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A model for Public Infrastructure Equalization in Transitional Economies

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1. Introduction

Many transitional economies have a shortage of infrastructure for the provision of public services (eg. health, education) that are important in developing human capital and raising the rate of economic growth. Moreover, the regional distribution of the available public capital for the provision of these services is often uneven implying that citizens also have inequitable access to the public services that are available.

A vivid example is South Africa, a country making the transition from a minority rule political system with substantial government intervention in the economy to one that is more reliant on markets, democracy and democratic institutions. South Africa has an overall shortage of public infrastructure for services such as education and health, but in particular, an extreme variation in the distribution of the available infrastructure across regions[1]. Service standards are high in some areas while in others there is virtually no infrastructure at all. This shortage of infrastructure and its regionally disparate distribution is known in South Africa as the 'capital backlog' problem and implementing policies to alleviate the problem is a priority of the national government both for economic and social stability reasons.

As in South Africa, national governments in transitional economies may also have access to some supplementary funds for additional spending on infrastructure. These funds might be provided by donor countries, international aid institutions or from their own budgetary resources. However, even if some additional resources are available

[1] In South Africa's case, this is a result of decisions made by previous Apartheid regimes.

policy-makers face two other major issues. The first is how they should allocate the pool of supplementary funds to each service (eg. education and health) and also to each region in a way that addresses the inequity between regions and at the same time raises the overall level of public infrastructure. The second issue is whether the pool of supplementary funds available is sufficient to meet the policy goal of substantially reducing capital backlogs over some realistic period of time (this is an especially important question in South Africa).

Here we construct a model that can be used as a simulation tool by policy makers to help them answer these types of questions. Specifically, we suppose that there is some pool of funds provided by the national government for additional expenditure on public infrastructure. The funds are available over some specified period of time, and in the simulations conducted for South Africa later in the paper, this period is taken to be ten years. The model then constructs infrastructure estimates over this period for each service of interest and each region on the assumption that current levels of capital expenditure continue. The next step is to construct estimates of the desired level of infrastructure over the same period using international benchmarks. For most transitional economies, South Africa included, the desired level of infrastructure lies above the actual (the difference being a capital backlog).

We then show that over time it is possible to increase the level of region and service specific infrastructure available until it is equal to the region and service specific desired level. During this process some degree of equalisation in public capital stocks is also achieved. Indeed, this is the ultimate aim of the model and the policy-makers who may use it. We call the track that would be followed in doing this an ideal or initial transition path. It represents the path that could be followed by the stock of infrastructure given sufficiently large additional capital expenditures. Of course, if the pool is big enough the transition from what is available now to the desired capital stock could be achieved very quickly.

The initial transition path, constructed mathematically within the simulation model, allows us to calculate service and region specific 'capital needs' in each year of the transition process. The need is the difference between the stock of capital associated with the ideal transition path and the actual stock (the one that would apply without any extra expenditures). Generally, these needs differ across regions (for the same service) because each region starts out with a different capital backlog inherited from the past (in South Africa the differences are large).

The capital needs calculated in this way are then used to estimate region and service specific 'shares' of the available pool of supplementary funds in each year. These shares are then applied to the available pool to determine the region, service and year specific allocation of the pool. Since, in general, the pool available is not sufficient to fill the calculated needs in each year, the actual process of transition falls below the ideal transition path. For this reason, the model also produces an 'actual transition path'. This is the track that is actually followed by the level of infrastructure under the scheme of supplementary expenditures.

As noted, the actual transition path lies below the ideal one but above the level of infrastructure that would prevail in the absence of intervention. In this case, the one that is likely to apply in transitional economies, by the end of the period of supplementary expenditures capital backlogs still persist but they are not as large as they would be in the absence of the scheme. Moreover, the regional inequities in levels of infrastructure will have been partly 'equalised'[2]. Of course, as discussed, if the pool of funds is sufficient to allow the actual transition path to follow the initially specified ideal path, by the end of the program period the backlogs will have been eliminated and full inter-regional equalisation achieved.

Before progressing with development of the model various other points require additional comment. The first is that we make no claim to having made any theoretical contribution. The contribution of the paper is a practical one, namely, to provide policy-makers in transitional economies with a practical and easy to use tool for assisting them in making decisions over the region and service specific allocation of scarce national funds to meet basic public infrastructure needs for services such as education and health (important in creating human capital). Second, the pool of funds available for supplementary public capital expenditures is assumed throughout our analysis to be determined outside of the model. This is because we concentrate on the issue of how to allocate a given pool among different regions and services and the consequences (for backlogs) of allocating pools of different sizes. Nevertheless, determining how large the pool should be is an important matter and in many countries this needs to be answered by macroeconomic forecasting models. The forecast of the available pool would then be an (exogenous) input into our model that determines the regional and service specific allocation.

