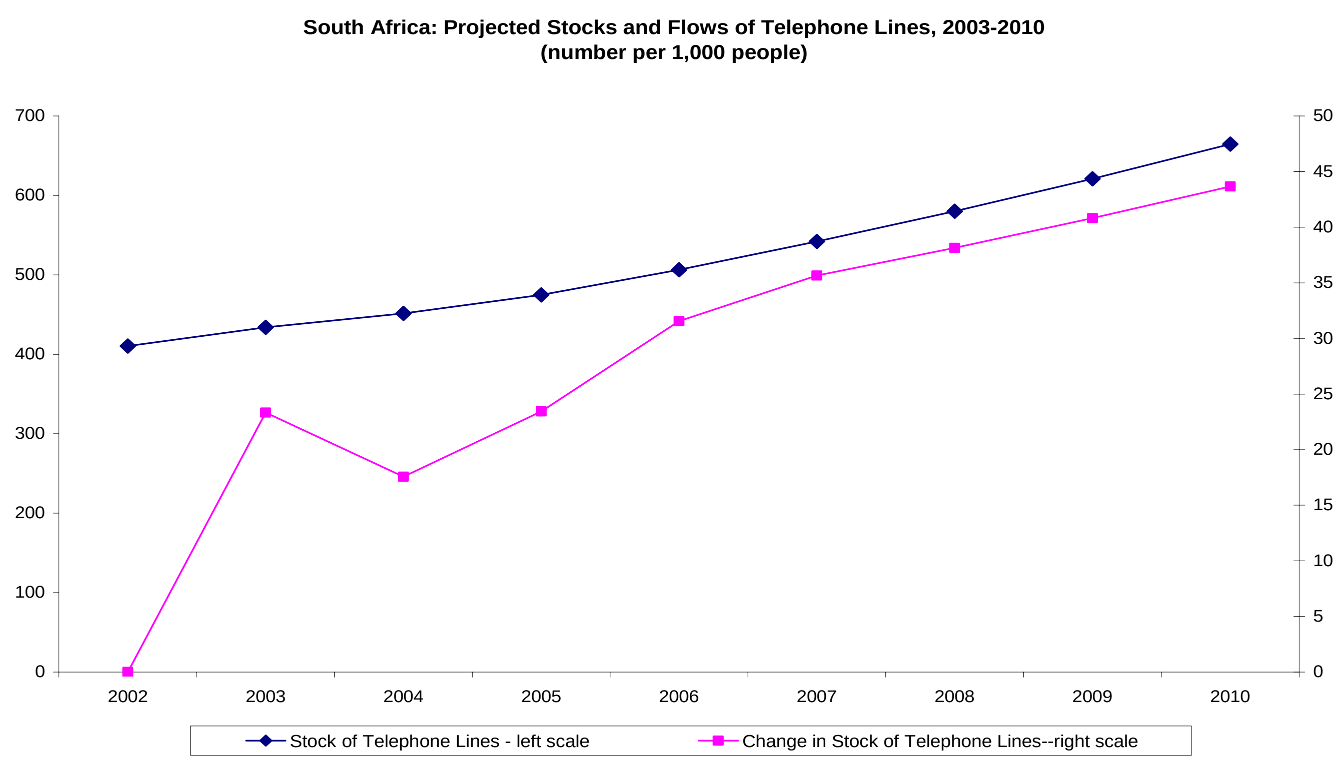

Figure 5b: 2003 – 2010 Forecast of Telephony Infrastructure Demand.

The estimates represent projected expansion in physical infrastructure (electricity production and telephone lines), and do not say anything about possible need for rehabilitation or upgrading or operations and maintenance expenditures. Hence both the physical and derived dollar value of required investments are likely to be lower-bound estimates.

To translate these forecast physical infrastructure into dollar values of required investment flows, we follow the simple approach earlier applied by Fay (2001) in estimating infrastructure financing needs in Latin America. We calculate the investment needs as the change in projected physical infrastructure multiplied by the cost of infrastructure as explained above (Table 3). Unit costs in Table 3 were inflation-adjusted over the period of projection for an average annual inflation rate of 4%.

