

The role of economic infrastructure in economic growth: building on experience

Economic infrastructure may be compared to the foundation of a building. It plays a supporting role, facilitating the multitude of productive economic activities that constitute the bulk of the economy, or gross domestic product.



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Broadly speaking, *economic* infrastructure comprises investments and related services that raise the productivity of other types of physical capital, e.g. transport, power, water systems, communication; and *social* infrastructure comprises investments and services that raise the productivity of human capital, e.g. education and health. The subject of this paper is the relationship between *economic* infrastructure and economic growth in South Africa. The relationship between social infrastructure and economic growth is just as complex and no less important, but should be the subject of a separate analysis.

The development of economic and social infrastructure in South Africa has a long and troubled history. Excellent in parts yet hopelessly inadequate in others, and riddled with the discriminatory practices and inequalities that were the hallmarks of the country's apartheid past, the South African infrastructural experience does not lend itself to generalisations or easy assessment.

History aside, if South Africans today perceive there to be infrastructural backlogs everywhere they look, they are not alone. Lamenting the poor condition of America's infrastructure in *The New York Times* in August and October, economist Paul Krugman described America as being 'on the unlit, unpaved road to nowhere'¹ and its roads, railways and sewer systems as 'antiquated and increasingly inadequate'². In October, *The Economist*³ had the following to say about infrastructure in Britain:

The dreadfulness of Britain's infrastructure has become legendary. Visitors to continental Europe and elsewhere return with awed tales of cheap, clean trains that run on time, zippy new roads and properly functioning airports, which are crossly compared with Britain's pot-holes, delays and check-in scrums.

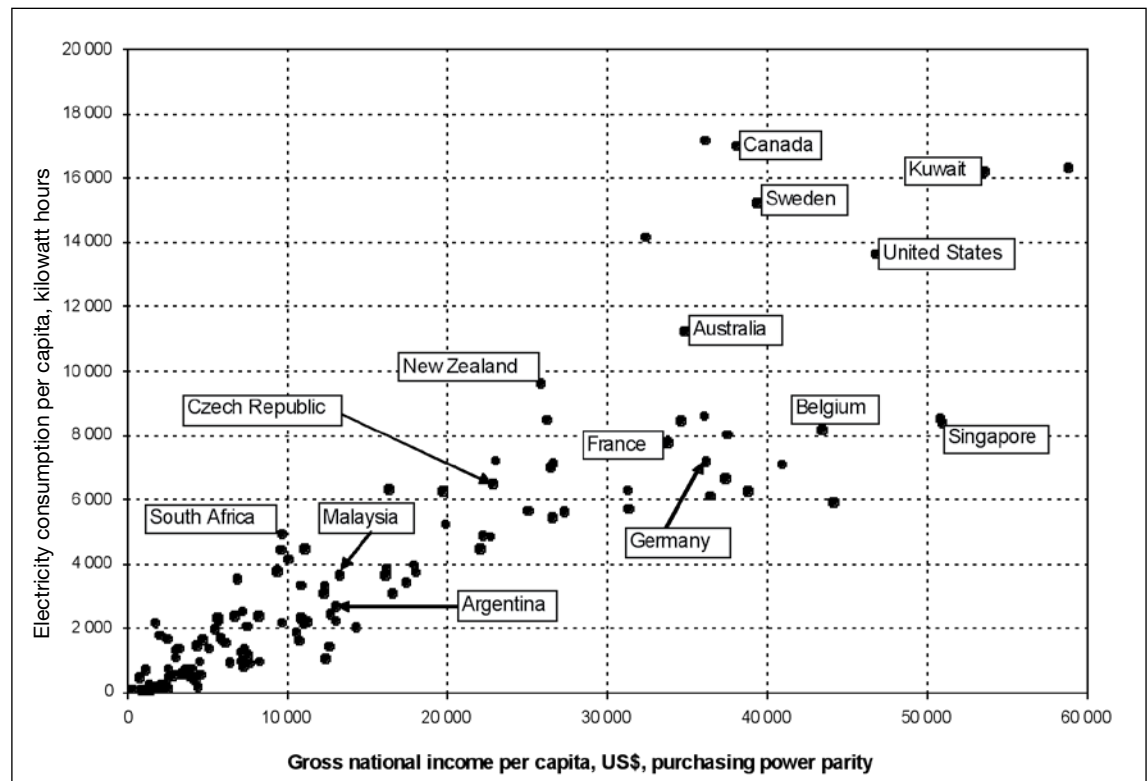
Why should there be such concern over the state of economic infrastructure, whether in South Africa or elsewhere? Apart from the sheer convenience of having enough electricity at an affordable price, clean water, efficient public transport, free-flowing traffic, and telephones that work, few would dispute the notion that there are close

links between economic infrastructure and economic growth. The evidence for such links is strong, whether in the form of quantitative or qualitative studies, whether over time or across regions or countries. In the following section I shall confine myself to just two examples.