Even so, the model is of considerable use in providing information on what the pool of funds ought to be since within the model we calculate the total need that must be filled in each period if capital backlogs are to be eliminated (or substantially reduced) over some period of time. Thus, the model answers the question of whether the resources available to a particular economy are sufficient to address its public capital backlog problems or whether the backlogs are too large to be handled within a time that is considered acceptable. As will be seen, this is important information that comes from the simulations for South Africa.

The outline of the paper is as follows. Section 2 develops the model formally, namely, it derives the main formulae of the model. Section 3 applies the model to South Africa and presents the results of various simulations. Also provided is a brief discussion of the input data constructed for the simulation. Conclusions are presented in Section 4.

2. Theory

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[2] In this sense, we can think of the model as a public capital equalisation scheme since it aims to reduce disparities in citizen access to basic public services important in the creation of human capital.

Consider an economy with a national government and i = 1,.....,I heterogenous regions that might represent economic areas, zones containing a particular ethnic group or a political jurisdiction such as a Province or State. The national government is responsible for providing s = 1,......,S public services, such as health, education, welfare and public transport. Suppose also that the national government wishes to increase the stock of service and region specific public infrastructure used in providing these services (eg. schools, roads, hospitals) over some period of time beginning in period $\tau = t$ (this might be the current period) and ending in some future period $\tau = t + n$. For example, if n is equal to 10, decision-makers may look to design a program to raise the level of infrastructure over a ten year period. To achieve this, we assume that the national government has access to some pool of funds, denoted by P_τ, that is to be used to achieve its goals. The problem faced by the centre is how to allocate the pool of funds among regions and services in a way that takes account of the different levels of public capital stock inherited from the past and different levels of on-going public capital expenditure.

The first step in constructing a model that will give policy makers the required information is to develop some notion of a 'desired' region and service specific capital stock that is ideally to be achieved by the end of the implementation period, $\tau = t + n$. In practical applications, such estimates could be obtained from international comparisons. For example, in the application of the model to South Africa in Section 3 we use estimates of actual stocks of public capital for Australia to construct estimates of desired region and service specific public capital stocks for South Africa.

This idea can be developed more formally if we denote $K^{*,s}_{i,t+n}$ as the region and service specific desired stock of public capital that is to be achieved by the end of the period over which the policy is to operate, $\tau = t + n$. It proves convenient to construct this estimate using the Perpetual Inventory Method (PIM), a commonly used methodology for constructing capital stock estimates (see Holtz-Eakin (1991)). The difference between our work and previous applications of this methodology is that we apply it to create future estimates of capital stocks rather than generate stock estimates from some previous period to the present. Our application of the approach takes an estimate of the desired stock of capital in the first period of the program, $K^{*,s}_{i,t}$, and then uses estimates of desired net capital expenditure and depreciation to construct an estimate of the desired capital stock for each ensuing period. Thus, we are able to construct an estimate of the desired service and region specific stock of public capital from period $\tau = t$ to period $\tau = t + n$ (the final year). Formally, we define the desired stock of public capital for service s in region i at the end of the program as

$$K^{*,s}_{i,t+n} = K^{*,s}_{i,t}(1-\delta)^n + \sum_{\tau=t}^{t+n-1} k^{*,s}_{i,\tau}(1-\delta)^{t+n-1-\tau} . \qquad (1)$$

The first term on the right hand side, $K^{*,s}_{i,t}$ is the (real) desired capital stock at time $\tau = t$ (the first period of implementation), δ is the rate of depreciation (which we suppose for convenience to be time, service and region invariant) and $k^{*,s}_{i,\tau}$ is a (real) desired net capital expenditure forecast for each period, service and region[3]. The set up assumes that an estimate of the value of $K^{*,s}_{i,t}$ is available at the beginning of period t and thus its depreciation starts during this period and continues through all the subsequent periods. The estimate for $k^{*,s}_{i,\tau}$ relates to the end of each period τ and therefore starts depreciating from period ♦⌧1 onwards.

The next step in developing the model is to estimate the actual level of service and region specific capital in each period of the program. Generally, this will deviate from the desired level with some regions being above and others below. Using PIM the actual capital stock at time $\tau = t + n$ is given by

$$K^{s}_{i,t+n} = K^{s}_{i,t}(1-\delta)^{n} + \sum_{\tau=t}^{t+n-1} k^{s}_{i,\tau}(1-\delta)^{t+n-1-\tau}\ , \qquad (2)$$

where $K^{s}_{i,t+n}$ is the (real) actual capital stock at time t + n for service s, $K^{s}_{i,t}$ is the (real) actual capital stock at time t for service s (this is an estimate of the actual stock of capital at the start of the scheme) and $k^{s}_{i,\tau}$ is the forecast flow of actual service and region specific capital expenditures between t and t + n. In an application of the model to a decentralised economy with sub-national political jurisdictions these might be the capital expenditures that national decision makers forecast will be undertaken by States or Provinces. Alternatively, in a unitary country they might be the forecast expenditures of the national government through its various agencies.