Table 4: South Africa – Infrastructure Investment Needs Forecast, The Current Growth Scenario*, 2003-2010

	Average Annual Investment Flows		
	In billions of US$	In billions of rand	In % of GDP
Power:			
Lower Bound:	0.29	1.87	0.11
Upper Bound:	0.52	3.37	0.20
Telecom:	1.98	12.90	0.75
Total (upper bound):	2.50	16.27	0.95

*Average annual growth projection (in %): 3.6%. Source: IMF and World Bank medium-term projection.

Source: The authors' estimates.

Using this method, we predict that total value of the electricity generating stock employing the lower bound cost structure is going to increase from US$ 4.03 billion (R 26.21 billion) in 2002 to US$ 5.29 billion (R 34.38 billion at an exchange rate of R6.5/$1) in 2005, and then to US$ 8.13 billion (R 52.87 billion) in 2010. Therefore, required average annual investments --- changes in stocks --- in electricity over the period 2003-2010 are of the order of $ 0.29 billion (R 1.87 billion) (See Table 4, and Figures 6a,b).

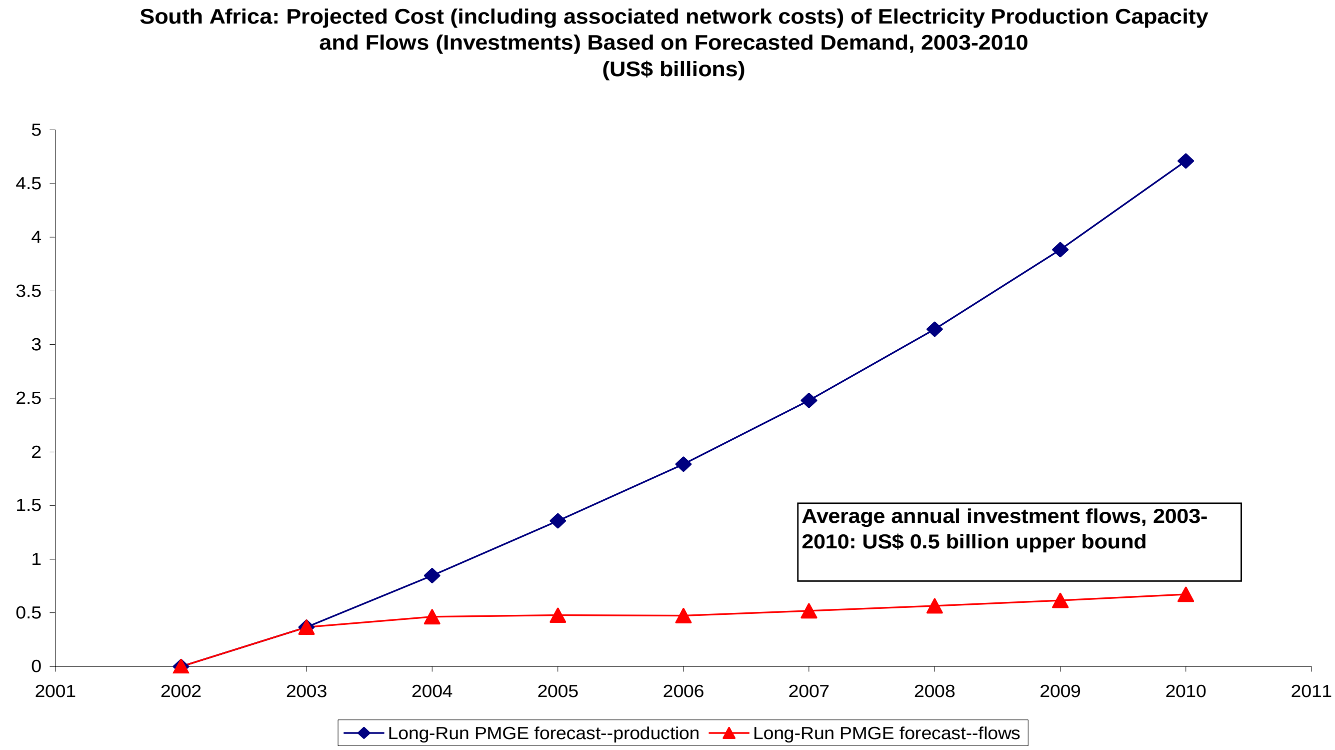

Figure 6a: 2003 – 2010 Forecast of Cost of Electricity Infrastructure Demand

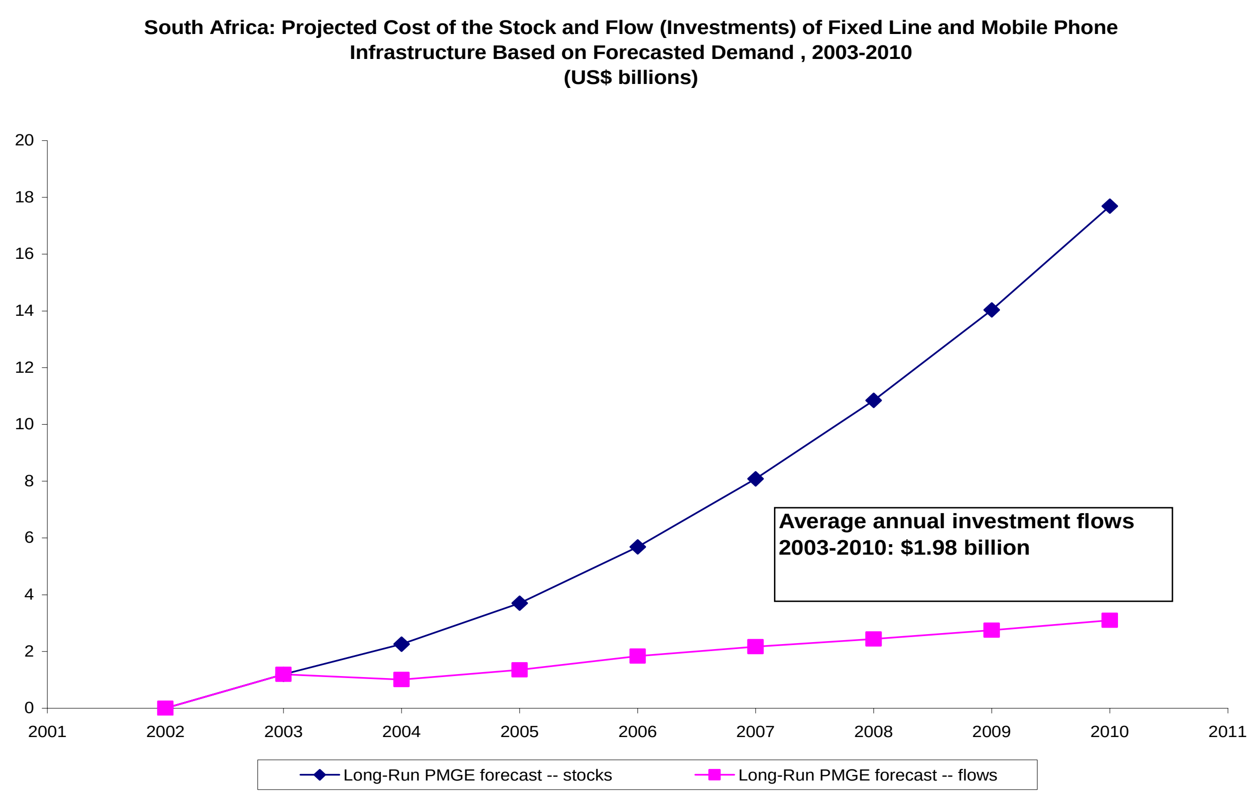

Figure 6b: 2003 – 2010 Forecast of Cost of Telephony Infrastructure Demand

Using the upper bound cost structure, we predict that total value of the **electricity** generating stock is going to increase from US$ 7.26 billion (R 47.17 billion) in 2002 to US$ 9.52 billion (R 61.88 billion at an exchange rate of R6.5/$1) in 2005, and then to US$ 14.64 billion (R 95.18 billion) in 2010. Therefore, ***required average annual investments in electricity over the period 2003-2010 are of the order of $ 0.52 billion (R 3.37 billion) or about 0.2% of GDP***[8] (See Table 4 and Figure 6a). Again, note that this covers only generation, excluding transmission and distribution and operations and maintenance expenditures.