Correlation between infrastructural investment and economic growth

The first example of the relationship between economic infrastructure and the economy is a cross-country comparison of electricity usage and gross national income (GNI). Figure 1 plots the per capita GNI of 124 countries against each country's per capita electricity usage in 2007. Each point on the graph represents a country. The correlation between income and electricity is strongly positive. Excluding the outliers Norway and Iceland, whose high rates of per capita electricity consumption lie well beyond the scale of Figure 1 (25 000 and 37 000 kilowatt hours respectively), the correlation is 89%. Low-income countries generate and use relatively low levels of electricity. High-income countries generate and use relatively high levels of electricity. It is reasonable to suppose that a similar pattern exists for other types of infrastructure and infrastructural services.

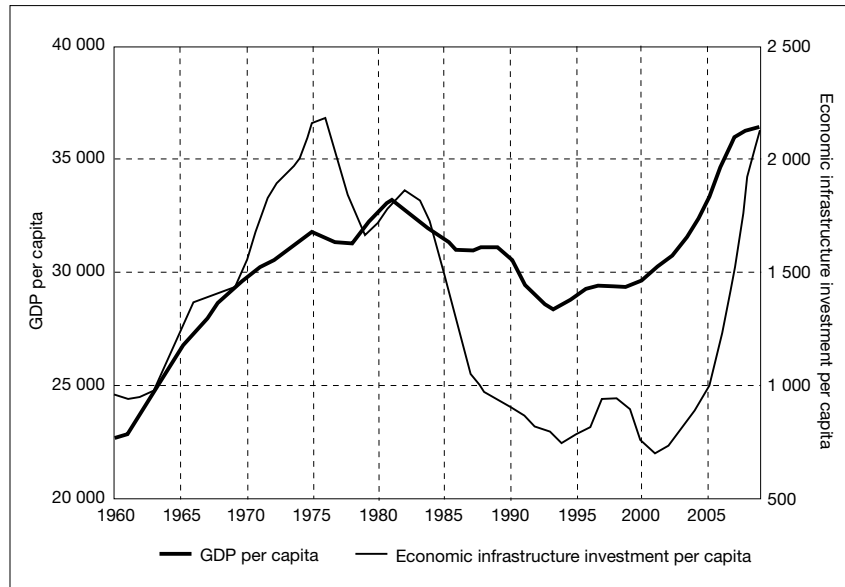
Figure 1 – Cross-country comparison of electricity consumption and gross national income, per capita, 2007



Data source: World Development Indicators

The second example is the South African experience between 1960 and 2009. Figure 2 shows the relationship between gross domestic product (GDP) (bold line) and public-sector economic infrastructural investment⁴ (light line), both measured per capita and in real terms (i.e. adjusted for inflation). The two series follow similar trends. Average annual growth rates for selected periods are shown in Table 1.

Figure 2 – South Africa: real GDP and public-sector economic infrastructural investment, per capita, rands, 2005 prices, moving average



Data source: South African Reserve Bank

Table 1 – South Africa: real GDP and public-sector economic infrastructural investment, per capita, average annual growth rates

Period	GDP per capita, % p.a.	Economic infrastructure investment per capita, % p.a.
1961–1976	2.2	6.0
1977–1978	-1.0	-15.7
1979–1982	1.5	4.0
1983–1993	-1.4	-8.1
1994–2002	0.9	0.3
2003–2008	3.2	19.3
2009	-2.7	19.5

Data source: South African Reserve Bank

From the early 1960s to mid-1970s, both series exhibited positive growth. Between the late 1970s and early 1980s performance was mixed, but then, too, the two series moved broadly in the same direction, first falling and then rising. Between the early 1980s and early 1990s, a period during which the disastrous economic consequences of the apartheid system became increasingly clear, both GDP and infrastructural investment declined in real per capita terms. Happily, between the mid-1990s and the early 2000s the long-term downward trends in both series were halted. Then followed a seven-year period of rapid expansion in infrastructural investment, on average 19.3% per annum (in real per capita terms) during the six years 2003–2008, with a similar performance in 2009. Real per capita GDP grew by 3.2% per annum during 2003–2008, but was negative in 2009 largely on account of the global economic recession.

