AN ANALYSIS OF ECONOMIC INFRASTRUCTURE INVESTMENT IN SOUTH AFRICA

PETER PERKINS, JOHANN FEDDERKE AND JOHN LUIZ *

Abstract
This paper analyses long-term trends in the development of South Africa’s economic infrastructure and discusses their relationship with the country’s long-term economic growth. A database covering national accounts data, railways, roads, ports, air travel, phone lines and electricity was established for this purpose, and may facilitate further quantitative research. PSS (Pesaran, Shin and Smith, 1996, 2001) F-tests are used to identify directions of association between economic infrastructure and economic growth. These indicate long-run forcing relationships from public-sector economic infrastructure investment and fixed capital stock to gross domestic product (GDP), from roads to GDP, and from GDP to a range of other types of infrastructure. There is also evidence of potential simultaneity between specific types of infrastructure and GDP. The evidence suggests three main findings. Firstly, the relationship between economic infrastructure and economic growth appears to run in both directions. Inadequate investment in infrastructure could create bottlenecks, and opportunities for promoting economic growth could be missed. Secondly, South Africa’s stock of economic infrastructure has developed in phases. Policymakers should focus on choosing or encouraging the right type of infrastructure at the right time. Thirdly, the need for investment in economic infrastructure never goes away. The maintenance and expansion of infrastructure are important dimensions of supporting economic activity in a growing economy, provided that individual projects are chosen on the basis of appropriate cost-benefit analyses.

Keywords: infrastructure, economic growth, South Africa, long-run development, railways, roads, ports, telephones, electricity

1. INTRODUCTION

IDENTIFYING DETERMINANTS of long-run economic growth remains central to the South African economic policy debate. Numerous contributions have both investigated the changing structure of economic growth in South Africa,¹ and addressed the impact of a number of its determinants.² Although a number of studies have examined the contribution of aggregate investment expenditure to economic growth, few have addressed the distinction between public and private investment expenditure in general, and the impact of infrastructure investment on long-run development in particular.³

* Respectively: Lecturer, School of Economic and Business Sciences, University of the Witwatersrand; Professor, School of Economics, University of Cape Town; Professor, Graduate School of Business Administration, University of the Witwatersrand. The authors would like to thank two anonymous referees for comments made on an earlier draft.

¹ See for instance Fedderke (2002) and Lewis (2002).

² Examples are the impact of public policy in Mariotti (2002), of financial deepening in Kularatne (2002), and of the determinants of total factor productivity growth in Fedderke (2001).

³ Kularatne (2002) and Mariotti (2002) both place aggregate investment into a multiple-equation framework of South African growth. DBSA (1998) represents one of the few prior studies that we are aware of that attempts to isolate the impact of infrastructure investment on growth in South Africa; DBSA (1998) summarizes the results of other studies.
Similarly, to date little attention has been paid to the determinants of infrastructure investment in South Africa.⁴

Yet within the public policy debate infrastructure investment has been re-emerging as a topic of significance. Investment by the public sector in South Africa’s economic infrastructure grew by 15 per cent in real terms in 2003, and government has indicated that further growth is in the pipeline. For instance, according to a five-year plan for transport and electricity outlined by government in October 2004, an amount of R165bn is to be invested in state-owned enterprises Transnet and Eskom during 2005-2009. The South African government’s renewed interest in infrastructure investment follows a long period of decline and stagnation (1976-2002), which gave rise to numerous concerns in the corporate sector regarding unreliable and/or expensive infrastructure services.⁵

An important aspect of both academic and policy debates surrounding infrastructure and its role as a driver of growth is the availability of consistent infrastructure time series in South Africa. This paper seeks to initiate more work on infrastructure and its role in development by collating a wide range of indicators on the development of infrastructure in South Africa over the 1870-2002 period. It also provides initial evidence on the nature of its interaction with output.

Section 2 of the paper provides brief background information on the existing literature concerning economic infrastructure and economic growth. Sections 3 to 7 analyse the long-term trends in individual measures of economic infrastructure in South Africa, namely national accounts data, railways, roads, ports, air travel, telephones and electricity. This includes preliminary tests on the relationship between economic infrastructure and South Africa’s long-run economic growth. The analysis is based on an updated database of infrastructure variables for South Africa. Statistics South Africa and its predecessors used to publish a wide range of data relating to infrastructure goods and services in South Africa, but the publication of most of these series was discontinued in the late 1980s and 1990s. This paper provides an update and makes early data more easily accessible; notes on individual series are provided in Appendix 2 of the paper. Section 8 discusses phases of infrastructure development, and section 9 provides a summary and conclusion.

2. ECONOMIC INFRASTRUCTURE AND ECONOMIC GROWTH

The relationship between an economy and its economic infrastructure is analogous to that between a building and its foundation. Economic infrastructure typically exists not for its own sake but rather to support various kinds of economic activity (Jimenez, 1995: 2774). Barro’s model of endogenous growth (Barro, 1990) demonstrates that an important attribute of infrastructure expenditure by the public sector is that it raises the marginal product of other capital used in the production process, although only up to a point. Government spending is subject to diminishing marginal product, and once this

---

⁴ We are not aware of any studies that address this question. By contrast, attempts to isolate the determinants of long-run private-sector investment expenditure are relatively plentiful – see for instance Fielding (1997, 1999) and Fedderke (2004).

⁵ There has been some debate as to whether this period of declining public investment was in fact the consequence of (correction for) a prior ‘over-expansion’ of public investment. (We thank an anonymous referee for highlighting this point.)
falls below unity (in a Cobb-Douglas specification of the model) the financing of additional infrastructure services through higher tax revenue becomes counterproductive.