Similarly, the value of the stock of total **telephone lines** is going to increase from US$ 16.5 billion (R 107.2 billion) in 2002 to US$ 22.3 billion (R 145 billion) in 2005, and then to US$ 40.3 billion (R 262.2 billion) in 2010***. Required average annual investments in telecom in the period 2003-2010 are therefore of the order of $ 1.98 billion (R 12.9 billion) or about 0.75% of GDP*** (See Table 4 and Figure 6b). Taken together, investment needs in electricity generation and telephone lines are of the order of US$2.5 billion (about 1% of GDP).

How do these investment requirements compare with local estimates of investment needs? For electricity, ESKOM has estimated average annual investment needs in electricity generation, which are approximately of the order of $US1.0 billion, but this includes the cost of investment and rehabilitation of transmission and distribution and a margin for peak demand (Eskom 2005). Therefore, our estimates related to electricity production only appear broadly in line with the ones prepared by ESKOM. It should also be noted that while our estimates rely on a robust, multi-country estimate of demand for electricity that is used to forecast South Africa's needs using projected demand variables, ESKOM's estimates rely on engineering projections based on South Africa's time series of electricity consumption. For telecom, we were unable to identify similar, "official" local estimates of investment requirements in the telecom sector, but our estimates are broadly in line with similar estimates done for other countries (e.g., in Latin America).

An Accelerated Growth Scenario

The above forecasts are based on the consensus IMF and World Bank predicted growth rate of South African GDP in medium term *before* the adoption of the accelerated and shared growth policy agenda. The forecasts also include corresponding growth rates in the agricultural, manufacturing and services sectors.

We now consider the infrastructure needs associated with an alternative, accelerated growth scenario with the average annual GDP growth rate of 6% identified by the South African government as a policy target.[9] The purpose is to illustrate how infrastructure

[8] All projected ratios of GDP use average, annual projected GDP for the forecast period.
[9] The sectoral growth rates that correspond to a 6% GDP growth rate were calculated by averaging previous sectoral contributions to GDP growth, and then scaling these up to correspond with a GDP growth rate of 6%. It should be noted that the assumption of the 6% average annual growth in this illustrative exercise

investment requirements would change if a *significantly* accelerated growth scenario were to materialize in the coming years. Such an exercise is relevant and timely for two reasons. First, South African economy has been growing at an accelerated average annual growth rate of about 4% per year since 2004 and the short term outlook remains strong. Second, the officially adopted accelerated and shared growth initiative of the South African government is aiming for just such 6% annual growth, albeit suggesting that might only be attainable after 2010. Our illustrative, accelerated growth scenario is features a more ambitious growth path of 6% already achieved during the period 2006-2010. As such, our two growth scenarios discussed in the paper should cover the range of possible growth paths in this period with associated investment requirements in electricity and telecom.

The forecast of infrastructure under our accelerated scenario now indicate that **electricity** production would grow from 4815.47 kwh per capita in 2002 to 5873.72 kwh per capita in 2005 (8% greater than the earlier forecast) and 8179.43 kwh per capita in 2010 (over 25% greater than the earlier forecast). Using the upper bound cost structure, the ***required average annual investments over the period 2005-2010 are now of the order of $0.96 billion (R6.23 billion), almost double the forecast under the lower, current GDP growth rate.***

For **telecom**, the model now forecasts growth in total telephones per 1,000 of population from 410 in 2002 to 571 in 2005 (20% greater than the earlier forecast), and then 1,000 in 2010 (50% greater than the earlier forecast). The large differences between these predictions and the earlier predictions are due to the considerable growth in the services—the largest sector of the economy--and because demand for telecom is driven largely by the service sector. ***Required average annual investments in telecom are now 116% greater than those calculated earlier, and are of the order of $4.28 billion (R27.83 billion) or about 2% of GDP.***

The main implication of considering the accelerated scenario is that it implies considerably higher infrastructure investment requirements to sustain the virtuous circle of productive infrastructure investments and growth. In electricity, our estimates indicate that average annual investment requirements in electricity production only would rise to the order of about $1.0 billion, which is close to what ESKOM currently projects but including transmission, distribution, rehabilitation, and peak requirements, probably of the order of at least about $US500 million (this also excludes distribution rehabilitation of areas that are under the control of local governments, rather than ESKOM, which may be substantial). ***In a nutshell, if the accelerated scenario were to materialize in the short term, it is possible that the ESKOM's current investment plans would fall well short of investment needs.*** In that case, ESKOM's scale, timeline, and financing structure of its investment scale up will need to be revised. Equally important, there would be a need to develop robust estimates of the cost of rehabilitation and maintenance of (and institutional requirements) of the distribution network under the control of the local governments.