The extended decline in living standards during the 1980s and early 1990s was particularly tragic when considering that for many other emerging market

economies this was a period of rapid economic growth and development. South Africa's investment malaise was by no means confined to economic infrastructure during the 12 years 1982–1993: the level of annual total investment (as measured by gross fixed capital formation including the private sector) declined in real terms, and as a proportion of GDP averaged 20 per cent (25 per cent during 1982–1985 and 18 per cent during 1986–1993). South Africa's savings rate also declined over this period. By contrast, high-growth emerging market economies in Asia maintained high rates of savings and investment (Table 2). It was not until 2005/6 (a quarter of a century) that South Africa returned to its 1981 high in terms of per capita real GDP (Figure 2).

Table 2 – Rates of investment and economic growth during 1982–1993

Country	GDP (real) % p.a.	Investment as a % of GDP
South Africa	0.7	20.3
Malaysia	6.8	31.8
Singapore	7.3	38.0
South Korea	8.4	32.1
Thailand	8.2	32.6

Data source: International Financial Statistics

Whereas the correlation between infrastructural investment and economic growth may be demonstrated with ease, causality between the two is more difficult to show. Is there any causality at all, or is their correlation merely coincidental? If there is causality, does infrastructural investment lead economic growth, or does economic growth lead infrastructural investment, or does the causality run in both directions depending on circumstances?

These are not the only difficult questions that arise regarding the provision of infrastructure and infrastructural services. If infrastructure does promote economic growth and development, just how much infrastructure is optimal? Do different types of infrastructure have different effects on the economy? Should infrastructure be provided exclusively by the public sector, or is there a role for the private sector as well? To the extent that infrastructure is or should be provided by the public sector, is it best funded through general tax revenues, user charges, foreign direct investment, or borrowing? What are the implications for the environment of different

methods of infrastructure provision, in particular the generation of electricity? How much emphasis should be placed on economic infrastructure compared with social infrastructure (health and education)? Can the experiences of one country or region provide easy lessons or models for other countries or regions? It lies far beyond the scope of this paper to provide answers to these and other tricky questions faced by policy makers in the field of infrastructure. Partial answers to some of them in the South African context may lie in the historical development of South Africa's economic infrastructure. This is discussed in the following section. The section following that addresses more explicitly the question of causality between economic infrastructure and economic growth in the context of the South African experience.

Historical development of economic infrastructure in South Africa

The building of South Africa's economic infrastructure during the 19th and 20th centuries was dominated by the state. Not exclusively, but certainly for the most part, it was the state that owned and operated railway lines, roads, harbours, airports, water systems, power stations and communication networks.⁵ As with social infrastructure, access to economic infrastructural services was in most cases determined along racial lines, heavily skewed in favour of the minority white population and away from the majority black population. The damage so done is incalculable, except to say that it must have been enormous; no assessment of it will be attempted here.

The history of rail in South Africa began in the 1860s, when the Natal Railway Company and the Cape Town Railway and Dock Company opened the first railway lines in and around Durban and Cape Town. It was not long before these developments were purchased by the Natal and Cape governments, and thereafter the growth of rail in South Africa became largely a government affair. By the late 1870s, four main lines were reaching inland from Cape Town, Durban, Port Elizabeth and East London, whose seaport infrastructure predated rail by many years.

The discoveries of diamonds in 1867 and gold in 1886 provided considerable impetus to the development of rail. Following the discovery of diamonds, Kimberley grew rapidly in wealth and population, and yet remained constrained by poor transport and communication services. Diamonds generated both the need and the resources for a railway link to Cape Town, a venture

that was achieved in 1885. Gold played an equivalent role in the case of Johannesburg, which by 1896 was connected to the four main ports in the Cape and Natal as well as Lourenço Marques (now Maputo). In the Transvaal Republic, the construction and operation of railway infrastructure was undertaken by the Netherlands Railway Company until the government took over this role in 1902.