Empirical estimates of the impact of infrastructure on economic growth vary widely. Aschauer (1989) found an elasticity of output with respect to non-military public capital stock of 0.39 in the United States, implying an implausibly high marginal product for public investment. Other studies that have indicated an important role for infrastructure in raising productivity include Munnell (1990a and 1990b), Easterly and Rebelo (1993), Lee et al. (1999), Pereira (2000), and Mitra et al. (2002). Different methodologies and econometric techniques were used in these studies, and these are a source of much controversy in the literature. Both Holtz-Eakin (1994) and Garcia-Milà et al. (1996) estimated the elasticity of output with respect to government capital to be close to zero in the United States, and concluded that many previous findings were spurious.

The Development Bank of Southern Africa (DBSA) (1998) reports several estimates of the elasticity of output with respect to infrastructure in South Africa. These are relatively high, ranging from 0.15 to 0.33. Some of these results are spurious, however, having been obtained using OLS and time series data.

A more comprehensive review of these and other studies is provided in Perkins (2003).

3. NATIONAL ACCOUNTS – ECONOMIC INFRASTRUCTURE INVESTMENT AND FIXED CAPITAL STOCK

The South African Reserve Bank (SARB) publishes the public-sector economic infrastructure components of South Africa’s gross fixed capital formation and fixed capital stock (both general government and public corporations). Fig. 1 shows indices of these measured per capita, and both demonstrate a long-term deterioration: from the mid-1970s in the case of investment, and from the mid-1980s in the case of fixed capital stock. Investment per capita fell from R1 268 in 1976 to R356 in 2002 (1995 prices), a collapse of 72 per cent. Investment fell from 8.1 per cent of GDP to 2.4 per cent of GDP, which lies below the international benchmark of approximately three to six per cent identified by Kessides (1993: ix). In 2002, 72 per cent of public-sector infrastructure investment consisted of transport, communication, power and water. The recovery of infrastructure investment in the 1990s and the subsequent slump (Fig. 1) were mainly the result of expansion programmes by Telkom and Eskom to extend telephone lines and electricity to areas which were under-serviced, as well as the purchase of new aircraft by South African Airways (South African Reserve Bank annual economic reports, 1996-2000).

6 Commenting on Aschauer’s results, Gramlich (1994) shows that Aschauer’s elasticity of 0.39 implies marginal products of approximately 0.75 in 1970 and 1 in 1991.

7 Within individual empirical studies, the effects of different types of infrastructure on economic growth vary substantially. For instance, Aschauer (1989) estimated an elasticity of 0.24 for “core” infrastructure (transport, power and water) in the United States, whereas the estimated elasticities for hospitals and educational buildings were much lower (0.06 and -0.01 respectively). Pereira (2000) found that the strongest positive infrastructure effect on economic growth came from power and transport, followed by buildings (e.g. hospitals and schools), then water and sewerage, then highways and streets.
The decline in infrastructure investment between the mid-1970s and 2002 was part of an overall decline in gross fixed capital formation as a percentage of GDP over the same period.

As a percentage of GDP, South Africa’s gross savings also fell during the 1980s and 1990s.\(^8\) Falling infrastructure investment may also have been a response to overcapacity in certain areas (Merrifield, 2000: 92). The World Bank (1994: 23) points out that “infrastructure investments are often ‘lumpy’… Costly episodes of over- or undercapacity often result.”

The long-run relationship between economic infrastructure and real GDP was tested employing the methodology of Pesaran, Shin and Smith (1996, 2001). Each pair of PSS F-tests establishes whether there exists a long-run equilibrium relationship between the two variables, as well as the direction of association. The PSS F-statistics for national accounts data based on per capita measures are provided in Table 1. Those marked with an asterisk indicate a forcing relationship, with the direction of the relationship indicated in the column heading. A fuller description of the methodology is provided in Appendix 1. The PSS F-statistics in Table 1 indicate forcing relationships from

---

\(^8\) After 1980 government consumption expenditure increased at the expense of government investment (Merrifield, 2000: 98). Before 1980 both types of spending rose at a similar pace, but thereafter there was a sharp shift in policy, possibly reflecting the government’s attempts to prop up a political system that was socially and economically unsustainable. Growing consumption expenditure was made possible not only through investment cutbacks but by a growing fiscal deficit as well. As a proportion of GDP, the national budget deficit rose from an average of 2.9 per cent in 1980-1986 to an average of 4.9 per cent in 1987-1994 (fiscal years to March). In the post-apartheid period, both consumption and investment were constrained by the government’s commitment to reducing the deficit as a proportion of GDP. It averaged 4.5 per cent in 1995-1998 and 1.8 per cent in 1999-2003. An analysis of government consumption expenditure and economic growth in South Africa is provided by Mariotti (2002).
infrastructure investment to GDP and from infrastructure fixed capital stock to GDP.

Table 1. PSS F-tests for the relationship between real GDP and infrastructure investment and infrastructure fixed capital stock ("INFR")

<table>
<thead>
<tr>
<th>Measure of infrastructure</th>
<th>Relationship between GDP per capita and INFR per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure investment</td>
<td>GDP as outcome variable; * indicates GDP determined by INFR</td>
</tr>
<tr>
<td></td>
<td>INFR as outcome variable; * indicates INFR determined by GDP</td>
</tr>
<tr>
<td>Infrastructure investment</td>
<td>6.39 * 0.88</td>
</tr>
<tr>
<td>Infrastructure fixed capital stock</td>
<td>7.69 * 2.78</td>
</tr>
</tbody>
</table>

(1) National accounts: real values

4. RAILWAYS

The discovery of diamonds in 1867, which gave rise to the town of Kimberley, played an important role in the early development of South Africa’s railway infrastructure. According to De Kock (1936) Kimberley’s population and wealth grew rapidly in the 1870s and 1880s, but were nevertheless constrained by poor transport and communication services. Collaboration between private enterprise and the colonial governments of the Cape and Natal had resulted in the construction of approximately 110km of railway lines in and around Cape Town and Durban between 1860 and 1867. Extending the line from Wellington to Kimberley (900km) was a massive undertaking, but tax revenues flowing from the diamond mines allowed it to proceed. The railway line reached Kimberley in 1885. Between 1875 and 1885, the average annual growth rate in South Africa’s railway lines was 29 per cent.

