South African Journal of Economics Vol. 75:4 December 2007

A GROWTH MODEL FOR SOUTH AFRICA

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Abstract
We examine the South African growth experience during 1960-2005 using an intertemporal growth model. The model combines old growth theory investment dynamics and new growth theory endogenous productivity growth. The consumption and investment decisions are intertemporal and assume open capital markets. Structural change is captured by separating the traded and nontraded sectors, and sectoral productivity growth is determined in a barriers-to-growth framework. Calibration of the model shows how the growth experience combines neoclassical convergence, technology spillovers with barriers and productivity-investment interaction. Counterfactual analysis shows the growth costs of sanctions and protectionism. The suggested model is an alternative to existing growth modelling in South Africa, in which investments are short-sighted and productivity growth is imposed exogenously.
JEL Classification: O33, O41, O55
Keywords: Growth constraints, productivity, barriers, South Africa

1. INTRODUCTION[1]

South Africa was a growth machine in the 1960s, after which followed a long period of stagnation with sanctions and the Apartheid struggle, followed by slow growth after the political transformation. Understanding the economic adjustment mechanisms and driving forces behind this growth story is a challenge. The existing literature includes economic history, econometric studies and economic modelling. Interesting contributions include those of Fedderke (2002), Feinstein (2005), Jones (2002), Lewis (2001), Lundahl (1999), and Plessis and Smit (2007). Economic modelling approaches include those of Thurlow (2005, 2006), who adds recursive dynamics to a computable general equilibrium (CGE) model, and Gibson and van Seventer (1997, 2000a,b) who construct a structuralist recursive model. The government has recently invited a group of experts to undertake a growth diagnostic, and inputs into this process have been produced by Aghion *et al.* (2006), Edwards and Lawrence (2006), Hausmann and Klinger (2006) and Rodrik (2006), among others. We contribute to the diagnostic by developing an intertemporal growth model including old and new growth theory, structural change

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[1] We appreciate discussions at the TIPS/NTNU 2004 workshop in Cape Town, the 27th National Economist Meeting in Oslo, staff seminar at the University of Nottingham, the 2005 ESRC workshop in Nottingham, the 2006 CSAE conference in Oxford, the 1st 2006 PEGNet Workshop in Kiel, the 5th 2006 INFER Workshop on International Economics in London, and the 2006 TIPS/DPRU Forum in Johannesburg, and comments without implications from Alice Amsden, Rob Davies, Xinshen Diao, Lawrence Edwards, Johannes Fedderke, Stephen Gelb, David Greenaway, Torfinn Harding, Ravi Kanbur, Oliver Morrissey, Terry Roe, Francis Teal, Dirk van Seventer, and a referee of the journal. The project is financed by the Norwegian Research Council.

between the traded and nontraded goods sectors, and separating between skilled and unskilled labour. The model is calibrated to reproduce the growth path for 1960-2005 and allows counterfactual growth analysis.

Applied growth models dealing with productivity dynamics have been developed for other countries and include those of Ngai (2004) for different country groups, Coleman (2005) for Japan, Duarte and Restuccia (2007) for Portugal, and Diao *et al.* (2005, 2006) for Thailand. We follow the tradition of calibrating the model to country data and include full general equilibrium effects.

In the evaluation of the growth performance we separate between three time periods: the high growth period 1960-1974, closed economy 1975-1993, and post Apartheid 1994-2005. The closed economy effects of international sanctions and import quotas are important to the growth path, but are typically hard to measure. We capture the degree of openness in the economy by calibrating a tariff equivalent that reproduces the actual trade path. The calibrated tariff equivalent decreases in the 1960s, then increases with a peak in the late 1980s, before decreasing rapidly after 1990.

The calibrated model explains South African growth during 1960-2005 as a result of neoclassical convergence, technology spillovers with barriers, and endogenous interplay between productivity and investment profitability. While the high growth period was driven by high returns to investment, stagnation followed sanctions and protectionism that served as barriers to productivity growth. The barriers implied a slowdown in productivity growth associated with reduced international and domestic spillovers and a fall in investment profitability. Elimination of sanctions and trade liberalization together with more human capital has stimulated economic growth with reduced barriers post Apartheid. The expansion of nontradables observed since 1980 is reproduced by the model and is mainly demand-side driven. The model assumes flexible domestic markets and concentrates on international productivity spillovers affecting investment. Domestic market imperfections represent an important area for future model extensions.

The model enables us to analyse a counterfactual scenario excluding the period with sanctions and protection to see how this has constrained growth and influenced economic structure. A more open economy stimulates growth through technology spillovers, less expensive capital goods and positive productivity-investment interaction. The degree of openness has conflicting effects on the economic structure. Increased access to foreign technology stimulates productivity growth in tradables, with part of the learning spilling over to nontradables. Lower tariffs imply more competition from abroad, and part of the domestic demand for tradables is shifted towards cheaper foreign goods. In the numerical simulations, the positive productivity effect dominates and the contraction of tradables is constrained. The results imply that the international isolation from the mid 1970s to the early 1990s harmed the traded sector the most.