For any particular region and service the desired public capital stock is below or above the actual stock in any period. For transitional economies it is more likely that the desired stock exceeds the actual stock implying a ‘capital stock backlog’ (or deficit) in each period. This situation is illustrated in Fig. 1 where the line ac represents the desired capital stock from the first period of the program to the final period and bd is the actual capital stock over the same period. The capital backlog in the first period $\tau = t$ is the distance ab while the backlog at the completion of the period of interest is cd. Note that as drawn the backlog increases over the period though this need not be the case. Whether the gap increases or decreases depends upon actual net capital expenditure in each period relative to desired net capital expenditure (with common depreciation)[4].

We are now in a position to develop the remaining mathematics of the model. Recall from the earlier discussion that the aim of the national government is to allocate a

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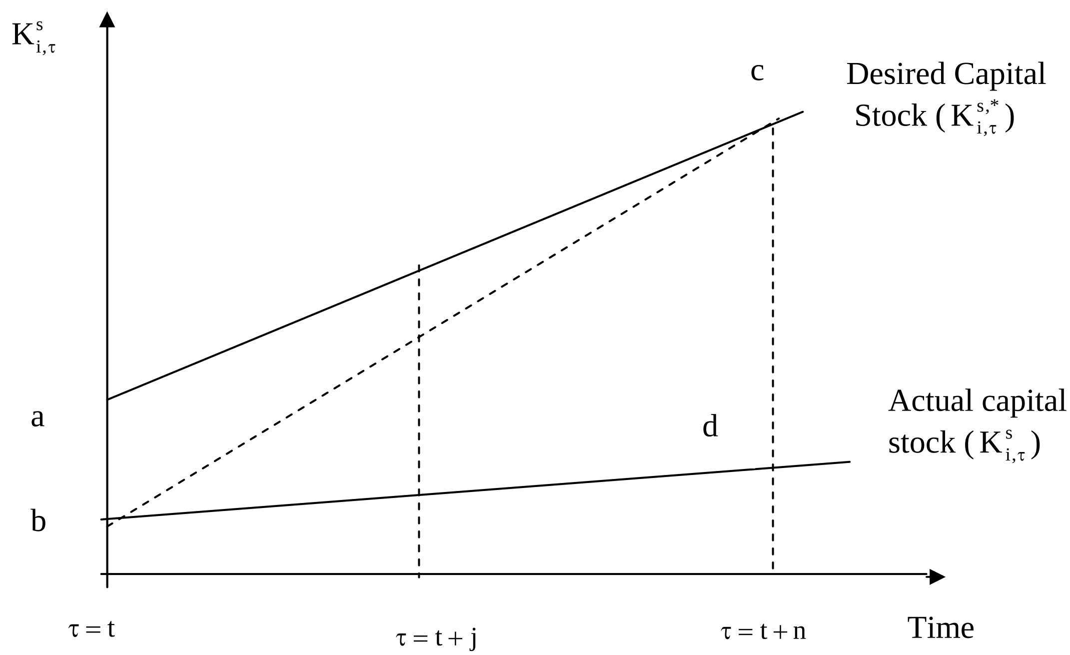
[3] As noted, equation (1) is an application of the PIM to future periods. Note also that: (i) the depreciation rate can be made variant with respect to time period, province and service without changing the qualitative results; and (ii) time is treated as a discrete variable and the capital stock undergoes a change once within a period of time (each year). Thus, time takes on only integer values.

[4] For convenience the desired and actual capital stocks are assumed to be linear functions of time but in general this is not the case.

pool of funds to each service and region to raise the actual stock of capital to the desired region and service specific level by the period $\tau = t + n$. In other words, we want to supplement existing capital spending so that the actual capital stock follows the line analogous to bc in Fig. 1 rather than bd. The slope of this line does not have to be constant. Any line that starts at b, ends at c and lies between bd and ac is acceptable. For simplicity we assume it to be linear.

Figure 1: Desired and Actual Capital Stocks for Service s in Region i



The following discussion concentrates on developing this aspect of the model. This requires that a number of steps be taken. The first one is to develop an expression that shows the extent to which capital expenditures would need to be supplemented over the program period in order to ensure that the actual and desired capital stocks are the same by $\tau = t + n$. This expression is then used to show the supplementary expenditures required in a representative period $\tau = t + j$ where $1 \le j \le n - 1$ (see Fig. 1)[5]. The supplementary expenditure requirements for this representative period j are then used as the basis for the further development of the model.