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reflects a more ambitious growth than in the official government documents that aim to achieve this target gradually, by 2010 (see Erwin 2005). The two growth scenarios are therefore used for illustrative purposes.

In telecom, the accelerated growth requirements of the order of some US$4 billion are very significant and it is not clear whether they can be met within the current industry and market structure set up. It will, therefore, need to be considered in the context of the broader regulatory reform of the sector to tap the potential efficiency gains from greater competition and higher investments.

Conclusion

The following main conclusions arise from this and related analyses.

First, new investments in infrastructure are required in South Africa to reverse the investment decline from the past several years and build the new capacity required to support accelerated growth, competitiveness, poverty reduction and more rapid economic and social integration of the society.

Second, our previous work on international benchmarking of infrastructure performance (Bogetić and Fedderke (2005 a) suggests solid service at reasonable quality compared to relevant benchmarks and, in some cases, very competitive prices. But there remain significant shortfalls relative to benchmarks in all infrastructure sectors, largely related to limited access and less than expected quality, especially in rural areas where most of the poor reside. It also shows that access to electricity in urban areas, for example, in South Africa (84%) remains below that of its main comparator group of countries—upper middle income group (90%). Access in rural areas is rather low (37%) although higher than the average in the same group of countries (30%), reflecting recent major efforts towards electrification.

Third, we estimated a long-run dynamic model of demand for electricity and telecom using panel data on 52 countries for the period 1980-2002; the model performs well in characterizing historical demand. We use the model to project demand forward in the 2003-2010 period for South Africa in order to derive preliminary estimates of the cost of required new investments in electricity and telephone lines under two growth scenarios for South Africa's economy.

Fourth, the estimates of required investments to meet demand for electricity and telephones under the current growth scenario of 3.6% per annum over the medium term are as follows:

Electricity production: US$0.5 billion per year or 0.2% of GDP per year

Telephone lines: US$1.98 billion per year or 0.75% of GDP per year

Fifth, the accelerated growth path of 6% per annum would result in approximately doubling of these investment requirements.

One caveat: these estimates are independent of any policy assessments of the optimal financing and ownership structure of the new investments in these infrastructure sectors. Our paper simply establishes these requirements for alternative growth scenarios. We also believe that meeting these requirements will be important not only for accelerating growth, but also for achieving greater equity and poverty reduction. The paper, however, does not say anything about more operational issues such as an optimal or appropriate mix of public versus private sector provision and internal versus external sources of financing, issues that have been discussed recently in South Africa's main annual and medium-term budget documents.

Finally, we hope that this analysis will contribute to the broader debates on electricity and telecom infrastructure and constraints to accelerated and shared growth in South Africa, as well as discussions about the likely investment requirements in these important infrastructure sectors.

Appendix A: List of Countries in Panel for Infrastructure Forecast

1	Algeria
2	Argentina
3	Bangladesh
4	Benin
5	Bolivia
6	Brazil
7	Cameroon
8	Chile
9	China
10	Colombia
11	Congo, Dem. Rep.
12	Congo, Rep.
13	Costa Rica
14	Denmark
15	Dominican Republic
16	Ecuador
17	Egypt, Arab Rep.
18	El Salvador
19	France
20	Gabon
21	Ghana
22	Guatemala
23	Honduras
24	India
25	Indonesia
26	Iran, Islamic Rep.
27	Jamaica
28	Japan
29	Jordan
30	Kenya
31	Malaysia
32	Mexico
33	Morocco
34	Nepal
35	Nicaragua
36	Nigeria
37	Pakistan
38	Panama
39	Paraguay
40	Peru
41	Philippines
42	Senegal
43	South Africa
44	Sri Lanka
45	Thailand
46	Trinidad and Tobago
47	Tunisia
48	Turkey
49	Uruguay
50	Venezuela, RB
51	Zambia
52	Zimbabwe

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