The paper presents the modelling of the productivity dynamics (Section 2), the integration of these dynamics into a general equilibrium growth model (Section 3), the reproduction of South Africa's economic development during 1960-2005 (Section 4), and offers a counterfactual analysis of openness (Section 5). Section 6 concludes.

2. ENDOGENOUS PRODUCTIVITY DYNAMICS

The productivity specification is motivated by recent advancements in growth theory, stylized facts about growth patterns, and econometric evidence for South Africa.

Acemoglu and Ventura (2002) observe that income differences between countries are permanent and the world income distribution is stable. Hall and Jones (1999) show how income differences represent variation in productivity levels, and that productivity growth is the key variable to understanding growth. This is consistent with a model where the individual country growth rate in the long run is determined by the world technology frontier and where the technology gap to the frontier is constant. All countries can benefit from the growth of the world technology frontier, albeit to different degrees and at different speeds, and dependent on the initial conditions. This approach has historical roots in the Gerschenkron (1962) type of catching-up growth formalized by Nelson and Phelps (1966) as technology adoption. Parente and Prescott (1994, 2005) develop the barriers to growth framework, and Klenow and Rodriguez-Clare (2005) offer an overview of alternative model formulations including international externalities.

We relate productivity growth in tradables to international technology spillovers. The degree of catch-up to the world frontier depends on trade policy and human capital barriers. There is broad agreement that international spillovers are important for productivity growth. In a study of R&D spillover in 77 developing countries, Coe *et al.* (1997) conclude that a developing country can boost its productivity by importing a larger variety of intermediate products and capital equipment embodying foreign knowledge. By taking into account the endogeneity of trade and institutional quality, Alcala and Ciccone (2004) confirm the positive effect of trade on productivity. Benhabib and Spiegel (1994) document the importance of human capital for both innovation and technology adoption. Hansson and Henrekson (1994) study the combined importance of human capital and trade for technology diffusion. In a cross-country study of 81 countries they find a significant effect of the initial technology gap on labour productivity growth, and the effect is strengthened when the capability to absorb foreign technology is taken into account. Both a higher level of human capital and more interaction with the rest of the world stimulate technological catch-up.

Productivity growth in nontradables is determined by the level of human capital and domestic spillovers. Interaction with the traded sector in the intermediate market contributes to productivity growth through backward linkages. An early demonstration of the inter-sectoral beneficial externalities of the traded sector is shown by Feder (1982). He finds that the export sector is productivity leading and contributes to positive productivity effects in other sectors of the economy. Javorcik (2004) applies firm-level data from Lithuania during 1996-2000 and offers empirical support for the existence of backward productivity spillovers. Using Chilean plant-level data, Alvarez and Lopez (2006) find strong support for the view that exporters improve the productivity of their intermediate suppliers.

Several studies find that both openness and domestic factors are important for productivity growth in South Africa. Harding and Rattsø (2007a) show how industrial productivity growth during 1970-2003 can be viewed as catching up to the world technology frontier influenced by human capital. Harding and Rattsø (2007b) address the endogeneity problem of trade policy and use other regions' tariff development as part of the WTO process as instruments for the tariff reductions since 1988. They find that tariff liberalization has been important for labour productivity growth. Fedderke (2005) puts more emphasis on domestic factors, and identifies the important effects of R&D and human capital on productivity growth.

The rate of growth of labour augmenting technical progress in tradables ($\hat{A}_{M,t}$) follows the specification in Rattsø and Stokke (2007), which is an extended version of the Benhabib and Spiegel (2005) model:

$$\hat{A}_{M,t} = H_t^{\theta_1} + \lambda_M H_t^{\theta_2} T_t^{\theta_3}\left(1 - \frac{A_{M,t}}{A_t^*}\right) \tag{1}$$

The first term on the right-hand side of equation (1) represents the contribution from innovation activities, while the second term is the technology adoption function. A_t^* is the frontier level of productivity and $A_{M,t}/A_t^*$ represents the technology gap to the world frontier. λ_M, θ_1, θ_2 and θ_3 are constant parameters. We measure human capital (H_t) by the share of skilled workers in the labour force. The skill-ratio is exogenous in the model, but is set according to the observed development during 1960-2005. Trade barriers are represented by total trade as a share of GDP (T_t), which is endogenously determined. The complementarity between trade and human capital in technology adoption is also investigated by Stokke (2004) for the case of Thailand. The linear relationship between productivity growth and the technology gap limits the advantage of backwardness compared with the Nelson-Phelps specification and gives possible divergence in cases of high barriers to technology adoption. This is consistent with empirical evidence showing convergence among open economies, while high trade barriers may generate a development trap (see Sachs and Warner, 1995).