In this regard, suppose that there is some annual flow of supplementary net capital expenditures in region i for service s between t and t + n. As noted earlier, these supplementary expenditures are to be provided from the pool of central funds. The expenditures are added to the existing actual net capital expenditures for service s in the

[5] j includes the first and next to last period of the policy program.

region in question and are denoted as $n^s_{i,\tau}$. With the supplementary expenditures included equation (2), which describes the actual capital stock in a given period, becomes,

$$K^s_{i,t+n} = K^s_{i,t}(1-\delta)^n + \sum_{\tau=t}^{t+n-1}(k^s_{i,\tau} + n^s_{i,\tau})(1-\delta)^{t+n-1-\tau} \qquad (3)$$

The (depreciated) sum of supplementary expenditures that is required from time t to t + n to ensure that the capital stock in region i for service s is equal to the desired stock by year t + n is found by equating expressions (3) and (1). With rearrangement this yields,

$$\sum_{\tau=t}^{t+n-1} n^s_{i,\tau}(1-\delta)^{t+n-1-\tau} = B^s_i(1-\delta)^n + E^s_i . \qquad (4)$$

The left hand side of (4) is the total flow of supplementary expenditures required to implement the transition along a path similar to bc (Fig. 1). The first term on the right hand side, $B^s_i = (K^{*,s}_{i,t} - K^s_{i,t})$, is the capital stock backlog inherited in period one and depreciated throughout the program. The term $E^s_i = \sum_{\tau=t}^{t+n-1}(k^{*,s}_{i,\tau} - k^s_{i,\tau})(1-\delta)^{t+n-1-\tau}$ is the (depreciated) difference between desired and actual net capital expenditures.

Thus, the right hand side of (4) has two components: one related to the capital backlog and the other to the deficiency in on-going capital expenditures. The total flow of supplementary expenditures required to achieve equality between actual and desired stocks is the sum of the two.

To proceed we must expand the left hand side of (4) and express it in terms of the supplementary expenditure required in a representative period j[6],

$$n^s_{i,t+j-1} = B^s_i(1-\delta)^j + \frac{E^s_i - F^s_{i,t+j-1}}{(1-\delta)^{n-j}} - \sum_{\tau=1}^{j-1} g^s_{i,t+\tau-1}(1-\delta)^{j-\tau} . \qquad (5)$$

This expression is a key one and requires careful explanation and interpretation. As noted, the term on the left hand side, $n^s_{i,t+j-1}$, is the supplementary expenditure required in year j. For convenience from now on we call this a ‘capital need’ for period j. As explained earlier, the first term on the right hand side is the inherited capital backlog, and E^s_i is the depreciated difference between the actual and desired expenditures.

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[8] In deriving (5) we assume the program of supplementary capital expenditures starts in time period t. Therefore, t is year 1 of the program. Time period t+j coincides with year j of the program.

The term $F^{s}_{i,t+j-1} = \sum_{\tau=t+j}^{t+n-1} n^{s}_{i,\tau}(1-\delta)^{t+n-1-\tau}$ is the total depreciated sum of future needs yet to be funded from period j to the end of the program. The presence of this term reveals an interesting feature of the model, namely, that the capital need in a representative period j depends on the sequence of future needs. The logic of this can be seen by noting that since the goal is set at $K^{*s}_{i,t+n}$, the greater is the need to be met later in the program the lower is the need to be filled now, and vice versa. The model requires that the sequence of future needs be defined at the start. Indeed, the sequence actually defines the line bc in Fig. 1 and we think of it as the 'initial transition path'. The term 'initial' is used because it represents the path that we initially aim to follow in order to achieve the desired outcome.

As shown later in the simulation for South Africa, depending on the size of the pool of funds available, P_τ, the actual process of transition may not follow this originally defined path. Instead, an 'actual transition path' will emerge as a result of implementing the program (this path is distinct from the initial transition path). Of course, if the pool of funds is sufficient in each period to meet all of the assessed needs then the actual and initially specified transition paths coincide. But in practice the pool of funds is insufficient and the actual process of transition lies below (this is the case for South Africa). Nevertheless, to solve the model for needs in each period one must specify the initial transition path.

