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THE ECONOMIC IMPORTANCE OF AN OPTIMAL ROAD INVESTMENT POLICY IN SOUTH AFRICA

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ABSTRACT

Productive expenditure on road infrastructure contributes to economic growth as a factor of production, complement to other factors of production, stimulus to factor accumulation, stimulus to aggregate demand, and industrial policy tool. On the other hand, unproductive or insufficient investment in road infrastructure may crowd out private sector investment, increase operational costs, reduce the life-span of private sector capital, necessitate private capital adjustment costs, decrease labour productivity, and impinge on human development. This paper uses economic growth theory to explain the roles of road infrastructure investment in the growth process, with reference made to studies that confirm the relevance, direction, and magnitude of these effects in South Africa. Details of national development policies, the geographic structure of the South African economy, the state of the country's rail sector, and freight, personal travel, proximity to basic services, rural-urban migration, and household agriculture statistics are also incorporated in the discussion to emphasise the importance of sound road investment policy in South Africa.

1 INTRODUCTION

The World Bank (1994:14) recognises that infrastructure, "if not the engine", is the "wheels of economic activity". World Bank supported road projects between 1974-1982 and 1983-1992 yielded respective average economic rates of return of 20 per cent and 29 per cent. These rates of return, which were the highest amongst 13 types of infrastructure, indicate the high potential economic growth payoff of investment in road infrastructure.

The macroeconomic channels through which road infrastructure investment affects growth are key to allaying the National Planning Commission's (NPC) (2012: 10) concern that South Africa has fallen into a low growth middle-income trap, whereby growth has stagnated at middle-income levels rather than describing a path to a high-income country. Road infrastructure investment, which includes maintenance, can address this trap's first feature of uncompetitive goods and services by reducing transport costs, reducing the need to maintain high inventories, and raising the productivity of labour and other capital inputs (Agenor, 2012: 11).

By increasing the marginal productivity of private inputs, road infrastructure investment can raise the rate of return on private capital and thereby create the necessary conditions to crowd in private investment. Following Hirschman's (1960) argument that savings in less developed countries are dependent on investment opportunities, efficient road infrastructure investment can ease the trap's second feature of low savings and investment rates.

Improved access to services and markets from road infrastructure investment can also improve the country's skill profile and lower the number of work seekers unable to enter the labour market, which are the third and fourth features of the trap (Agenor, 2012: 11). The skills deficit is a main contributor to the currently high level of structural unemployment in South Africa.

These channels generally yield a positive relationship between road infrastructure investment and economic growth. But road infrastructure investment can also have a negative economic effect, as in 4 of the 64 road transport studies reviewed by Straub (2008), when: life-cycle road construction and maintenance costs exceed a road's contribution to economic growth; road infrastructure investment disproportionately crowds out private investment; or insufficient road infrastructure investment increases vehicle operating costs, reduces the life-span of public and private capital, imposes private capital adjustment costs, decreases labour productivity, or hinders the development of human capital. These risks are all present in South Africa given the extent of the country's road network (which at 750 000 km is the 10th longest in the world), the high proportion of low volume gravel roads (79% of the network), generally deteriorated road conditions, and currently mediocre but falling service levels (World Economic Forum, 2018).

This paper uses economic growth theory to explore the potential effects of road infrastructure investment on growth in South Africa. The potential benefits of road infrastructure investment are viewed alongside the costs of inefficient expenditure, bearing in mind the spatial characteristics of the national economy, the decline in the rail sector, and the various functions fulfilled by roads. Economic growth theory, in the form of an aggregate production function, is introduced in Section 2 to identify the general direct and indirect effects of road infrastructure investment on economic growth. These effects are respectively discussed in Sections 3 and 4, with illustrative data used to contextualise the analysis. The conclusion affirms the critical role of road infrastructure investment in the economy, and the need for a road investment policy able to fulfil the mandates set for the sector by the 1996 White Paper on National Transport Policy: address citizens' basic rights, develop human capital, and grow the economy.