The rate of growth of labour augmenting technical progress in nontradables ($\hat{A}_{S,t}$) is specified as follows:

$$\hat{A}_{S,t} = H_t^{\gamma_1} + \lambda_S H_t^{\gamma_2} N_t^{\gamma_3}\left(1 - \frac{A_{S,t}}{A_{M,t}}\right) \tag{2}$$

The first term on the right-hand side of equation (2) represents the contribution from innovation activities, while the second term captures the domestic spillovers. Learning from the traded sector depends on the degree of interaction in the intermediate market, the human capital level and the technological distance between the domestic sectors. N_t represents the nontraded sector's intermediate supply to tradables as a share of GDP, while $A_{S,t}/A_{M,t}$ is the domestic technology gap. λ_S, γ_1, γ_2 and γ_3 are constant parameters. As with international technology spillovers, the nontraded sector benefits from a large technology gap relative to tradables (low value of $A_{S,t}/A_{M,t}$). This follows from higher learning potential, and the degree of catch-up towards tradables depends on the extent of spillovers (N_t) and the ability to take advantage of them (H_t).

Under symmetric growth, long-run productivity growth is given by the exogenous frontier growth rate g, and both the international and the domestic technology gap are constant. The degree of catch-up depends on the level of barriers to technology adoption and the innovative capacity of the economy. The long-run equilibrium consequently implies a proportional relationship between $A_{M,t}$ and A_t^*, and between $A_{S,t}$ and $A_{M,t}$:

$$A_{M,t} = \frac{H_t^{\theta_1} + \lambda_M H_t^{\theta_2} T_t^{\theta_3} - g}{\lambda_M H_t^{\theta_2} T_t^{\theta_3}} \cdot A_t^* \tag{3}$$

$$A_{S,t} = \frac{H_t^{\gamma_1} + \lambda_S H_t^{\gamma_2} N_t^{\gamma_3} - g}{\lambda_S H_t^{\gamma_2} N_t^{\gamma_3}} \cdot A_{M,t} \tag{4}$$

The equilibrium values of human capital, the trade share and the intermediate share are constant, and, together with the frontier growth rate and the parameters, they determine relative productivities. Changes in the sources of innovation and spillovers (domestic or international) generate transitional growth to a new technology gap. The dynamics are consistent with the common understanding that differences in income levels are permanent, while differences in growth rates are transitory (Acemoglu and Ventura, 2002).

The formulation allows parameterization according to characteristics of the South African economy and implies endogenous productivity growth responding to changes in the skill-ratio, the trade share and the degree of interaction at the intermediate market. Future theoretical and empirical research can strengthen the foundation for the specific form of the productivity relationship.

3. THE GROWTH MODEL

South Africa has a long tradition of economy-wide modelling, but is typically oriented towards microeconomic allocation and policy issues with many sectors. Growth model analyses have grown out of static models with short-sighted investment allocation and exogenous productivity growth. One starting point has been the standard CGE model of resource allocation developed by Thurlow and van Seventer (2002). Thurlow (2005) extends the model into a dynamic version with recursive updating of investment and productivity. Thurlow (2006) combines these dynamics with a microsimulation model to analyse the impact of trade liberalization on growth, employment and poverty. Gibson and van Seventer (1997, 2000a,b) have developed alternative variations of a more aggregated structuralist model emphasizing model closure, sectoral interaction and macro distribution. Their dynamics are also of the updating sort. Both these models offer interesting projections and policy analyses, but they do not have much to say about the endogenous growth mechanisms. Aggregate investment is either determined by savings or investment demand is short sighted and productivity growth is imposed exogenously. This motivates our construction of a model capturing intertemporal allocation and endogenous productivity growth to have a closer look at the dynamics of the economy.

We offer intertemporal consistency and separation between transition and long-run balanced growth. The productivity dynamics explained above are embedded in a general equilibrium growth model. We assume standard intertemporal decision making of a representative firm and a representative household. The model captures a small open economy with imperfect substitution between domestic and foreign goods. The growth pattern does not influence world prices or the world interest rate, which are exogenously given. Investments can be financed through foreign borrowing, and the decisions about savings and investment can therefore be separated, although with a long-run restriction on foreign debt.

The core of the model is the production technology, the representative firm investment decision and the household consumption-saving decision. The productivity dynamics are

presented in Section 2, while the production functions and the intertemporal dynamics are outlined below.[2]

Sectoral value added ($X_{i,t}$) is defined as a Cobb-Douglas function of unskilled labour ($Lu_{i,t}$), skilled labour ($Ls_{i,t}$) and capital ($K_{i,t}$):

$$X_{i,t} = A_{i,t}^{\alpha_{1,i}+\alpha_{2,i}} Lu_{i,t}^{\alpha_{1,i}} Ls_{i,t}^{\alpha_{2,i}} K_{i,t}^{1-\alpha_{1,i}-\alpha_{2,i}} \quad i = M, S \tag{5}$$

where the subscripts M and S represent the traded and the nontraded sectors, respectively. Labour and capital are mobile between domestic sectors and are allocated based on marginal productivities. Sectoral labour augmenting technical progress ($A_{i,t}$) develops endogenously according to equations (1) and (2). Intermediate goods are employed according to fixed input-output coefficients.