The last term in (5) is the sum of previously distributed grants where $g^{s}_{i,t+\tau-1} = \frac{n^{s}_{i,t+\tau-1}}{\sum_{i,s} n^{s}_{i,t+\tau-1}} P_{t+\tau-1}$. It appears in the equation because the capital need for period j is dependent on the needs already filled by the policy program in previous periods. Before commencement of the program this term is zero since no supplementary expenditures have been made so far. The following discussion shows how the g terms are calculated. In order to simplify we demonstrate the calculation for year 1 of implementation. The estimate of g on each successive period is done in a similar fashion. In this regard, we define the total capital expenditure need for region i at time $\tau = t$ as the total need for each service, calculated in (5) above, summed across all services. The total need for all regions at time $\tau = t$ is the need for each region summed over all regions. The total actual supplementary expenditure provided to region i in year $\tau = t$ is simply

$$G_{i,t} = \frac{\sum_{s} n^{s}_{i,t}}{\sum_{i,s} n^{s}_{i,t}} P_t \quad . \qquad (6)$$

Equation (6) defines the share of the total pool of funds available for the program and allocated to region i (where the pool P_t is assumed to be exogenous). The size of P_t is determined by fiscal and political constraints. If region i has relatively high capital needs, perhaps because it has relatively large backlogs or relatively low on-going actual capital expenditures, it will receive a relatively larger allocation from the pool. The scheme therefore directs scarce national funds available for supplementary spending on capital to the most needy regions and services. The actual allocation for service s in region i at time t (the term used on the right hand side of (5)) can be written as

$$g^s_{i,t} = \frac{n^s_{i,t}}{\sum_{i,s} n^s_{i,t}} P_t . \tag{7}$$

The approach is one that calculates the capital need for each service, province and time period from the 'bottom up' using (5). These needs are then used to construct shares that allocate each dollar from the given pool P_τ to the most needy services and provinces[7]. The magnitude of the allocation that flows to each service and province is scaled up or down depending on national fiscal constraints and the size of the pool. Thus, the scheme can be designed independently of the policies that determine the size of the grant pool since its primary purpose is to calculate the shares of the pool that are to be allocated to each region and service[8].

In any period j, if the previous g's have been equal to the assessed needs then the actual transition path is the same as the initially specified one, that is, the actual transition follows the path bc in Fig. 1. However, if the previous g's are insufficient the actual transition path is below bc. This implies that equality between actual and desired capital stocks is not achieved by the end of the program period, t+n. In this case (the one that applies in South Africa for instance), the program would have to be extended to ensure completion. The actual capital stock accumulated by the (initially envisaged) end of the program period, t+n, will then be defined by

$$K^s_{i,t+n} = K^s_{i,t}(1-\delta)^n + \sum_{\tau=t}^{t+n-1} (k^s_{i,\tau} + g^s_{i,\tau})(1-\delta)^{t+n-1-\tau} . \tag{8}$$

As can be seen from the expression above, since the grants distributed are insufficient when compared to calculated needs, the final capital stock will fall short of

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[7] So designed, the scheme is free from potential for Provinces to engage in strategic behaviour, i.e. altering their expenditure decisions to influence the size of their grant. This happens because capital expenditures of each Province are calculated as historical forecasts which are made prior to the beginning of the operation of the scheme.

[8] Nevertheless, as mentioned briefly in the Introduction, the model also provides important policy information on the magnitude of the capital needs of a particular country in any given year that can be used to inform any debate over the size of the pool. This information is obtained by summing all needs, as calculated from (5), across regions and services. The resulting number is a measure of the total capital need in period τ for the economy in question (it is likely that the number far exceeds the resources available for spending on capital). In this sense, therefore, the scheme gives information on what funds a country would need to allocate to public capital, in each year, in order to correct for the shortage of public capital.

the desired amount. More generally, the capital stock that emerges in each period of the program is

$$K^s_{i,t+j} = K^s_{i,t}(1-\delta)^j + \sum_{\tau=t}^{t+j-1}(k^s_{i,\tau} + g^s_{i,\tau})(1-\delta)^{t+j-1-\tau} \tag{9}$$

This expression traces out the actual transition path that is followed under the program. Note, once again, that if the distributed grants equal the needs, (9) becomes (3): the actual and initially specified transition paths coincide. However, for most transition economies it is likely that the pool of funds available to raise capital formation at the regional level is insufficient. As will be shown below, this is the case for South Africa under reasonable assumptions about the size of the pool.

3. Simulations for South Africa

Having developed the key expressions for the model it is now possible to construct a computer-based simulation program that can be applied to any transitional economy, for which there is appropriate data, to produce estimates of how one would allocate supplementary capital expenditures to heterogenous regions. The Financial and Fiscal Commission (FFC), the body with constitutional authority for inter-governmental matters in South Africa, agreed to assist with the construction of an input data set. The simulation model considers all of the nine South African provinces: Western Cape, Eastern Cape, Northern Cape, Free State, Kwazulu-Natal, North West, Gauteng, Mpumalanga, and Northern Province. The services included are education, health and welfare. The simulation is based on the scheme being implemented in 2002 with a transition period of 10 years till 2012.