South Africa's network of railway lines was largely in place by 1930, and the growth in railway infrastructure thereafter was mainly in the form of rolling stock. Locomotives, coaching stock and goods stock continued to increase in number quite steadily between 1930 and 1980, after which they fell victim to South Africa's sharp fall-off in infrastructural investment (Figure 2). Not only did they fall in number, but their remaining lifespan as productive assets continued to fall as well, with negative consequences for reliability. The rise and decline of rail in South Africa is summarised in Table 3.

Table 3 – Rail infrastructure and services (South Africa)

	Railway lines	Loco-motives	Coaching stock	Goods stock	Goods stock carrying capacity	Passenger journeys	Revenue-earning traffic
	route km	number	number	number	million tonnes	million	million tonnes
1880	1 621						
1910	11 331	1 405	2 071	22 576	0.355	33.7	9.7
1930	18 445	2 193	3 668	37 546	0.783	80.5	20.4
1980	20 353	4 907	10 704	188 799	6.291	691.3	174.9
1995	21 079	3 574	6 740	135 155	6.161	416.0	176.0
2003	20 796	3 253	6 588	114 135	5.593	468.2	179.5

Data sources: Statistics South Africa; Central South African Railways (Report of the general manager of railways); Official Year Book of the Union; South African Railways and Harbours (Report of the general manager of railways and harbours / Annual reports); Union Statistics for Fifty Years; Spoornet

The development of rail in 20th-century South Africa was accompanied by the development of roads. The first trip by road between Cape Town and Johannesburg is reported to have taken place in 1905, an 11-day journey plagued by dust, pot-holes and farm gates.⁶ The expansion of national and provincial roads and the traffic they supported are shown in Table 4.

Table 4 – National and provincial roads, and vehicles (South Africa)

	National and provincial paved and unpaved roads *	National and provincial paved roads *	Passenger vehicles	Goods vehicles
	kilometres	kilometres	million	million
1915	75 279			
1930	115 076		0.170	0.016
1940	142 573	2 235	0.341	0.049
1950	145 063	7 057	0.500	0.124
1960	183 316 **	17 592	1.000	0.212
1970	185 523	33 120	1.674	0.394
1980	183 844	45 948	2.621	0.874
1990	181 290	53 446	3.927	1.273

* Intercity roads (urban roads excluded)

** Includes 25 000 km of roads previously classified as tertiary roads

Data sources: Statistics South Africa; National Traffic Information System; Official Year Book of the Union; South African National Roads Agency; Union Statistics for Fifty Years

South Africa's ports and airports handled ever-growing volumes of cargo and passengers during the 20th century. A summary is provided in Table 5. The sharp increase in cargo handled by the ports in the 1970s resulted in large measure from the opening of Richards Bay and Saldanha.

Table 5 – Cargo handled by ports, and air passengers (South Africa)

	Cargo handled by ports	SAA passengers (domestic and international)	International air passengers
	harbour tons (m)	million	million
1910	4.5		
1930	7.2		
1950	10.4	0.160	
1970	25.4	1.499	0.746
1980	78.7	3.983	1.608
1990	107.5	5.181	1.952
2000	162.7	5.856	5.770

Data sources: Statistics South Africa; National Ports Authority; Official Year Book of the Union; South African Airways; South African Transport Services (Annual reports)

Telegraphic and telephonic communications were introduced in the 1870s and 1880s. Twentieth-century progress in the number of fixed (land) telephone lines is shown in Table 6. Prior to 1991 telephone infrastructure and services were provided by the Department of Posts and Telecommunications, which then became Telkom, initially still wholly owned by the South African government but subsequently listed on the Johannesburg and New York stock exchanges in 2003. Cellular phones appeared in South Africa in the 1990s, and rapidly overtook the number of fixed phone lines. The cellular phone market was driven in large measure by private enterprise, though with Telkom also owning a substantial share of the market.

Table 6 – Fixed phone lines and electricity generation (South Africa)

	Fixed phone lines (Telkom)	Electricity generated (Eskom and other producers)
	million	gigawatt hours
1920	0.030	1 277
1930	0.070	2 454
1940	0.142	7 168
1950	0.277	11 187
1960	0.633	22 561
1970	0.879	50 791
1980	1.508	98 951
1990	3.080	165 384
2000	5.493	210 577

Data sources: Statistics South Africa; Official Year Book of the Union; Union Statistics for Fifty Years; Telkom