The representative firm makes its investment decision according to intertemporal profit maximization, subject to the accumulation of the aggregate capital stock ($K_t = K_{M,t} + K_{S,t}$) over time:

$$\underset{I_t, K_t}{Max} \sum_{t=1}^{\infty} (1+r)^{-t} [Rk_t \cdot K_t - (PI_t \cdot I_t + ADJ_t)] \tag{6}$$

$$s.t.\ K_{t+1} = K_t \cdot (1-\delta) + I_t \tag{7}$$

where r is the exogenous world market interest rate, Rk_t is the capital rental rate, PI_t is the unit cost of investment, I_t is aggregate investments, ADJ_t is investment adjustment costs, and δ is the rate of depreciation. Following the common practice in the literature, unit adjustment costs are specified as a positive function of the investment-capital ratio. Therefore, total adjustment costs are given as:

$$ADJ_t = a \cdot P_{M,t} \cdot \frac{I_t^2}{K_t} \tag{8}$$

where a is a constant parameter and P_M is the composite price of traded goods.

Differentiating the intertemporal profit function with respect to K_t gives the following no-arbitrage condition:

$$r \cdot q_{t-1} = Rk_t + a \cdot P_{M,t} \cdot \left(\frac{I_t}{K_t}\right)^2 - \delta \cdot q_t + \dot{q}_t \tag{9}$$

Equation (9) states that the marginal return to capital must equal the interest payments on a perfectly substitutable asset with a value of q_{t-1}, where q is the shadow price of capital. The first term on the right-hand side is the capital rental rate, while the second term is the partial derivative of the adjustment cost function with respect to capital. The marginal return to capital must be adjusted by the depreciation rate and by the capital gain or loss, $\dot{q}_t$.

The representative consumer maximizes an intertemporal utility function taking into account the current budget constraint for each period:

[2] Documentation of data, model and calibration is given in a separate appendix available at http://www.svt.ntnu.no/iso/Hildegunn.Stokke/default.htm

$$Max \sum_{t=1}^{\infty} (1+\rho)^{-t} U(Q_t) \tag{10}$$

$$s.t.\ PQ_t \cdot Q_t = Y_t - SAV_t \tag{11}$$

Assuming an intertemporal elasticity of substitution equal to unity, the utility function is defined as $U(Q_t) = \ln Q_t$, where Q_t is aggregate consumption in period t. PQ_t is the aggregate consumption price, Y_t is household income, SAV_t is private savings, and ρ is the positive rate of time preference. Utility maximization gives the Euler equation for optimal allocation of consumption over time:

$$\frac{PQ_{t+1} \cdot Q_{t+1}}{PQ_t \cdot Q_t} = \frac{1+r}{1+\rho} \tag{12}$$

The growth in consumption depends on the interest rate, the time preference rate and the price path.

The growth model describes an economy with macroeconomic stability, full employment of resources, flexible allocation of resources between sectors according to profitability, and an open capital market. Domestic market imperfections represent a challenge for future research. Some rigidity is built in with cost of investment adjustment and imperfect substitution between domestic and foreign goods. The model consequently operates with a composite good. Imports are endogenously determined through an Armington composite system, while exports are determined through constant elasticity of transformation (CET) functions. The labour market formulation separates between unskilled and skilled labour.

In the long-run equilibrium, the economy growth rate is exogenously given as $g + n$, where g is the frontier rate of labour augmenting technical progress and n is the labour supply growth rate. The domestic and the international technology gap are constant. The model reproduction of South African growth during 1960-2005 (explained in the next section) is of a transitional character.

4. REPRODUCING GROWTH AND STRUCTURAL CHANGE IN SOUTH AFRICA

South Africa achieved remarkably high growth from 1960 to the mid-1970s, here called the high-growth period. Economic growth stagnated in the mid-1970s with the struggle for liberalization and the international isolation. Many developing and developed economies experienced economic stagnation because of the oil crisis, but the proportional decline in the growth rate was much larger in South Africa. Average GDP growth rate dropped from 5.5% in the high-growth period to 1.6% during 1975-1993. This indicates that the growth process also was affected by local economic and political factors. Sanctions against the Apartheid regime were tightened during a period when political unrest and labour strikes affected economic development. At the same time South Africa experienced rapid structural change, with the nontraded sector increasing from 45% to 65% of GDP during the two decades. In the post Apartheid period economic performance has improved, but the growth has been erratic and low on average.