Similarly, the discovery of gold on the Witwatersrand in 1886 had a marked effect on the railways, as it generated both demand for transport services and the revenues with which to finance them. Despite episodes of stiff resistance from the Transvaal Republic, by 1892 Johannesburg was connected by rail to Cape Town, Port Elizabeth and East London, and by 1896 to Durban. The Johannesburg - Lourenço Marques
(now Maputo) line, which President Kruger and his predecessors had been promoting for years as a means of attaining economic independence from Britain, was completed in 1894. The annual growth rate of railway lines averaged 5.7 per cent between 1885 and 1910 and 2.5 per cent between 1910 and 1930. Growth after 1930 was slow, with the level of railway lines resembling a plateau at the top of a rather steep mountain (Fig. 2). But until the 1980s, the network supported relatively brisk growth rates in rolling stock and even brisker growth rates in railway traffic (both passengers and freight), thus helping to sustain economic growth. These growth rates are compared in Table 2. After 1980 rolling stock fell sharply (Fig. 2) as South Africa’s overall investment rate fell and as roads came to play an increasingly important role in the country’s transport system.

Table 2. Average annual growth rates in railway infrastructure and traffic and real GDP

<table>
<thead>
<tr>
<th>Measure of Infrastructure or</th>
<th>1911-1930</th>
<th>1930-1980</th>
<th>1980-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway lines</td>
<td>2.2</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Locomotives</td>
<td>2.4</td>
<td>1.6</td>
<td>-1.8</td>
</tr>
<tr>
<td>Coaching stock</td>
<td>2.7</td>
<td>2.2</td>
<td>-2.2</td>
</tr>
<tr>
<td>Goods stock</td>
<td>2.6</td>
<td>3.3</td>
<td>-2.2</td>
</tr>
<tr>
<td>Carrying capacity (goods)</td>
<td>4.0</td>
<td>4.3</td>
<td>-0.5</td>
</tr>
<tr>
<td>Passenger journeys</td>
<td>4.2</td>
<td>4.4</td>
<td>-1.7</td>
</tr>
<tr>
<td>Goods freight</td>
<td>3.8</td>
<td>4.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Real GDP</td>
<td>2.0</td>
<td>4.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table 3. PSS F-tests for the relationship between real GDP and railway goods and services (RAIL)

<table>
<thead>
<tr>
<th>Measure of Infrastructure or</th>
<th>Relationship between GDP and RAIL</th>
<th>Relationship between GDP and RAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP as outcome variable;</td>
<td>* indicates GDP determined by RAIL.</td>
<td>*indicates RAIL determined by GDP</td>
</tr>
<tr>
<td>Railway lines</td>
<td>0.52</td>
<td>5.79 *</td>
</tr>
<tr>
<td>Locomotives</td>
<td>8.96 *</td>
<td>12.00 *</td>
</tr>
<tr>
<td>Coaching stock</td>
<td>4.49</td>
<td>9.98 *</td>
</tr>
<tr>
<td>Goods stock</td>
<td>6.61 *</td>
<td>6.17 *</td>
</tr>
<tr>
<td>Carrying capacity (goods)</td>
<td>5.72</td>
<td>4.35</td>
</tr>
<tr>
<td>Passenger journeys</td>
<td>2.60</td>
<td>8.33 *</td>
</tr>
<tr>
<td>Freight</td>
<td>5.30</td>
<td>2.40</td>
</tr>
</tbody>
</table>

Table 3 shows PSS F-statistics for South Africa’s real GDP and a range of railway infrastructure goods and services. They indicate long-run forcing relationships from GDP to railway lines, from GDP to coaching stock, and from GDP to passenger journeys, as well as potential simultaneity between GDP and locomotives and between GDP and goods stock.

5. ROADS

South Africa’s early roads began as footpaths and wagon tracks, which were subsequently developed into earth roads and then gravelled roads (Houghton, 1976: 201 and Floor, 1985: 14). Time series are available for national and provincial roads; urban roads and minor rural roads are excluded from the analysis. Growth rates

---

9 By 1930, South Africa’s railway lines measured 18 445 route kilometres, and the country’s network of railway lines was substantially in place. In 2003 the distance stood at 20 796 route kilometres. Of the 20 930 route kilometres in 1989, 17 240km were single track, 3 460km were double track, and the remainder were greater than double track, implying a single track equivalent distance of approximately 25 000km.
for roads and road traffic are shown in Table 4.10

Table 4. Average annual growth rates in roads, road traffic and real GDP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total national and provincial roads (paved and unpaved)</td>
<td>2.1</td>
<td>0.5</td>
<td>0.04</td>
<td>–</td>
</tr>
<tr>
<td>Paved national and provincial roads</td>
<td>–</td>
<td>11.6</td>
<td>3.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Passenger vehicles</td>
<td>11.4</td>
<td>4.3</td>
<td>4.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Goods vehicles</td>
<td>22.1</td>
<td>8.3</td>
<td>5.6</td>
<td>1.7</td>
</tr>
<tr>
<td>Real GDP</td>
<td>5.6</td>
<td>4.1</td>
<td>3.2</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Note: “–” indicates that the data are not available or not applicable; Appendix 2 provides notes on individual time series.