2 ECONOMIC GROWTH THEORY

Following Straub (2008), Aghion and Howitt (1998), Agénor (2004), and Agénor and Moreno-Dodson (2006), economic growth theory is applied as a framework to assess the relative value of road infrastructure investment. These effects are represented in reduced form by the following aggregate production function, which can be framed either in terms of quantities or quality of road infrastructure:

$$Q = A(\theta, KI).F(K, L, G(KI))$$

where Q is real aggregate output, K is non-infrastructure capital stock, KI is infrastructure capital stock (which includes road infrastructure), L is aggregate hours worked by the labour force, and $A(.)$ a standard productivity term. KI enters the production function $F(.)$ through a function $G(KI)$.

Following the assumption that the stock of infrastructure has pure public good attributes and produces services in a non-rival and non-excludable way, infrastructure can be captured in this formulation of the production function as an additional factor of production *(G(KI)=KI)*. But this assumption is unrealistic as some infrastructure investment is mediated through markets and thus characterised as a private good, and secondly, even when private operators are involved, factors such as price regulation mean that service charges are often not market determined (Straub, 2008). So rather than being simply an additional factor production, infrastructure *KI* enters the production function through the service provided by this type of capital *(G(KI)=I(KI))*. *I(KI)* is an intermediate inputs variable, which does reflect the nature of roads. An increase in *KI* would therefore lower the cost of related intermediate inputs – such as road transport - that enter firms' production functions. Whether an additional factor of production or intermediate input variable, *G(KI)* captures the "direct" effects of road infrastructure discussed in Section 3.

This formulation of the production function also distinguishes between two sources of increases in the productivity parameter *A*: generic efficiency-enhancing externalities, represented by θ, and efficiency-enhancing externalities specifically linked to the accumulation of infrastructure capital (Straub, 2008). These efficiency-enhancing externalities are referred to as the "indirect" effects of road infrastructure, which are explored further in Section 4.

This formulation makes no specific assumption on the nature of returns to scale. The elasticity of infrastructure introduced as part of the *F(.)* function and the strength of potential externalities determine whether an investment in road infrastructure accommodates diminishing, constant, or increasing returns. The subsequent sections draw on studies and illustrative data to explore whether road infrastructure investment, through its direct and indirect effects on aggregate production, is likely to act simply as a capital accumulation device or whether it has the potential to foster endogenous growth processes in South Africa.

3 DIRECT EFFECTS OF ROAD INFRASTRUCTURE ON ECONOMIC GROWTH

Road infrastructure investment influences economic growth through a direct productivity effect that arises from roads being an input in the production process of many goods and services. This input relates to the cost of moving goods by road between their places of production and final points of consumption. Specialisation of individual functions in the production process has boosted the level of reliance on the road network, with many products now consisting of separate components produced at different locations. The Council for Scientific and Industrial Research (CSIR) (2013) indicate the relative transport intensity of the South African economy by comparing transport's 61.6% contribution to total logistics costs in 2013 with the global average of 39%. The National Department of Transport (2006) records the direct cost of transport as a percentage of the value of sectoral output at 6.3% for agriculture, 5.2% for mining, 4.6% for manufacturing, 2.6% for construction, 4.4% for trade, and 4.5% for community services. Efficient road infrastructure investment that supports lower transport costs would reduce the associated production costs and promote profitability, investment, and growth.

Importantly, 87.9% of South Africa's freight tonnage in 2013 was transported by road (CSIR, 2013). The significant resources devoted to road transport and this intermodal freight split are contrary to international trends, where rail is often the most cost-effective and therefore dominant transport mode for large, uniform cargoes travelling long distances. This reliance on road infrastructure is largely explained by South Africa's unique spatial characteristics

and the decline in the rail sector. The country's primary demand zone, Gauteng, is inland along with the source of many export commodities and products. While many of the associated goods should ideally be moved by rail, with roads only providing adequate first- and last-mile connectivity to and from transport hubs, insufficient investment in rail and deregulation of road freight transport during the 1980s accentuated the role of road infrastructure (National Department of Transport, 2006: 80). Trasnet's (2013) aim is to shift 80% of large, uniform, containerised freight back to rail, with road transport remaining the preferred method for only time-sensitive goods requiring high levels of flexibility. But this shift is planned over a 30-year time horizon, which is longer than the design life of most sealed roads. This means that road infrastructure will continue to dominate freight transport over at least the medium term.