Table 1. South African growth experience 1961-2005

	1961-1974 High growth	1975-1993 Closed economy	1994-2005 Post Apartheid
Actual GDP growth rate	5.5 %	1.6 %	3.3 %
Calibrated GDP growth rate	5.5 %	3.6 %	3.1 %
Growth in total trade	5.0 %	1.0 %	5.5 %
Growth in gross fixed capital formation	8.1 %	–0.2 %	4.9 %

Source: World Bank, World Development Indicators.

The growth model described above is calibrated to reproduce the main elements of the economic development in South Africa during recent decades. Starting with a consistent database in the base year 1998, we calibrate backwards a growth path that is close to the observed real GDP growth during 1960-2005. To reproduce actual GDP growth, the initial levels of capital and productivity are scaled down compared with the steady state path. Initially, the international technology gap ($A_{M,t}/A^*_t$) equals 0.32, which is broadly consistent with empirical evidence offered by Edwards and Golub (2003) and van Dijk (2003). The initial domestic technology gap ($A_{S,t}/A_{M,t}$) equals 0.43, and implies that the productivity level is higher in tradables than in nontradables. The scaling back serves as an exogenous shock that takes the economy outside the equilibrium long-run path in 1960. The initial capital stock and productivity levels are below the long-run path and economic growth is driven by endogenous adjustment back to equilibrium growth.

The model parameters are calibrated consistent with long-run equilibrium, where the long-run growth rate is assumed to equal 2% (1.3% technological progress rate and 0.7% labour growth).[3] The long-run growth path must be consistent with the macroeconomic equilibrium as represented by the Euler equation: $r = (1 + \rho)(1 + g + n)$-1, where $g + n$ is the exogenous long-run growth rate. The elasticities of substitution in the Armington and CET functions are set consistent with national and international estimates as documented by Gibson (2003). These elasticities represent substitution possibilities between domestic and foreign goods (Armington), and between sales to domestic markets versus export markets (CET). Table 1 in the Appendix presents the values of selected calibrated parameters.

The supply of different labour types is set according to TIPS (2006) data on employment shares by skill level.[4] The share of unskilled labour in the total labour force declines from 0.78 to 0.44 during 1960-2005, with a corresponding increase in the skilled labour share from 0.22 to 0.56. The share of skilled workers in the labour force represents our measure of human capital in the productivity specification.

An important element of the South African experience is the changing trade conditions over time, and in particular the international isolation from the mid-1970s to the early 1990s. The empirical literature addressing foreign trade and trade policy faces the problem that sanctions cannot be measured directly. As in Rattsø and Stokke (2007), we capture the protectionist effect of international isolation by calibrating export and import taxes in order to reproduce the observed export and import paths during 1960-2005. The terms of trade and real effective exchange rate are calibrated consistent with the data to adjust for the impact of world price shocks on the trade level. Total trade taxes as

[3] The assumption of 0.7% labour growth is consistent with data on average annual employment growth in South Africa during 1971-2005 (TIPS, 2006).

[4] The supplies of skilled and unskilled labour are extended backwards to 1960 based on average growth rates during 1970-2005.

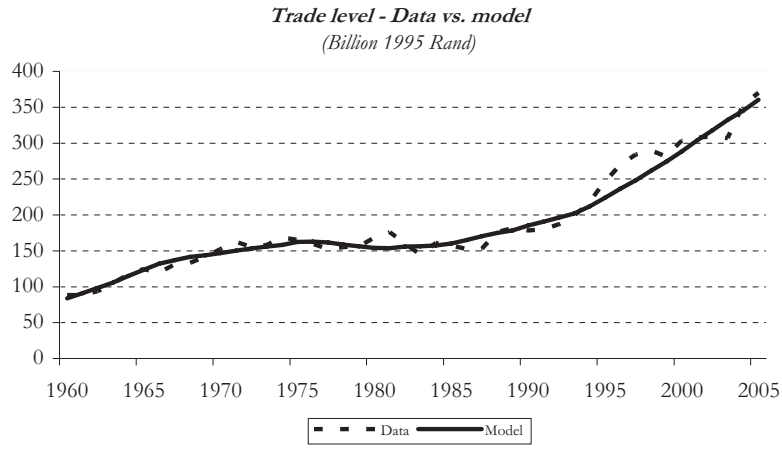

Figure 1. Total trade: calibrated path of model versus actual path (given in Billions of 1995 Rand)

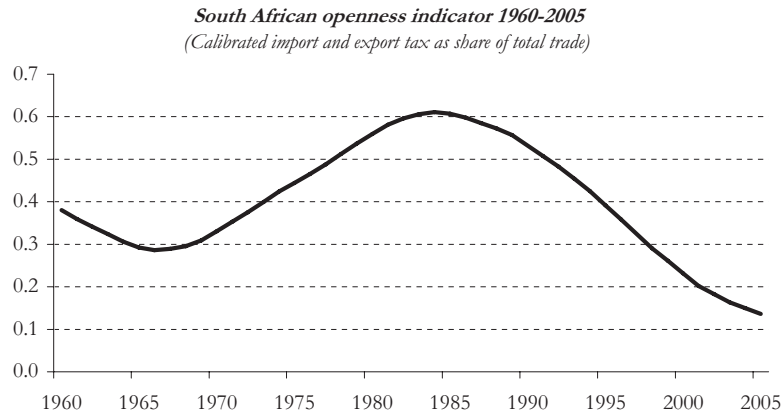

Figure 2. Calibrated openness indicator for South Africa 1960-2005. Measured as import tax and export tax as share of total trade

a share of trade represents our measure of openness. Fig. 1 reports the reproduction of the trade path, while the tariff equivalent is illustrated in Fig. 2.