Construction of the data set proceeds in three basic stages that can best be appreciated by referring back to Fig. 1. From there it can be seen that to construct the line bd in Fig.1 requires estimates of time, service and province specific actual capital expenditures from 2002 to 2011. These were obtained from official Reserve Bank of South Africa capital expenditure forecasts extrapolated to the year 2011. Also required is an estimate of the initial capital stock. This we obtain by taking Reserve Bank estimates of aggregate capital stocks and applying capital expenditure weights to derive the service and province specific capital stock estimates for the first year, 2002. An estimate of the public capital depreciation rate was obtained from Levtchenkova and Petchey (2000) for Australia. The stocks then are obtained using PIM.

Constructing data for the line ac in Fig.1, the one representing the desired capital stock, proceeded as follows. First, we used per capita estimates of service specific capital stocks for Australia to construct estimates of the respective service and province specific desired capital stock for South Africa for the year 2002. We then constructed estimates of desired capital expenditures for each service and province for the period 2002 to 2011 based on Australian expenditure data. Applying the depreciation rate used for the construction of the actual series we were then able to construct service and province specific estimates of the desired capital stock for each year from 2002 to 2012.

The initial estimate for the pool of funds that might conceivably be made available by the national government to fund supplementary capital spending on public infrastructure for health, education and welfare is R5 billion for 2002. This is the equivalent of about $US0.580 billion, accounting for just 0.5 percent of South Africa's GDP in that year. The FFC estimate of the size of the pool for 2002 was then extrapolated for the remaining periods of the scheme.

The theoretical model described in Section 2 was then programmed within Excel. Combined with the constructed input data set this enabled us to calculate for South Africa (for each service and province) the initial backlogs, the initially specified and actual transition paths, and the degree to which the goal of equality between actual and desired capital stocks is met by the end of the policy program. These outputs of the model can best be summarised diagrammatically.

Before doing this, it is useful to examine the size of the capital backlogs at the beginning and end of the scheme. The comparison is interesting since it gives us a snapshot of how successful the policy is in achieving its aim of eliminating the capital backlogs, for a given pool of funds (Table 1). The data indicate that for all provinces and services the backlog actually increases over the program period. This is because the pool of R5 billion allocated as supplementary expenditure in the first year (and escalated by 10 percent in the following years) is inadequate in achieving the aims of the policy. The pool is insufficient to redress the backlogs inherited at the start of the program and does not even make up for the on-going gap between actual and desired capital expenditures (taking into account depreciation). Nevertheless, the backlogs emerging after 10 years of the policy would be even larger without the program.

This raises an important issue for South Africa. If the FFC believes that a pool of R5 billion is the one that is feasible within existing resources, then our simulations suggest that the country will not be able to achieve any satisfactory reduction in its backlogs, in terms of the overall magnitude or regional disparities, even over a ten year period.

Table 1: Initial and Final Backlogs* (Rand million).

Province	Education	Health	Welfare

	Initial Backlog	After 10 years	Initial Backlog	After 10 years	Initial Backlog	After 10 years
WC	11117	18384	8140	19954	514	2207
EC	15191	25423	14428	32156	1217	3768
NC	2612	4135	1731	4129	106	432
FS	7756	12790	5787	13555	441	1508
KN	23136	38871	3143	28368	1177	4603
NW	8008	14538	6940	17377	712	2079
GT	18194	31632	7354	25613	1599	4540
MP	6698	12082	3831	12733	475	1561
NP	15619	24515	8454	22971	942	2924
Total	**108331**	**182370**	**59808**	**176856**	**7183**	**23622**

* The following abbreviations for the names of provinces are used: WC - Western Cape, EC - Eastern Cape, NC - Northern Cape, FS – Free State, KN - Kwazulu-Natal, NW – North West, GT – Gauteng, MP – Mpumalanga, NP - Northern Province.

It is also interesting to examine the shares of the pool that would be allocated to each region (summed across the three services) from 2002 to 2011. This gives us valuable information on how the scheme ranks the regions of South Africa in terms of public capital need (Table 2). We can see from the shares that the scheme identifies Kwazulu-Natal as the most 'needy' province since it is allocated the highest share in every year. The richest province is found to be Northern Cape. Also, notice that the relative ranking of provinces according to the calculated shares does not change much over time. This is because of the problem noted above that the size of the pool of funds available is so small that the program does not achieve any notable results in moving the regions towards the desired capital stock or changing their relative ranking (ie. equalising citizens' access to public capital on a regional basis).