The bulk of South Africa's electricity is provided by Eskom (Table 6). Just as the early development of rail was closely associated with mining, so too was the expansion of electricity generation capacity. Not only did the mines require large quantities of electricity to operate, but South Africa had vast reserves of coal with which to produce electricity at a relatively low cost. Industry and households alike benefited from a cheap and reliable supply of electricity for decades, and Eskom came to be regarded by many as a model of what any successful state-owned enterprise should be (apart, that is, from the lopsided provision of services along racial lines). However, as we entered the 21st century, there were growing concerns about future generation capacity, concerns that were compounded by a lack of clarity over the respective roles of Eskom, various government departments and the private sector in building

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capacity to meet future demand. By early 2008, Eskom's ability to meet demand had become severely stretched and the country was subjected to a series of blackouts, a repeat of which has thus far been averted through demand-side management and a slowdown in the economy.

Causality between infrastructural investment and economic growth

If the preceding account of South Africa's historical development of its infrastructure creates an impression of good planning, efficient progress and excellence, it should be hastily dispelled, or at least heavily qualified. The decline in railway infrastructure after 1980 was increasingly met with complaints of poor and unreliable service, and much of the freight previously transported by rail (or which was better suited to rail) was shifted to road. With the additional volumes of freight on the roads, and growth in road passenger vehicles brought about in part by an inadequate public

transportation system, the roads became increasingly congested and difficult to maintain in the late 20th century. Congestion at some of the ports became a growing problem. Before the commercialisation of Telkom in the 1990s, although the telephone network was generally reliable, customer service (new installations and repair work) was slow and frustrating. Electricity fared better, though those chickens, too, came home to roost in early 2008, along with steep increases in electricity prices not long after.

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effects in infrastructure may hamper economic growth; and equally difficult to quantify the impact of a growing economy (with associated growth in tax revenue) on the provision of infrastructure. Internationally the empirical literature on the subject has produced mixed results, with some studies showing relatively strong and positive effects on economic growth from additional infrastructure provision, but others showing much weaker or even negligible effects (see Perkins *et al.*, 2005). Before summarising some of the empirical estimates that have been attempted for South Africa, a simple model of the relationship between growth and infrastructure may be outlined as follows.

The theoretical case for infrastructural investment having a positive impact on economic growth is provided by Barro's growth model⁷ in which output (per worker) is a function of both private-sector investment and public-sector provision of productive services, an important example of which is infrastructural services. The rationale for treating these expenditures separately is that they are not substitutes. The large-scale nature of infrastructural projects (with associated high expenditure and high risk), the difficulty of collecting user charges (not in all but in some cases), and the presence of positive externalities are all obstacles to the optimal provision of productive services such as infrastructure if left to the private sector. In Barro's model, public-sector services raise the marginal product of private-sector capital, which in turn raises the rate of economic growth.⁸

If small or modest amounts of infrastructural investment have a favourable impact on economic growth, does it follow that ever greater amounts of infrastructural

investment would have ever more favourable effects on the economy? Most certainly not. In the Barro model, starting from a relatively low level of productive services provided by the public sector, economic growth increases as the level of public-sector productive services increases. However, the improvement in economic growth is moderated by two effects, namely an ever-decreasing marginal product of public-sector expenditure, and a tax effect that is growth-negative. Thus there exists an optimal level of public-sector expenditure on productive services at which the rate of economic growth is optimised, beyond which the negative tax effect dominates the productivity effect and the rate of economic growth declines (eventually turning negative).⁹

Such a result in theory, namely that there is some level of infrastructural investment that is optimal for economic growth, should come as no surprise. At one end of the spectrum, an economy without power stations (for example) is unlikely to progress. At the other end, to build more power-generation capacity than could ever be used would clearly be wasteful and therefore harmful to economic growth. The challenge which researchers and policy makers face is to estimate just the right type and amount of infrastructural investment that should be undertaken, along with appropriate timing. The fact that such decisions must take place in the face of great uncertainty about the future makes them all the more difficult.

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The relationship between infrastructural investment and economic growth in South Africa has been examined by scholars.¹⁰ Empirical investigation was undertaken using long-term time series of national accounts data and individual measures of infrastructure and infrastructure-related variables, namely those for transport, communication and power discussed above.

In Perkins *et al.*¹¹ public-sector investment in economic infrastructure was found to have a positive effect on GDP growth, as were roads and road passenger vehicles. GDP growth was found to have a positive effect on railway lines, rail coaching stock, rail passengers, cargo handled at ports, SAA passengers, and fixed phone lines. Two-way relationships (or more accurately potential simultaneity) were found between GDP growth and: rail locomotives, rail goods stock, road goods vehicles, and electricity generation. More generally, Perkins *et al.*¹² concluded that ‘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.’