Following the tariff cuts during the 1960s, the slow growth of exports and imports in the 1970s and 1980s requires a gradual increase of the tariff-equivalent, with a peak in the late 1980s of about 60%. After 1990 the removal of sanctions together with a gradual liberalization of the trade policy increased trade rapidly, reflected in the model by decreasing tariffs. In the numerical simulations, the tariff-equivalent represents the barrier to international spillovers. The tariff-equivalent path is consistent with existing measures of openness in South Africa provided by Aron and Muellbauer (2002, 2007) and Edwards and Lawrence (2006).

Fig. 3 shows how we track the actual growth rate as a steady decline in the model growth rate during 1960-1990, followed by constant growth post Apartheid. The calibrated economic growth rate during the high-growth period 1961-1974 is 5.5% on

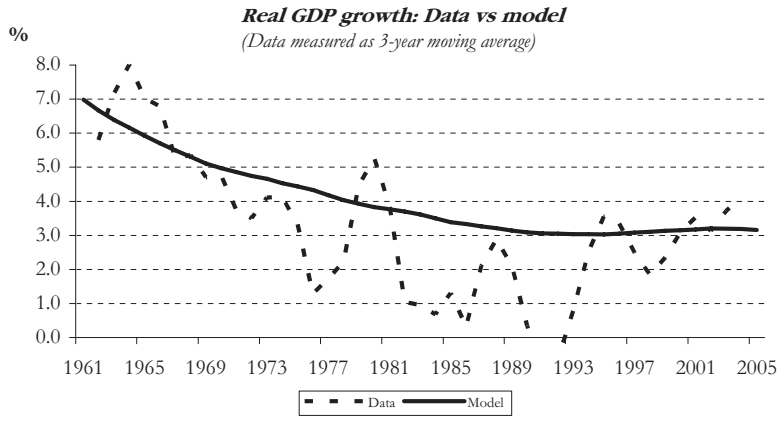

Figure 3. GDP growth rate: calibrated path of model versus actual growth (measured as 3-year moving average)

average, while the growth rate during the closed economy period (1975-1993) averages 3.6%. The post Apartheid period has a stable model growth rate of about 3.1%. The average calibrated growth rate is compared with the observed growth rate in Table 1.

The early growth period (1961-1974) broadly follows the prediction of the model with high, but declining, growth. The profit opportunities are large with low capital stock and encourage high investment. In standard fashion the marginal return to capital is reduced over time. This is the core of the neoclassical convergence mechanism. In the beginning of the growth period the low level of the capital stock gives high marginal returns to investment with consequent high investment growth and capital accumulation. The capital and GDP growth rates decline over time with decreasing returns to investment. Part of the investment is imported from abroad with imperfect substitution between foreign and domestic goods. The traded sector benefits from technology spillovers embodied in foreign capital goods, but the low level of human capital constrains productivity growth and catch-up. Relative productivity between tradables and the world frontier increases from 0.32 to about 0.35 during the high growth period (see Fig. 6 in Section 5). Productivity growth in nontradables is low bacause of a lack of human capital and the domestic technology gap increases over time.

During 1975-1993 the negative growth trend is stronger. The international isolation represented by an increasing tariff-equivalent affects productivity growth in tradables by increasing the trade barrier to technology adoption and limiting the transfer of foreign spillovers. Despite an increasing skill-ratio the traded sector is unable to catch-up towards the world frontier, and the international technology gap remains roughly constant during the closed economy period. The low productivity level together with the contraction of the traded sector since the early 1980s limits the extent of domestic spillovers to the nontraded sector. South Africa could have compensated for the reduced openness with higher domestic investments. As seen from Table 1, this did not happen. The reason is that the cost of investment increases as imports of capital goods become more expensive, and lower productivity growth further reduces the profitability of investments. The fall in investment growth strengthens the negative effect on productivity growth by reducing the