Although road infrastructure investment may have significant effects on transport costs, it is not a sufficient condition for economic growth. The impact depends on the complementarities of a road investment and how supply matches demand. Investment in a road with low demand or few and weak complementarities can yield a negative economic return, as shown by Klevchuk and Jenkins (2004) who reference 3 roads in Limpopo that had negative economic net present values despite a supposed connection to key economic sectors. Maintaining these roads as part of the infrastructure capital stock diverts funds from productive alternatives and risks disincentivising and crowding out (via taxes) private investment.

4 INDIRECT EFFECTS OF ROAD INFRASTRUCTURE ON ECONOMIC GROWTH

4.1 Maintenance, private capital durability, and road accidents

Key benefits of a sound road infrastructure investment policy are fuller life-spans for roads, savings in vehicle operating costs (VOC), better duration of relevant private capital such as vehicles, and improved road safety (Straub, 2008). These factors impact public, private, and commercial users, with the benefits to the latter of trade expansion, promoting export diversification, and attraction of foreign direct investment. But road maintenance is often neglected because of the visibility offered by new roads and politicians' bias towards short time horizons, with a mismatch between the duration of political office terms and the relatively long design life of a road.

Kannemeyer (2016) details the negative effects of delayed road maintenance. The respective repair costs for a road in poor and very poor conditions are 6 and 18 times higher than the cost of preventative maintenance for a road in very good condition. Budget reallocation or additional revenues are needed to compensate for delayed maintenance, which unnecessarily diverts resources from productive alternatives. Higher VOCs imposed on private road users from the continued neglect of already deteriorated roads would erode any agency savings.

VOC savings result from an improved road surface. Better quality roads tend to reduce petrol consumption, extend tyre life, decrease cargo damages, and lower vehicle maintenance costs. The 6th Annual State of Logistics Survey for South Africa (CSIR, 2009) included a case study on the effects of deteriorating road quality, measured by the International Roughness Index (IRI), on vehicle maintenance and repair costs. The average maintenance and repairs costs for trucks travelling on poor quality roads were approximately double (121% higher) that of trucks travelling on good quality roads. Bearing in mind that maintenance and repairs are a component of logistic costs, poor quality roads raised total company logistic costs by 10%. From a technical perspective, Chatti and Zaabar (2012)

show that an increase in IRI from 3m/km to 4m/km and 5m/km increases the vehicle repair and maintenance costs for heavy trucks by 10% and 50%, respectively. Road quality affects fuel consumption differently according to the topography and the weight and speed of a vehicle. But a simple comparative study of truck traffic on South African highways found fuel consumption to be 15% higher on poor versus good quality roads (Van Der Walt, 2011). Chatti and Zaabar (2012) confirm that fuel consumption of heavy trucks increases by approximately 1% at 96km/h and 2% at 56km/h for every increase of 1m/km in the IRI. Poor quality roads were shown by Lowne (1969) to shorten expected tyre life by two-thirds, which correlates with Chatti and Zaarbar's (2012) estimate of a 1% increase in the tyre wear of heavy trucks travelling at 88km/h for every 1m/km increase in IRI. Van Der Merwe (2011) attributes a 1-2% increase in the volume of damaged cargo to poor quality roads. Road infrastructure investment therefore exerts a significant effect on real aggregate output through the global competitiveness of local goods and the volume of marketable produce.