Apart from a structural data break between 1956 and 1957, total roads essentially display a plateau effect after 1940. In 1938, the National Road Board decided that all national roads should be paved, rather than 25 per cent as previously planned. Prior to 1940, the development of South Africa’s national and provincial road network is best measured by total roads (most of which were unpaved), whereas after 1940 road development is best measured by paved roads. Between 1940 and 2001, South Africa’s national and provincial paved roads increased from around 2 000km to around 63 000km. The declining growth rates for paved roads may indicate that a plateau effect is developing, but one caveat in this regard is that improvements such as the addition of road lanes are not reflected in the measured distance.11

Fig. 3 compares the growth in paved roads with the growth in traffic which they have supported. The strong rise in vehicles transporting goods has been accompanied by the illegal overloading of vehicles, which causes serious damage to the country’s road infrastructure.12

10 The choice of periods in Table 4 was determined by a substantial structural break in the series for total roads between 1956 and 1957 (approximately 25 000km of tertiary roads in the Orange Free State were reclassified and therefore included in the data for the first time), and difficulty in extending the time series for total roads after 1993 (responsibility for the funding of provincial roads was passed to the provinces in 1994, and since then consistent data for this time series do not appear to be available). Canning (1998:534) notes that consistent data on roads tend to be problematic internationally.

11 Of the 57 034km of national and provincial paved roads recorded for 1993, dual-carriage roads measured 2 405km (4.2 per cent) and single-carriage roads measured 54 629km (95.8 per cent).

12 The South African National Roads Agency (SANRA) has estimated that overloading causes R600 million of damage to South Africa’s paved roads annually (see page 19 of SANRA’s document Horizon 2010, which sets out the agency’s strategic vision for South Africa’s roads). The financing of road maintenance and development is a key concern for SANRA, whose 2002 annual report (Chairman’s report: 3) stated that limited financial resources were a major challenge and could adversely affect the condition of the road network. The Department of Transport (1998: 51) estimated that investment in roads in the late 1990s met approximately 75 per cent of long-term capital requirements, but that only 35 per cent of the needs for long-distance roads were adequately funded (1998: 79). It found that 30 to 40 per cent of South Africa’s trucks were over loaded, causing 60 per cent of the damage to the road network (1998: 82). In recent years, national and provincial spending rose strongly from R3.7bn in 2000/01 to an estimated R6.4bn in 2003/04, an average annual growth rate of 20 per cent. (excluding SANRA’s toll revenue and municipal spending) (National Treasury: Medium Term
Table 5. PSS F-tests for the relationship between real GDP and roads and vehicles (“ROAD”)

<table>
<thead>
<tr>
<th>Measure of infrastructure or infrastructure service</th>
<th>Relationship between GDP and ROAD</th>
<th>Relationship between GDP and ROADS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP as outcome variable; *indicates GDP determined by ROAD</td>
<td>ROAD as outcome variable; * indicates ROAD determined by GDP</td>
</tr>
<tr>
<td>Unpaved and paved roads</td>
<td>6.38 *</td>
<td>3.78</td>
</tr>
<tr>
<td>Paved roads</td>
<td>5.90 *</td>
<td>1.39</td>
</tr>
<tr>
<td>Passenger vehicles</td>
<td>11.05 *</td>
<td>5.72</td>
</tr>
<tr>
<td>Goods vehicles</td>
<td>8.96 *</td>
<td>7.23 *</td>
</tr>
</tbody>
</table>

Table 5 indicates long-run forcing relationships from roads and passenger vehicles to GDP, and potential simultaneity between goods vehicles and GDP. Jones and Müller (1992: 77) argue that transport systems allow producers to supply larger quantities than can be consumed at their place of production, which results not only in higher output but also specialization and lower unit production costs.13

6. PORTS AND AIR TRAVEL

Whereas railways and roads are typically competitors in the supply of transport services, railways and roads on the one hand, and ports on the other, are typically complementary, especially in a country such as South Africa which does not have the

---

13 An early account of the relationship between roads and economic development in South Africa is provided by De Kock in his discussion of the period 1836–1856 (1936: 37-38): “The lack of adequate transportation facilities had always been a serious deterrent to the development of agriculture and wool-growing. In order to offset the disadvantages resulting from the absence of navigable waterways and railways, it was essential to have a good system of roads… Accordingly, in 1844, the construction of a series of public highways, bridges and mountain passes was set on foot. This improvement of the system of internal transportation contributed in no small degree to the subsequent development.”
benefit of major inland navigable waterways. Frankel (1938: 33) argues that railways were of great importance in the colonization of Africa, but that without ports they were useless.

The National Ports Authority (NPA) of South Africa controls and manages the ports at Cape Town, Durban, Port Elizabeth, East London, Richards Bay, Saldanha, and Mossel Bay. The growth in the annual volume of cargo handled at these seven ports is shown in Table 6.

Table 6. Average annual growth rates in cargo at ports, air passengers and real GDP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cargo handled at ports</td>
<td>2.1</td>
<td>5.0</td>
<td>7.0</td>
<td>3.5</td>
</tr>
<tr>
<td>SAA passengers (domestic and international)</td>
<td>–</td>
<td>12.3</td>
<td>2.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Passenger on international flights at SA airports</td>
<td>–</td>
<td>17.4(1)</td>
<td>3.6</td>
<td>8.5</td>
</tr>
<tr>
<td>Real GDP</td>
<td>3.3</td>
<td>4.8</td>
<td>1.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

(1) 1962–1975

Although cargo is not a direct measure of infrastructure, it nevertheless demonstrates the ports’ capacity to handle rising volumes, e.g. between 1976 and 1979 the volume doubled from 38 million harbour tons to 76 million harbour tons, the result of opening Richards Bay and Saldanha harbours. Further substantial increases in the 1980s and 1990s relate to South African exports and imports, whose combined volume rose by 158 per cent between 1979 and 2001 (cargo handled at the ports rose by 114 per cent and real GDP rose by 51 per cent). However, high growth in cargo handled contributed at times to congestion problems at some ports. In Young (2003: 18) the Durban Container Terminal was reported to be working at 26 per cent above its intended capacity. The Department of Transport (1998: 42) stated that interviews with freight customers revealed high levels of dissatisfaction with service levels at some of the ports, and estimated (1998: 51) that investment in the ports in the late 1990s was running at around 35 per cent of their long-term capital requirements. Various initiatives are under way or under consideration to raise capacity at South Africa’s ports, and a new deepwater port, Ngqura, is under construction next to the Coega industrial development zone in the Eastern Cape. According to the NPA, Ngqura is needed to provide additional container capacity.14