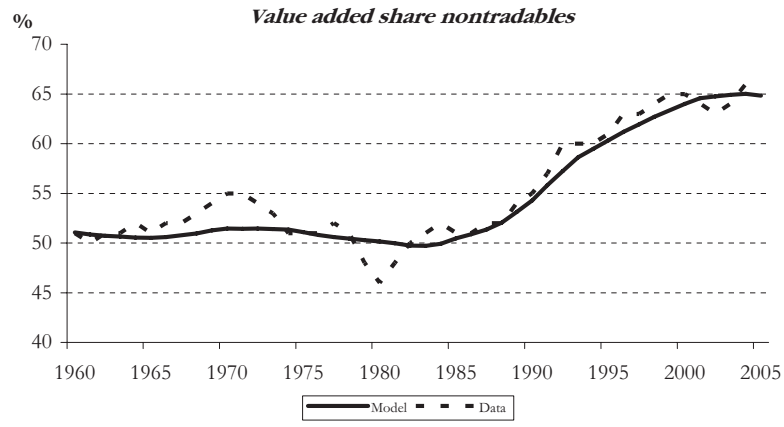

Figure 4. Value added share for the South African nontraded sector: calibrated path of model versus actual path

growth in foreign trade. The growth path of the model is consistent with the low level of investment and the technological stagnation observed in South Africa during the closed economy period, and follows from fewer international and domestic technology spillovers, more expensive foreign capital goods, and productivity-investment interaction.

In the post Apartheid period, the negative growth trend is offset and the growth rate stabilizes at around 3%. The elimination of sanctions together with trade liberalization reduces the costs of imported investment goods and opens the economy to more technology adoption. Again, the investment and productivity effects reinforce each other, but now in a positive direction. This period is characterized by some catching up relative to the technological frontier, which can be related to lower trade barriers and an increasing skill-ratio. The productivity response is limited, however, and the model predicts no take off or returns to high growth.

The reproduction of the structural change in South Africa is illustrated in Fig. 4. The expansion of nontradables since 1980 is mainly demand-side driven. The observed consumption pattern is stable during the 1960s and 1970s, while the share of nontraded goods in total consumption increases after 1980. In the model, the change in the consumption pattern is captured through a Stone-Geary demand system with non-homothetic preferences. The income elasticity is relatively higher for nontraded goods, and demand gradually shifts away from traded goods. To reproduce the rapid expansion of nontradables, the nontraded consumption share is increased by more than the actual numbers. Our interpretation is that the dramatic shift to nontradables after 1980 is related to extraordinary factors, notably the gold revenue increase (not captured by the model). Stokke (2007) shows the relevance of the gold price increase in the 1970s (and the associated increase in resource income) to the contraction of the traded sector in South Africa.

The degree of openness has opposite effects on structural change. Reduced access to foreign technology decreases productivity growth in tradables, and affects nontraded productivity via fewer domestic spillovers. Higher tariffs imply less competition from abroad and part of the demand for tradables is shifted towards domestic goods at the cost of more expensive foreign goods. Whether the international isolation in the 1980s

contributed to the contraction of the traded sector is investigated through a counterfactual experiment in the next section.

As illustrated in this section, the South African growth experience during 1960-2005 can be explained by neoclassical convergence, international spillovers with barriers related to trade and human capital, domestic spillovers affected by tradables productivity and structural change, and endogenous interplay between productivity and investment profitability. The growth constraints are most pronounced during the closed economy period, but while productivity conditions are improved, investment profitability is still held back when the country enters the 1990s. The ability to simultaneously reproduce the growth path, the degree of openness and the trade path, and the structural change, acts as a robustness check on the model specification and strengthens the view that the model mechanisms are important in understanding the South African experience.

5. COUNTERFACTUAL ANALYSIS OF OPENNESS

The growth model allows a counterfactual analysis of the role of international trade and thereby the effect of sanctions and protectionism. As explained in Section 4, we have calibrated a tariff-equivalent growing from the late 1960s and with a peak in the late 1980s to reproduce the actual trade and growth path. Eliminating the rise in the tariff-equivalent during the period of sanctions and protectionism, we can simulate the economic development in a more open economy. In the experiment, the tariff equivalent decreases gradually from 40% in 1960 (gradual trade liberalization). The new GDP growth path is shown in Fig. 5. The main message is that South Africa could have avoided some of the decline in the growth rate. The sanctions and protectionism have contributed to more costly investment goods and fewer technology spillovers and consequently to constrained economic growth. The growth effect adds up to a rather large permanent income gap between the two scenarios.