The Road Traffic Management Corporation (RTMC) (2016) recorded 11 144 fatal, 40 117 major (serious injuries), 132 609 minor (slight injuries), and 648 560 non-serious (vehicle damage only) road accidents in South Africa in 2015. Considering the costs associated with casualty, treating injuries, ongoing care of persons with disabilities, vehicle repair, incident management, insurance administration, and emergency services, the RTMC estimates that these accidents cost the South African economy R142.9 billion, or 3.4% of GDP in 2015. This is high compared to the average of 2.2% of GDP in low- and middle-income countries. To the extent that road conditions are a contributing factor to road accidents, road investment policy that lowered accident rates through improved road conditions would free R618 031, R109 694, and R2 094 per major, minor, and non-serious accident for alternative productive uses. Further gains in output would be realised through the stock and productivity of labour.

4.2 Adjustment costs

Investment in road infrastructure enhances the reliability of the road service. This reduces or removes the need for users to invest in substitutes as a hedge against service interruptions (Straub, 2008). Moreover, the state is often able to provide roads at a lower cost than the private sector given its ability to achieve significant economies of scale. Both free private resources for investment in productive alternatives.

4.3 Productivity of other inputs

Improvements in total factor productivity (TFP) are brought about by the efficiency with which the factors of production are combined to generate growth in output. As roads are a complement to other production factors, efficient road infrastructure investment can raise the productivity of other inputs in the production process. This can increase output for a given level of inputs and lower the cost of these inputs, extending the scope of private investment opportunities.

Fedderke and Bogetic (2009) applied an endogenous growth model to assess the impact of 19 infrastructure measures on TFP in South Africa from 1970 to 1993. The total road network had a strong, positive, and statistically significant impact on TFP, with a 1% increase in the road network associated with a 2.8 percentage point increase in productivity growth. Paved roads had a stronger positive impact on TFP, with a 1% increase in the paved road network yielding a 4.9 percentage point increase in the manufacturing sector's productivity growth. The strength of these impacts must be considered in relation to the extent of South Africa's road network, where a 1% increase is associated on the margin with 7 500 km of road. The

CSIR (2013) note that between 2008 and 2012 provinces and municipalities built only 90 km and 1 477 km of new roads, respectively. It is necessary to note that the evolution of the road network since 1993, which has grown with urban expansion and local economic development objectives, is likely to have a bearing on the estimated impact of road investment on TFP.

The movement of people is also a key source of transport costs. Commuting is an opportunity cost, monetary drain, and stress factor for workers. According to the 2013 National Household Travel Survey (Statistics South Africa, 2014), 2.9 million workers walked and 3.9 million drove to work. The mean time travelled to place of work was 34 minutes for those walking, 38 minutes by car, 50 minutes by taxi, and 74 minutes by bus, bearing in mind that 19.2% of those travelling by vehicle were delayed by switching transport mode on the way. But 8.8%, 53.2%, 26.0%, and 14.9% of those respectively travelling by foot, bus, taxi, and car spent more than an hour travelling to work each day. Road infrastructure investment has historically had a positive effect on labour productivity in South Africa by reducing travel times and stresses, with Fedderke and Bogetic (2009) estimating elasticities of 2.95 for the total road network and 1.08 for paved roads.

Fedderke and Bogetic (2009) note that, under a Barrow style endogenous growth model with a balanced budget constraint, increased taxes to fund public infrastructure lower the growth rate (referred to as the tax effect) while increased public infrastructure raises the growth rate through its effect on the marginal product of private capital (referred to as the capital productivity effect). The capital productivity effect dominates at lower levels of public infrastructure provision, while the tax effect dominates at higher levels of such provision. This demonstrates that investment in roads can raise growth only within limits. Once the marginal product of capital has diminished to the point where the tax effect dominates, additional road investment harms growth.