In the absence of a direct measure of South Africa’s air transport infrastructure over time, Table 6 shows the growth of passengers on South African Airways (SAA) and passengers on international flights leaving from or arriving at South African airports. In general there was brisk growth before 1975, much slower growth during the politically-fraught 1975-1994 period (when economic growth was also low), and a substantial

14 A study by Hosking and Bond (2000) questions the feasibility of Coega. The nearby harbour at Port Elizabeth handles only a fraction of the volumes at Richards Bay and Durban, and there is a lack of connecting transport infrastructure. Pollution could impose substantial costs on the fishing and citrus industries as well as human health, and ecotourism could be adversely affected. They conclude that Coega’s projected costs appear too great for it to proceed successfully given the limited projected employment and other benefits. This raises questions about the efficiency of port development when this is viewed as an instrument of regional development, rather than solely as a transport development. It is likely that the cost-benefit parameters would be very different (we thank an anonymous referee for making this point).
recovery in growth in the post-apartheid period.15

Table 7 indicates long-run forcing relationships from GDP to the volume of cargo handled at the ports, and from GDP to the number of passengers transported by SAA. There is no evidence from the PSS-F tests of a relationship between GDP and international air passengers.

Table 7. PSS F-tests for the relationship between real GDP and cargo handled at ports ("PORT") and air passengers ("PASS")

<table>
<thead>
<tr>
<th>Measure of infrastructure or infrastructure service</th>
<th>Relationship between GDP and PORT or PASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GDP as outcome variable; * indicates GDP determined by PORT or PASS</td>
</tr>
<tr>
<td>Ports (cargo)</td>
<td>3.87</td>
</tr>
<tr>
<td>SAA passengers</td>
<td>4.71</td>
</tr>
<tr>
<td>International air passengers</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>PORT or PASS as outcome variable; * indicates PORT or PASS determined by GDP</td>
</tr>
<tr>
<td></td>
<td>19.73 *</td>
</tr>
<tr>
<td></td>
<td>6.41 *</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
</tr>
</tbody>
</table>

7. TELEPHONES AND ELECTRICITY

In 1876 telegraphic communication was established between Cape Town and Kimberly, once again indicating a link between mining (diamonds in this case) and infrastructure. South Africa’s first telephone exchanges were opened in Port Elizabeth in 1882 and Cape Town in 1884 (Official Year Book of the Union, 1917: 675). Today the country’s landline telephone infrastructure is provided by Telkom SA Limited, which also has a 50 per cent holding in Vodacom, South Africa’s largest mobile telephone service provider.16 In addition to supplying traditional telephone services, Telkom’s infrastructure also provides a range of other communication services which have become essential for South African businesses to become globally competitive, e.g. fax, email, internet, data transmission.

Table 8 shows relatively strong growth rates for fixed phone lines during most of the 20th century, even after the mid-1970s when investment growth in South Africa was generally weak.

Table 8. Average annual growth rates in phone lines, electricity generated, and real GDP

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed phone lines</td>
<td>7.7</td>
<td>5.9</td>
<td>6.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Mobile phone lines</td>
<td></td>
<td></td>
<td></td>
<td>108.3 (1)</td>
</tr>
<tr>
<td>Electricity generated</td>
<td>7.5</td>
<td>7.9</td>
<td>6.1</td>
<td>2.3</td>
</tr>
<tr>
<td>Real GDP</td>
<td>4.9</td>
<td>5.1</td>
<td>2.4</td>
<td>1.9</td>
</tr>
</tbody>
</table>

(1) 1992-2002

15 In financial 2003, SAA operated a fleet of 64 aircraft, of which it owned 15 and leased 49. The fleet is being upgraded through the introduction of 39 Airbus aircraft between 2003 and 2005. Compared with the aircraft they are replacing, the new aircraft are more fuel-efficient, have lower maintenance costs and provide more comfort for passengers (SAA audited group results for the year ended 31 March 2003). The Department of Transport (1998: 50) reported that within South Africa’s transport system, only airports (and foreign airlines using those airports) were making sufficient investments to replace and upgrade their assets.

16 In 1991, Telkom was incorporated and registered as a public limited liability company, wholly owned by the South African government. In May 1997 it was partially privatized, and in March 2003 it was listed on the JSE Securities Exchange and the New York Stock Exchange (with the South African government retaining a substantial share). In March 2003, Vodacom had an estimated 57 per cent share of South Africa’s mobile phone market.
The annual average growth rate for 1970-1990 was 6.5 per cent, probably reflecting the global upward trend in information technology. The slower growth in 1990-2002 must have been the result, at least in part, of strong competition from the mobile phone market, which grew from 7 000 in 1992 to 13.9 million in 2003. A brief history of electricity in South Africa is provided by the Development Bank of Southern Africa (1998: 14). In 1906, the Victoria Falls and Transvaal Power Company (VFTPC) was established by the British South Africa Company, the German equipment supplier AEG, and German banks. Electricity demand from the gold mines resulted in rapid growth, and in 1923 the electricity sold by VFTPC to the mines exceeded the combined electricity consumption of London, Sheffield and Birmingham. Eskom (previously the Electricity Supply Commission, or Escom) was established by government in 1922 as a means of supplying electricity at cost. The VFTPC was nationalized in 1948, Eskom expanded its capacity to meet growing electricity demand (e.g. from the development of the Free State goldmines in the 1950s), and municipalities discontinued electricity production as they found it cheaper to purchase electricity from Eskom, leaving Eskom as a virtual monopoly. In 2002, Eskom was converted from a statutory body to a public company (Eskom Holdings Limited) with the South African government as the sole shareholder.