More openness reduces the cost of adopting foreign technology by limiting the trade barriers to technology transfer, and productivity growth in tradables is stimulated. The period of technological stagnation is avoided and the economy catches up relative to the

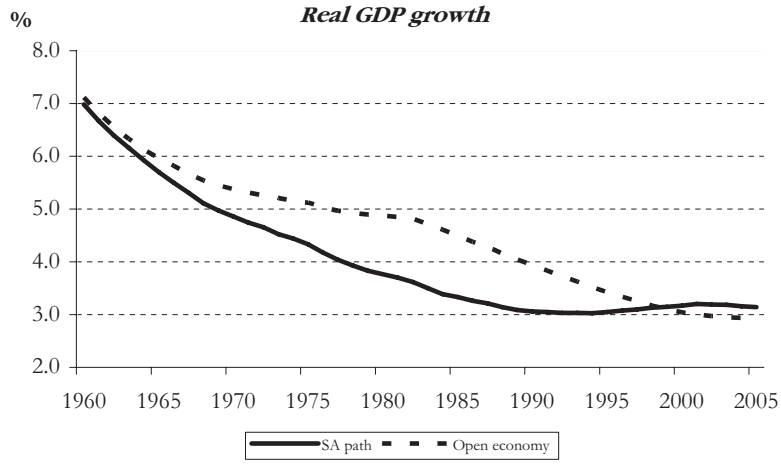

Figure 5. Real GDP growth: calibrated path versus counterfactual path

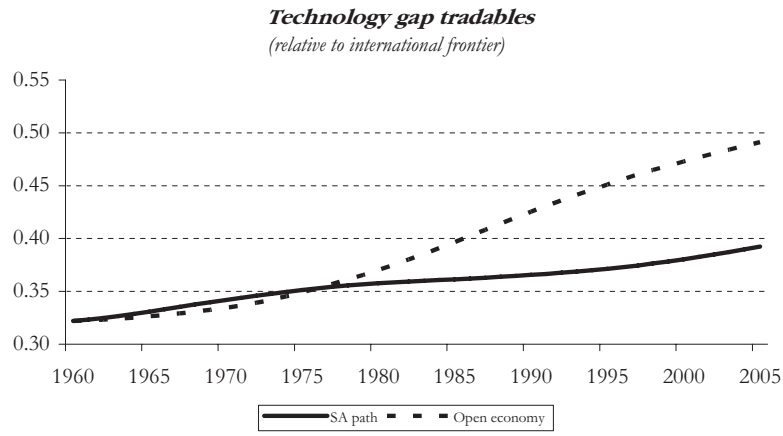

Figure 6. Productivity level in tradables relative to the world frontier: calibrated path versus counterfactual path

frontier. As seen from Fig. 6, relative productivity increases from 0.32 to about 0.5, and generates a permanent productivity gap between the two scenarios. Part of the learning spills over to the nontraded sector via interaction in the intermediate market, but the domestic technology gap widens with a more open economy. The technological distance between the traded and the nontraded sector increases. This means that the international isolation from the mid 1970s to the early 1990s harmed the traded sector the most. This follows from its dependence on foreign technology.

The profitability of capital accumulation is stimulated by cheaper foreign capital goods and higher productivity growth. Decreasing returns to investment are offset, and capital growth remains high over time. Increased capital accumulation implies more trade, which generates further technology spillovers from abroad. The productivity-investment interaction stimulates growth and contributes to the large growth differential between the two scenarios during transition.

There are opposite effects of a more open economy on the economic structure. Tradables productivity is stimulated relatively more than productivity in the nontraded sector, but at the same time some domestic demand shifts towards cheaper foreign goods. In the numerical simulations the first effect dominates, and the contraction of the traded sector is constrained by a more open economy. The magnitude of the effect is rather small, indicating that the structural change is mainly demand-side driven.

6. CONCLUDING REMARKS

We offer a two-sector growth model reproducing the main elements of the South African experience during 1960-2005, including the growth path, the degree of openness and trade path, and the structural change. Important features of the model are an independent investment decision based on intertemporal profit maximization, allocation of consumption and savings determined by intertemporal utility maximization, and endogenous productivity dynamics related to domestic and international technology spillovers. The suggested model is in contrast to existing growth modelling in South

Africa, in which investments are short sighted and productivity growth is imposed exogenously.

Numerical simulations show how the growth experience can be understood as neoclassical convergence, international spillovers with barriers related to trade and human capital, domestic spillovers affected by tradables productivity and structural change, and endogenous interplay between productivity and investment profitability. Economic growth in South Africa post Apartheid has been reluctant and there is widespread disappointment about the recent growth results. The lack of growth response to increased openness and human capital points to domestic market imperfections beyond the growth constraints discussed in this paper. Future research should address the domestic market challenges in combination with the productivity growth analysis presented here.

APPENDIX

Table 1. Selected calibrated parameters

Parameter	Description	Value
r	World market interest rate	0.11
ρ	Time preference rate	0.09
g	Long-run technical progress rate	0.013
n	Labour growth rate	0.007
δ	Rate of depreciation	0.04
θ_1	Parameter in the productivity specification, tradables	0.6
θ_2	Parameter in the productivity specification, tradables	0.6
θ_3	Parameter in the productivity specification, tradables	1.3
γ_1	Parameter in the productivity specification, nontradables	0.3
γ_2	Parameter in the productivity specification, nontradables	0.3
γ_3	Parameter in the productivity specification, nontradables	1.2
σ_m	Armington elasticity	3.0
σ_e	CET elasticity	2.0

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