4.4 Human development

Access to schools and healthcare facilities are determinants of human capital formation. Road infrastructure investment that minimises access constraints can generate higher output through a healthier and better skilled workforce. This channel is particularly relevant given the inferior access that rural communities have to basic services because of apartheid's policy of separate development and the subsequent maladministration of the road sector (National Department of Transport, 2007). Limited road access has resulted in 3 million children walking for more than an hour to and from schools, with such travel burdens often leading to increased enrolment ages, higher drop-out rates, and generally poorer education outcomes (World Bank, 1999; Lebo and Schelling, 2001). The NPC (2012: 305) partially blames road access limitations for the fact that half of every cohort that enters the South African school system is lost by the end of Grade 12. A similar point holds for the health sector, where the NPC (2012: 335) called for the road network's impact on health outcomes to be specifically considered.

Figures 1, 2, and 3 illustrate the distance from communities to the nearest basic service centres based on the 2011 census data, 2017 hospital registry, and 2016Q2 primary, secondary, and special school databases (Statistics South Africa, 2011; National Department of Health, 2017; National Department of Basic Education, 2018). Access constraints are present across the country, but especially in sparsely populated areas of the Northern Cape and Limpopo, and highlight the importance of road infrastructure investment for human capital formation.

Figure 1: Distance to nearest healthcare facility

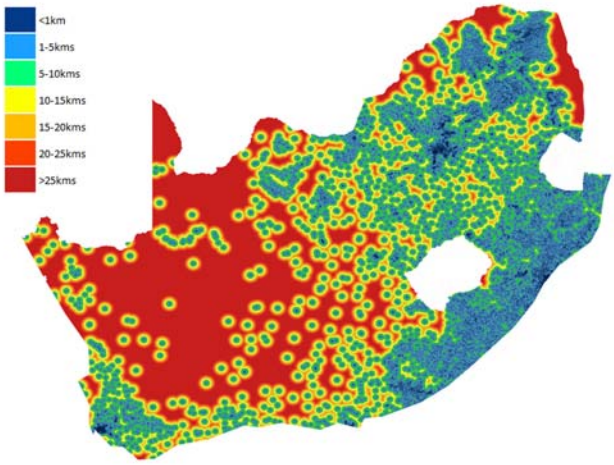

Figure 2: Distance to nearest primary school

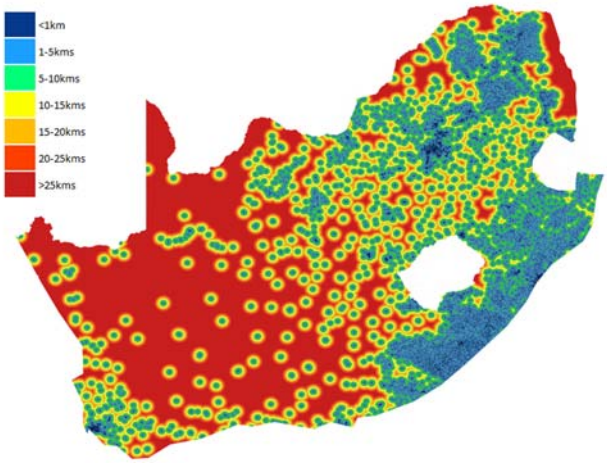

Figure 3: Distance to nearest secondary school

4.5 Economies of scale and scope

Road infrastructure investment can promote: economies of scale; network externalities; better inventory management; market change; different patterns of agglomeration; and more efficient market clearing and competition (Hulten et al. 2005). These impacts support government's aim to create a high growth, export orientated economy partly through large business clusters such as Industrial Development Zones and Spatial Development Initiatives. The economies of scale and streamlined provision of infrastructure at these centres generates increasing returns from the enhanced synergies between the factors of production and lowers entry barriers for firms.

One sector that would benefit from these effects is household and small-scale agriculture. The 2011 Census recorded approximately 2.9 million household farms, with a high

concentration in isolated rural regions. The relevant channels from road infrastructure investment to economic growth in this sector include lower input prices and hence lower production costs; higher sales volumes from improved market access; higher profitability from access to external markets in larger towns or rural centres where prices are higher compared to local alternatives; and more cultivation and crop diversification from the higher producer profits and market access (National Department of Transport, 2006: 40; Dennis, 1998; Khandker and Koolwal, 2011). Efficient road infrastructure investment can therefore shift farmers' production frontier outwards, thus yielding higher output and investment.