Annual growth in electricity generation was strong until the late 1980s. In the 1990s Eskom embarked on an electrification programme to expand its services to areas which had been neglected during apartheid, but the annual growth rate in electricity generation nevertheless slowed to 2.3 per cent from 6.1 per cent in the 1980s. In contrast to the amount of electricity actually generated, Eskom’s total power station net maximum capacity was relatively stable in the period 1993-2002 (ranging from around 36 000 megawatts to around 40 000MW). Peak demand, however, grew from 23 169MW in 1993 (62 per cent of capacity) to 31 928MW in 2003 (approximately 80 per cent of capacity), an average growth rate of 3.3 per cent per annum. With this rate of growth and the need for a reserve margin, current capacity may be inadequate to handle peak demand as early as 2007. Eskom is considering various options to expand its capacity, one of which is to resurrect three mothballed power stations. New power stations will also be required, but it is unclear who will construct these. Government has expressed interest in mobilizing private-sector involvement in electricity generation, but whether or not there are private-sector operators who are able and willing to enter this market on any significant scale remains to be seen.

Table 9 indicates a long-run forcing from GDP to the number of fixed phone lines, and potential simultaneity between GDP and electricity.

<table>
<thead>
<tr>
<th>Measure of infrastructure or infrastructure service</th>
<th>Relationship between GDP and TELE or ELEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed phone lines</td>
<td>Relationship between GDP and TELE or ELEC</td>
</tr>
<tr>
<td>3.06</td>
<td>15.72 *</td>
</tr>
<tr>
<td>11.87 *</td>
<td>14.33 *</td>
</tr>
</tbody>
</table>

8. PHASES OF INFRASTRUCTURE DEVELOPMENT

Fig. 4 shows selected indices of infrastructure development in South Africa, and Table 10 shows long-term growth rates for these and other measures. They suggest that
infrastructure development tends to take place in phases. As growth in one area declines, growth in another area rises. Given the links between infrastructure growth and economic growth indicated by the PSS F-tests, it is quite plausible that phases of infrastructure development took place in response to changes in the structure of the economy and also exerted some influence on changes in the structure of the economy.

Figure 4. South Africa: indices of infrastructure

Since the economy’s infrastructure requirements tend to change over time, and since infrastructure projects tend to take place on a large scale and are therefore expensive, this pattern of infrastructure phasing is unsurprising and is likely to continue.

Table 10. Average annual growth rates of infrastructure goods and services

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway lines</td>
<td>17.0</td>
<td>6.2</td>
<td>4.0</td>
<td>2.9</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Locomotives</td>
<td>0.3 (1)</td>
<td>2.1</td>
<td>1.4</td>
<td>2.9</td>
<td>2.0</td>
<td>-1.7</td>
</tr>
<tr>
<td>Coaching stock</td>
<td>2.4 (3)</td>
<td>2.7</td>
<td>1.4</td>
<td>2.9</td>
<td>2.1</td>
<td>-2.1</td>
</tr>
<tr>
<td>Goods stock</td>
<td>1.7 (5)</td>
<td>3.0</td>
<td>2.6</td>
<td>3.1</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Goods stock carrying capacity</td>
<td>3.8 (2)</td>
<td>4.0</td>
<td>4.8</td>
<td>3.9</td>
<td>-0.2</td>
<td></td>
</tr>
<tr>
<td>Passenger journeys</td>
<td>3.8 (3)</td>
<td>4.0</td>
<td>4.5</td>
<td>4.2</td>
<td>-1.0</td>
<td></td>
</tr>
<tr>
<td>Revenue-earning freight</td>
<td>5.4 (6)</td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Total (nat. &amp; pr.)</td>
<td>2.0</td>
<td>1.3 (3)</td>
<td>0.1</td>
<td>-0.1 (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paved (nat. &amp; pr.)</td>
<td>15.0</td>
<td>5.3</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger vehicles</td>
<td>12.1 (6)</td>
<td>5.0</td>
<td>5.2</td>
<td>2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goods vehicles</td>
<td>23.5 (7)</td>
<td>7.2</td>
<td>7.5</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAA passengers</td>
<td>9.1 (8)</td>
<td>12.9</td>
<td>2.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passengers on international flights at SA airports</td>
<td>13.0 (9)</td>
<td>5.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity generated</td>
<td>8.8</td>
<td>6.0</td>
<td>7.5</td>
<td>3.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed lines</td>
<td>7.8</td>
<td>7.9</td>
<td>4.2</td>
<td>5.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile lines</td>
<td>7.8</td>
<td>7.9</td>
<td>4.2</td>
<td>10.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total lines (fixed plus mobile)</td>
<td>7.8</td>
<td>7.9</td>
<td>4.2</td>
<td>10.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) 1905-1919 (2) 1910-1919 (3) 0.5 if the 1957 inclusion of previously unclassified roads is disregarded (4) 1980-1993 (5) 1921-1939 (6) 1950-1959 (7) 1963-1979 (8) 1993-2001

© 2005 Economic Society of South Africa. 222
Public-sector investment in South Africa’s economic infrastructure rose as a percentage of GDP between 1960 and 1976, but this was followed by a long-term decline. The period of strongest growth in South Africa’s railway lines was 1875-1930, after which there was little change in the route-kilometre distance. We have characterized this as a “plateau effect”. Railway rolling stock continued to grow after 1930 but fell sharply after 1980, partly reflecting the general decline in investment spending by government. Similarly to railways, national and provincial roads reached a plateau around 1940, but the paving of national and provincial roads then began in earnest. This supported rapid growth in road traffic. One of the country’s oldest forms of infrastructure is its ports, the capacity of which was expanded substantially in the 1970s (Richards Bay and Saldanha). A new port (Ngqura) is under construction at Coega. During the second half of the 20th century air travel became widely available. In contrast to other measures of infrastructure goods and services, fixed telephone lines grew rapidly in the 1980s and 1990s in response to the worldwide revolution in information technology, and there was explosive growth in mobile phones in the 1990s and early 21st century. Existing electricity generation capacity may be inadequate to handle peak electricity demand as early as 2007, which has created an urgent need for new capacity.