Table 2: Shares for Provinces (summed across services)

Province	2002	2003	2004	2005	2005	2007	2008	2009	2010	2011
WC	0.10252	0.10346	0.10432	0.10512	0.10556	0.10581	0.10609	0.10617	0.10616	0.10599

EC	0.15994	0.16006	0.16077	0.16153	0.16176	0.16171	0.16174	0.16150	0.16095	0.16006
NC	0.02247	0.02241	0.02251	0.02264	0.02271	0.02274	0.02278	0.02279	0.02277	0.02272
FS	0.07148	0.07144	0.07184	0.07229	0.07255	0.07269	0.07289	0.07298	0.07294	0.07279
KN	0.18853	0.18968	0.18649	0.18274	0.18148	0.18154	0.18271	0.18419	0.18608	0.18822
NW	0.08795	0.08774	0.08812	0.08860	0.08884	0.08895	0.08912	0.08917	0.08907	0.08880
GT	0.16766	0.16604	0.16592	0.16602	0.16565	0.16501	0.16288	0.16155	0.16100	0.16094
MP	0.06923	0.06891	0.06910	0.06937	0.06945	0.06943	0.06945	0.06931	0.06891	0.06883
NP	0.13023	0.13026	0.13092	0.13166	0.13200	0.13213	0.13234	0.13235	0.13213	0.13165

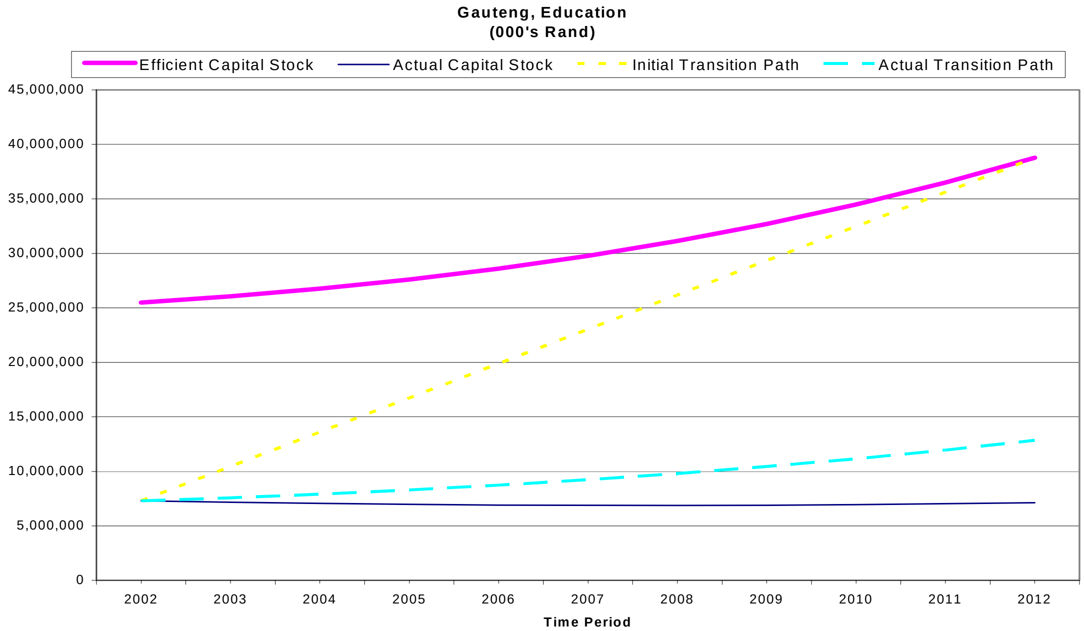
*Abbreviations are the same as in Table 1.

We now provide a more comprehensive presentation of the output data of the model. This is done in diagrammatic form for one particular region in South Africa, the Province of Gauteng, and one service, education[9]. This region is selected because it includes the city of Johannesburg and cities such as Soweto, the largest population concentrations in the country.

In Fig. 2 below we plot the desired capital stock, the actual capital stock in the absence of the program, the initially specified transition path and the actual transition path. Again, the pool of funds is R5 billion in 2002 and grows by 10 percent per year over the ten year program. As indicated above, the actual transition path lies below the initially specified path[10]. Because at each stage of the program the pool is inadequate to fill the previously identified capital needs the gap between the desired and actual capital stock with supplementary expenditures continues to widen over the policy period (though less so than it would without the policy).

[9] The simulation model can produce an analogous plot for each service and Province in the country.
[10] As discussed in Section 2, we assume that the initial transition path is linear.