Investment in urban road infrastructure during the urban concentration process can avoid risks to cities' growth prospects by reducing potential inner-city congestion (Straub, 2008). But once congestion does pose a significant challenge to growth, as seen in many South African metros, investment in road infrastructure that provides inner city connections and promotes regional development can catalyse deconcentration to counteract agglomeration forces.

4.6 Rural-urban migration

6.8 million citizens migrated from rural to urban areas between 2001 and 2011, raising the urban population from 57% to 63% (Statistics South Africa, 2011). Inadequate rural incomes, job opportunities, and connective infrastructure contributed to this trend. Beyond any benefits to regional economic activity, road infrastructure investment that supports rural development or strengthens the link between rural and urban areas is a vital tool for matching rates of rural-urban migration to rates of expansion of urban infrastructure. Increasing levels of urban congestion and infrastructure failure magnify the relevance of this outcome.

4.7 Road policy as a form of industrial policy

Road investment policy is also claimed to be a form of industrial policy. Because major trade routes and urban roads facilitate the movement of large volumes of different goods, road infrastructure investment allows policy-makers to improve the general business environment and then to rely on market dynamics to select the winning sectors. This is sometimes preferable to making uncertain pre-selections, as done in the New Growth Path, National Development Plan, and the Industrial Policy Action Plan which explicitly prioritise sectors of the economy. Although a road's design and route may be planned for a specific set of primary users, and in that way cater to a chosen sector, the road still facilitates multi-sectoral traffic and thus poses fewer risks to narrowing potential investor interest.

In addition, investment in road infrastructure can influence the distribution of economic gains. Combes and Lafourcade (2005) demonstrate that while road infrastructure made only a minor contribution to the decline in transport costs in France between 1978 and 1998, it was road policy that determined the distribution of the economic gains.

The NPC (2012: 119) acknowledges that South Africa's problem of unemployment is too big for market-based solutions to solve in the next 10 to 20 years. Even in the most optimistic scenarios many people are likely to remain out of work. Public employment programmes that recruit low-skilled workers for public infrastructure projects are therefore an essential element of any employment strategy. Road projects can generate employment through cost-effective labour-intensive construction and maintenance practices. Effective trade-off of capital for labour at least stimulates short-run aggregate demand, while permanent job

creation and on-the-job skills training for these extra workers raises long-term potential economic growth.

5 CONCLUSION

Hirschman's (1960) theory of unbalanced growth suggests that growth is communicated in an uneven fashion from one sector of the economy to another. Efficient investment in the master industry will therefore lead to upstream and downstream benefits in connected sectors. Perkins et al. (2005) prove that for South Africa causality runs from investment in road infrastructure to economic growth. But the degree to which investment in road infrastructure affects growth, and whether this contribution is even positive, depends on the efficiency of the investment.

Within constitutional constraints, road investment policy should allocate the sector's limited resources such that the combined direct and indirect effects of road infrastructure on economic growth are maximised. The sector's mandates to address citizens' basic rights, develop human capital, and grow the economy are thus linked. Road infrastructure that provides access to basic service centres supports the development of human capital (to the extent that road access is a constraint on education outcomes), which then adds to aggregate output. Crucially, the various benefits of road infrastructure investment are central to any effort to fully address the structural challenges that have led South Africa into the low growth middle-income trap.

But while many studies point to the economic benefits of road infrastructure investment, there are also examples to warn policy-makers against inefficient expenditure. Whilst insufficient road infrastructure investment limits citizens' access and deters private investors, over-capitalisation risks crowding-out private investment. Any misdirected investment also has a limiting effect on growth. Road investment policy must therefore support efficient decision making amongst the national, 9 provincial, and 213 municipal road departments to ensure the sector fully plays its role in realising the NPC's vision of an inclusive, export-orientated, high growth economy.

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