The results of the PSS F-tests reported in this study may be summarized as follows. In South Africa, growth in GDP tends to drive growth in individual physical measures of infrastructure-related goods and services, rather than vice versa. Roads are an exception, since there is evidence that they have a strong effect on GDP growth: the correlation coefficient between paved roads and real GDP is 0.996 for the period 1938-2001, and the PSS F-tests indicate a long-run forcing relationship from roads to GDP. An analysis of national accounting figures suggest that infrastructure investment seems to drive GDP growth. These patterns suggest two forms of constraint that infrastructure may exercise on economic growth. Firstly, if policymakers fail to provide additional infrastructure in response to the greater demand for infrastructure generated by GDP growth, further GDP growth could be hampered by bottlenecks, e.g. congestion at some of South Africa’s ports, and unreliable railway services. Secondly, underinvestment in certain types of infrastructure, e.g. roads, may leave potential areas of economic growth unexploited.

The preceding analysis suggests three main findings with regard to economic infrastructure and economic growth in South Africa. These are as follows.

Firstly, the relationship between economic infrastructure and economic growth appears to run in both directions. Economic growth provides both the need for, and the resources to fund, various types of infrastructure. Provided that infrastructure projects take place in response to appropriate cost-benefit analyses, they are more likely to promote GDP growth than hinder it. Alternatively, the failure to provide appropriate infrastructure services may hamper GDP growth.

Secondly, South Africa’s stock of economic infrastructure has developed in phases. The growth rates of individual measures of infrastructure fluctuated substantially over time, in some cases even turning negative, and the historical pattern of infrastructure development differed substantially between sectors. Providing the right type of infrastructure at the right time will be an important dimension of South Africa’s continued economic development.

Thirdly, the need for investment in economic infrastructure never goes away. Until
such time as existing infrastructure becomes obsolete it needs to be maintained, and as
certain infrastructure programmes reach maturity new ones should be implemented,
always in response to the economy’s changing needs and cost-benefit analyses. The
continued need for appropriate infrastructure investment should be recognized in
public-sector budgets from the national level to the municipal level, and public-sector
agents need to be accountable for spending their capital allocations effectively. While
some degree of fluctuation in the level of infrastructure investment may be harmless or
even appropriate, a long-term decline in infrastructure investment in relation to GDP,
such as that experienced by South Africa between the mid-1970s and 2002, would
probably be undesirable.

Appendix 1: Testing for the direction of association between variables

In order to explore the directions of association between the variables included in this study, we
employ the test statistic proposed by Pesaran, Shin and Smith (1996, 2001) (PSS F-statistic).\(^\text{17}\)
Suppose that the question is whether there exists a long-run relationship between the set of
variables \(y_t, x_{1,t}, \ldots, x_{n,t}\). Univariate time series characteristics of the data are not known for certain.
The PSS approach to testing for the presence of a long-run relationship proceeds by estimating
the error correction specification given by:

\[
\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{j=1}^{n} \sum_{i=1}^{p} \gamma_{j,i} \Delta x_{j,t-i} + \left( \delta_1 y_{t-1} + \sum_{k=2}^{n+1} \delta_k x_{k,t-1} \right) + \varepsilon_t.
\]

The order of augmentation, \(p\), is determined by the need to render the error term white noise,
and is chosen from the set of all feasible lag structure combinations by means of an information
criterion.\(^\text{18}\) The test proceeds by computing the standard F-statistic for the joint significance of
\(\delta_1 = \delta_2 = \ldots = \delta_{n+1} = 0\). While the distribution of the test statistic is non-standard, and influenced
by whether the \(x_{i,t}\) are I(0) or I(1), the critical values are tabulated by Pesaran, Shin and Smith
(1996, 2001), with \(x_{i,t}\) I(0) \(\forall\) providing a lower bound value, and \(x_{i,t}\) I(1) \(\forall\) providing an upper
bound value, to the test statistic. The test statistic is computed with each of the \(y_t, x_{1,t}, \ldots, x_{n,t}\) as
the dependent variable. Where the estimated test statistic exceeds the upper bound value, we
reject \(\delta_1 = \delta_2 = \ldots = \delta_{n+1} = 0\), and infer the presence of a long-run equilibrium relationship. Where
the estimated test statistic lies below the lower bound value, we accept \(\delta_1 = \delta_2 = \ldots = \delta_{n+1} = 0\),
and infer the absence of a long-run equilibrium relationship. The test is indeterminate either
where the computed test statistic lies between the upper and lower bound values (in which case
it is not clear whether a long-run relationship between the variables is present), or where more
than one variable is confirmed as the outcome variable of a long-run equilibrium relationship (in
which case the long-run relationships between the variables would not be unique).\(^\text{19}\)

In the current application, where there is an intercept but no trend, and the relationship being
tested for is between GDP and individual measures of infrastructure, the lower bound critical
value of the test statistic is 4.934 and the upper bound critical value of the test statistic is 5.764,
att the five per cent level of significance.