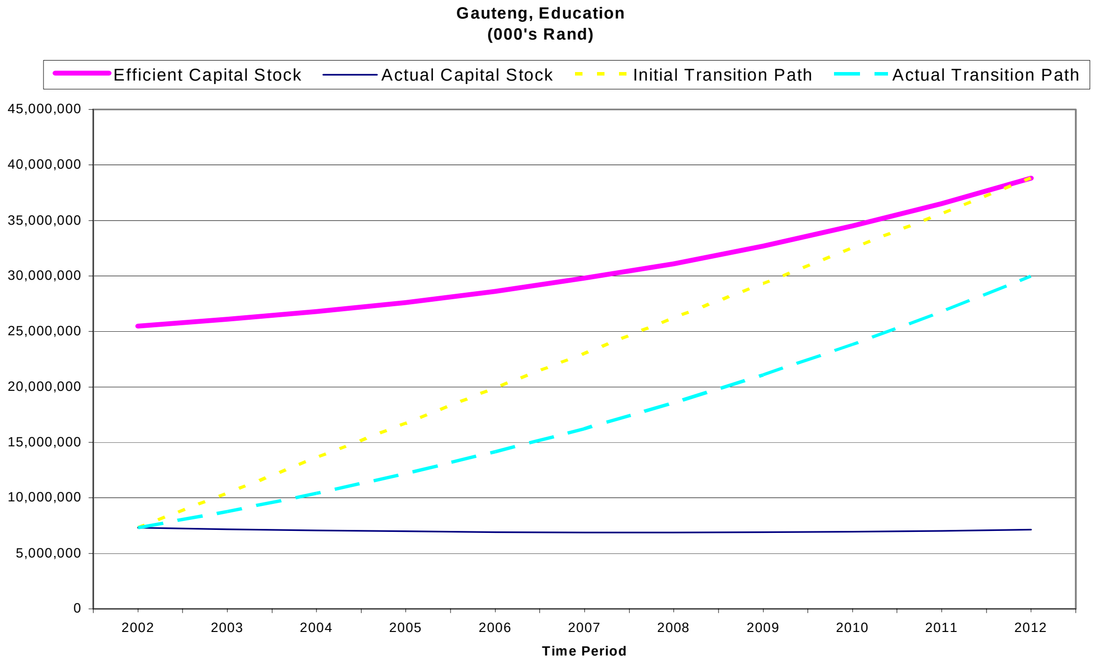
Figure 2: Transition for Education in the Province of Gauteng Pool of R5 billion (0.5% of GDP)



As before, the simulation shows that a pool of R5 billion is insufficient to yield any reasonable degree of transition by the end of the program. With this level of resources, it would require additional implementations of the scheme with an increased pool size to eliminate the backlogs. Completing the transition to a high income economy with a level of public service provision and equality of access found in high income economies would take a generation (eg., thirty to forty years).

Alternatively, policy-makers might increase the size of the pool to raise the actual transition path. Using the simulation model it is a simple matter to find the pool of funds required to achieve a greater degree of transition. The ability to do this is of considerable importance in transitional economies, South Africa included, where policy-makers often have no information on the amount of resources they would need to devote to reducing public capital backlogs. In Fig. 3 we present a plot, once again for education in Gauteng, where by the end of the program period just over half of the backlog is eliminated. Achieving this result requires a pool of R20 billion in 2002, four times the amount that the FFC expects would be made available at the start of the scheme. This is the equivalent of about $US2.3 billion for 2002 or 2 percent of South Africa's present GDP.

Figure 3: Transition for Education in the Province of Gauteng Pool of R20 billion (2% of GDP)



4. Conclusion

In this paper we have developed a model that would allow policy-makers in transitional economies to allocate supplementary capital expenditures on public infrastructure in such a way that raises the overall level of infrastructure and provides greater equality in its regional distribution, that is, equalises to some extent. The proposed model has important features, most notably, its ability to take account of the inter-temporal nature of capital arising from its durability and ability to provide a flow of services over many years. This means that the model must take account of past capital expenditures and hence the capital stock built in previous years. The model must also take account of what is to be provided in the future (the transition path) while allowing for the fact that capital depreciates over time. Without accounting for this interdependence within the formal structure of the model, it would be impossible to follow any meaningful transition path for the regions of the economy in question.

We also showed how the model can be made operational if one has an input data set for a particular economy. This was demonstrated by applying the model to the Republic of South Africa and providing selected results from simulations for that country. The simulations show that, given the magnitude of the capital backlogs in South Africa, and deficiencies in on-going capital expenditure, as well as the size of the pool currently proposed (0.5 percent of GDP), little progress would be made in raising the level of public infrastructure or in improving its regional distribution (ie. only limited equalisation would be achieved). We then showed that if South African policy-makers could increase the pool to 2 percent of GDP, about half of the present backlogs would be eliminated by the year 2011 and a much greater degree of equalisation achieved in the availability of public infrastructure, and hence the services provided using that infrastructure.

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