The same data set was investigated in Fedderke *et al.*¹³ The main results to emerge from a variety of specifications were that electricity generation had a positive and direct impact on GDP and that public-sector infrastructural investment had the effect of promoting private-sector investment in physical capital, which in turn had a positive impact on GDP. ‘The empirical results are generally supportive of the South African fiscal authorities’ renewed interest in public-sector investment since 2002’¹⁴.

Conclusion

Over the long term, namely the half century 1960–2009 shown in Figure 2, public-sector investment in economic infrastructure averaged approximately four per cent of South Africa's GDP. Considering the amount of economic activity which that four per cent facilitated and supported, and apart from investment in social infrastructure such as health and education, it would be difficult to find another category of expenditure of comparable size that is of equal importance in promoting economic growth.

Nevertheless, investments in infrastructure must be undertaken with care. Constructing a highway or railway between two previously unconnected centres of economic activity may reasonably be expected to have a beneficial impact on economic growth. Linking two uninhabited areas with no prospects for economic development would simply be wasteful. In other words, the growth-enhancing effects of economic infrastructure are not automatic; they must be considered with care in each situation, and weighed against the costs.

Since the mid-1990s, there has been growing recognition of the importance of investing in economic infrastructure in South Africa. The extended period of decline that started in the early 1980s (or even before) was brought to an end, the level of investment was stabilised, and between 2002 and 2009 there was an upsurge across a range of investment types.

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Airport and Sandton was completed in 2010, with further extensions to be completed in 2011; bus rapid transport systems have been implemented; and Eskom has embarked on a long-term investment programme to build new electricity generation capacity. In communications, cellular phones and the internet have arguably been the outstanding feature of economic infrastructural development since the late 1990s, not only in South Africa but across the globe. The private sector has played a leading role in the information and communication technology revolution, with governments playing an important regulatory role.

Much remains to be done. In electricity alone the demands are enormous. Eskom plans to double its generation capacity from approximately 40 000 MW in 2010 to 80 000 MW in 2026. Considering that a substantial portion of the existing 40 000 MW capacity will expire before then (power stations depreciate), this is a daunting prospect.

If South Africa's economy is to move to a high-growth path, sufficiently high to bring down unemployment in any meaningful way, sustained investment in its economic infrastructure will be integral to achieving that outcome. Given the multitude of demands on the public purse and the temptation to neglect infrastructural investment when times are tough, and the difficulty of taking long-

term decisions in the presence of enormous uncertainty, this is easier said than done. But it cannot be avoided. Beyond recognition of the importance of economic infrastructure for economic growth, crucial to the continued renewal and expansion of our economic infrastructure will be careful assessment based on a number of issues. These include cost-benefit analysis; efficient spending of available funds and effective implementation of projects from beginning to end; finding sustainable solutions to funding shortfalls; public consultation and debate; building partnerships between the private and public sectors; co-ordination between all participants and other stakeholders, all of whose roles should be made clear; and above all, clear planning and strong leadership. The objective for policy makers across all levels of government must be to plan for and provide economic infrastructure that is not too much, not too little, but just the right amount, just the right type, and at just the right time and just the right price. It is a difficult challenge indeed.

NOTES

- 1 2010a
- 2 2010b
- 3 2010
- 4 Gross fixed capital formation.
- 5 An important, or rather crucial, private-sector contribution to South Africa's infrastructural development that ought to be acknowledged is that of the private-sector civil engineering and construction firms contracted by the state to undertake the work of putting infrastructure in place.
- 6 Van Lingen et al., 1960: 141
- 7 Barro, 1990
- 8 See Fedderke et al. (2006) for a detailed explanation of the Barro model.
- 9 In a Cobb-Douglas representation of the Barro model with constant returns to scale, the optimal point is reached when the marginal product of public-sector expenditure falls to one.
- 10 Perkins et al. (2005) and Fedderke et al. (2006)
- 11 (2005). PSS (Pesaran, Shin and Smith) F-tests were used to identify directions of association between economic infrastructure and GDP.
- 12 2005: 223
- 13 (2006) using a vector error-correction mechanism framework.
- 14 Fedderke et al., 2006: 1052

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