\(^{17}\) See also the discussion in Pesaran (1997) and Pesaran and Shin (1995a, 1995b).
\(^{18}\) For instance Akaike.
\(^{19}\) The test is analogous to a Granger causality test, but in the presence of non-stationary data.
Of course, there exists an array of tests designed to establish the univariate time series
characteristics of the data. The tests are not always conclusive, however. This renders the PSS F-
test suitable in the current context.
Appendix 2: Data sources and technical notes

Where necessary, statistics from different sources have been standardized, e.g., miles have been converted into kilometres, sterling into rands, short tons into metric tonnes. Abbreviations used in the notes below are as follows:

CGH: Cape of Good Hope (Report of the general manager of railways)
CN: Colony of Natal (Report of the general manager of railways)
CSAR: Central South African Railways (Report of the general manager of railways)
NATIS: National Traffic Information System
NGR: Natal Government Railways (Report of the general manager of railways)
NPA: National Ports Authority
OYBU: Official Year Book of the Union
SAA: South African Airways
SANRA: South African National Roads Agency
SARB: South African Reserve Bank (database)
SARH: South African Railways and Harbours (Report of the general manager of railways and harbours / Annual reports)
SATS: South African Transport Services (Annual reports)
SSA: Statistics South Africa or its predecessors (South African Statistics and database)
US: Union Statistics for Fifty Years

Real gross domestic product (GDP)

*Sources: SSA, SARB*

Figures for nominal and real GDP 1946-2002 are from the SARB database. Nominal GDP was extrapolated back to 1911 using percentage changes from nominal value added, published in SSA 1980. Nominal GDP for 1911-1945 was then inflated to 1995 prices using an estimate of the GDP deflator. The latter was extrapolated back to 1911 using percentage changes from an average of wholesale and retail price indices (US).

Population

*Sources: Census figures for 1904 and 1911, US, SSA*

Mid-year estimates were used. The figures for 1991-2002 are those published by SSA. Some of the earlier figures published by SSA exclude the former TBVC areas. To overcome this exclusion and other revisions, the series was extrapolated back using growth rates calculated from SSA, US and census (1904 and 1911) population figures.

Economic infrastructure: gross fixed capital formation and fixed capital stock (1995 prices)

*Source: SARB*

Rail: open railway lines (route kilometres)

*Sources: OYBU, US, SSA, Spoornet*


Data from 1945: 1065mm gauge only; earlier data include 610mm gauge.

Many of the published figures include Namibia, but the Namibian figures were obtained separately and excluded in order to show South Africa only.

Rail: locomotives (steam, diesel and electric) (number).

*Sources: CGH, NGR, CSAR, US, SSA, Spoornet*


1905: interpolated (Transvaal and Orange Free State unavailable).

Rail: coaching stock (number)

*Sources: CGH, NGR, CSAR, US, SSA, Spoornet*


1905: interpolated (Transvaal and Orange Free State unavailable).

Rail: goods stock (number)
Sources: CGH, NGR, CSAR, US, S.A.A, Spoornet
1905: interpolated (Transvaal and Orange Free State unavailable).

Rail: carrying capacity of goods stock (tonnes)
Sources: US, S.A.A, Spoornet

Rail: passenger journeys (number)
Sources: CGH, CN, NGR, S.A.RH, US, S.A.A, Spoornet
1873-1880: Cape only. 1881–1902: Cape and Natal only.

Rail: revenue-earning traffic
Sources: CGH, CN, NGR, S.A.RH, US, S.A.A, Spoornet
1873-1880: Cape only. 1881–1902: Cape and Natal only.
1903-1908: estimated from graph (SARH 1910, p152).

Roads: total distance (kilometres)
Sources: OYBU, US, S.A.A, CSIR
March of year. The quality of the data is questionable; data for unpaved roads appear to be unreliable in many countries (Canning, 1998). No provision is made for the number of lanes.

Roads: paved distance (kilometres)
Sources: OYBU, US, S.A.A, CSIR, S.A.NRA
March of year. Owing to the series being discontinued by SSA, the period 1994-2000 was interpolated using a constant annual growth rate.

Roads: passenger and commercial (goods) vehicles (number)
Sources: S.A.A, NATIS
Passenger vehicles include cars, minibuses, buses and motorcycles. Commercial vehicles are vehicles for the transport of goods.
Before 1979, the data include motor dealers’ stocks and exclude vehicles exempt from licensing. From 1979, the data exclude motor dealers’ stocks and include vehicles exempt from licensing. In 1979, these changes had the following offsetting effects: -20 084 and +65 746 for goods vehicles, and -74 388 and +25 698 for passenger vehicles.

Ports: cargo handled (harbour tons)
Source: OYBU, SSA, NPA
Namibia included for the years 1955–1974.
Petroleum is excluded.

Air travel: passengers carried by South African Airways (SAA) (number)
Source: S.A.A, S.A.TS, S.A.A
Note that the figures refer to SAA only.

Air travel: international passengers passing through South African airports (number)
Source: S.A.A
Note that the figures refer to all airlines, including SAA.

Fixed phone lines (number)
Sources: OYBU, Canning (1998), Telkom
Mobile phone lines (number)
Sources: Vodacom, Telkom
March of year.

Electricity generated (gigawatt hours)
Sources: US, SSA

Producer (wholesale) price index
Sources: US, SSA

Consumer (retail) price index
Sources: US, SSA

REFERENCES

CAPE OF GOOD HOPE. Report of the general manager of railways. Various years.
CENTRAL SOUTH AFRICAN RAILWAYS. Report of the general manager of railways. Various years.
COLONY OF NATAL. Report of the general manager of railways. Various years.


NATAL GOVERNMENT RAILWAYS. Report of the general manager of railways. Various years.


SOUTH AFRICAN NATIONAL ROADS AGENCY. Annual report for 2002.


____ Annual report. Various years.


SOUTH AFRICAN RESERVE BANK database.

SOUTH AFRICAN TRANSPORT SERVICES. Annual report. Various years.


