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THE INTERACTION BETWEEN GROWTH, OPENNESS AND INEQUALITY: INTERTEMPORAL RAMSEY GROWTH MODEL ANALYSIS OF SOUTH AFRICA

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The interaction between growth, openness and inequality: Intertemporal Ramsey growth model analysis of South Africa*)

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Abstract
South Africa offers an interesting case study of the effects of openness because of the experiences with international sanctions and active trade policy. Shifts in productivity growth and income distribution before, under and after sanctions indicate the importance of foreign trade. The economic adjustment mechanisms involved are investigated in an intertemporal Ramsey growth model with endogenous skill-bias in technology and separating between labor and household types. Openness in particular affects the balance between innovation and adoption in the productivity growth. Economic growth under sanctions has been slow, but with an increase in the relative wage of unskilled labor. The model allows for counterfactual analysis of no-sanctions and offers a calibrated tariff-equivalence measure of the sanction effect. Openness is shown to imply technology adoption with skill bias that improves growth, but worsen income distribution. Demand-side responses, shifts in the consumption pattern, strengthen the distributive effects. The tradeoff between foreign spillover driven productivity growth and income distribution obviously is a challenge for growth policy.

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1. Introduction

The relationship between growth, openness and inequality is of key concern in the development debate. An enormous literature has addressed these questions in theoretical and empirical studies. The effect of trade on growth has received most attention, but also the relation to poverty has been investigated. Frankel and Romer (1999) and Dollar and Kraay (2004) represent important empirical contributions. The cross-country empirical evidence is controversial, however, as discussed by Rodriguez and Rodrik (2001). It is consequently of interest to add new approaches to get a better understanding of the adjustment mechanisms involved. South Africa is an interesting case study of the dynamics of growth and distribution. The trade regime has been changing over time, and in particular with a long period of international sanctions. The dual economy combines capital-intensive modern manufacturing with large unskilled employment and underemployment. The volatility of growth and the large inequalities are a challenge for research and policy.

In this paper we study the growth mechanisms using an intertemporal general equilibrium model. Economic growth is generated by endogenous investment allocation and productivity growth. Foreign trade and capital flows are endogenous and the openness is influenced by tariffs and sanctions calculated as tariff-equivalent. Income distribution is measured by the relative wages between skilled, semi-skilled and unskilled labor and by separating between rich and poor labor households and capitalist households. Given the standard Ramsey core of the model, we emphasize productivity dynamics driven by innovation and adoption and including endogenous skill bias.

Productivity growth in semi-industrialized economies like South Africa is driven by a combination of innovation and adoption. While innovations are determined by domestic production activity, technology adoption is a foreign spillover. The balance between the domestic and foreign sources of growth is in focus here, as analyzed by Eaton and Kortum (1997). The starting point of the literature is the catching-up advantage of backwardness called the Veblen-Gerschenkron-effect. The mechanism was first formalized by Nelson and Phelps (1966). They assume exogenous growth of a best practice world technology frontier, and the productivity level of the backward country responds to the productivity distance to best practice. All countries can take benefit of the growth of the world technology frontier, albeit in different degrees and speeds, and dependent on the initial conditions. A modern restatement is offered by Parente and Prescott (1994) introducing the concept barriers to technology adoption. Improvement in productivity is linked to the distance to the exogenous world technology frontier, and investment is needed to benefit from the world technology.

A broad empirical literature has addressed the sources of total factor productivity (TFP) 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. Cameron (1998) has written a helpful survey of studies of the relationship between innovation and growth. Innovations do contribute to growth, and with spillovers between countries, but R&D activity is limited outside the already rich.

Several studies indicate the importance of both openness and domestic factors in the TFP growth in South Africa. Jonsson and Subramanian (2001), with their basis at the IMF, are the most enthusiastic about the productivity effect of an open economy. They also find an important role of machinery and equipment investment for TFP growth. Fedderke (2002) offers a richer study and puts more emphasis to domestic factors. He identifies important effects of R&D and the ratio of skilled to unskilled labor in TFP growth. Harding and Rattsø (2004) address the endogeneity problem of openness and concentrate on tariff measures. They identify a shift from domestic to foreign sources of productivity growth after sanctions. Inspired by this literature we study the endogenous formation of productivity growth driven by adoption and innovation. The adoption part is related to the degree of interaction with the rest of the world through international trade, while the innovation part is related to the investment level.

The productivity growth is linked to income distribution by introducing skilled, semi-skilled and unskilled labor and possible skill bias. The specification of technological bias is based on the assumption of an unskilled intensive economy, and is linked to the relative importance of technology adoption and innovation as sources of productivity growth. New technology innovated in skill-intensive developed countries is likely to be skill-biased following from directed technical change (Acemoglu, 1998). Adoption of foreign technology is therefore assumed to generate productivity growth biased towards skilled workers, and the degree of bias increases with the openness of the economy and the availability of foreign technology. Local improvement of technology can be directed based on given factor endowments, which in an unskilled-intensive economy implies technical change biased towards unskilled workers. The more dependent the economy is on adoption of foreign technology, the higher is the degree of skill-bias in technical change. Empirical support is offered by Zhu and Trefler (2003).

This productivity dynamics is embedded in the Ramsey growth model and calibrated to reproduce the main growth path of South Africa during 1960-2003 and projected to 2010. To capture the dual structure of the South African economy, we distinguish between a modern sector using semi-skilled and skilled labor more intensively and a traditional unskilled-intensive sector. In addition, government services are treated as a separate sector. On the consumption side, we separate between poor households based on unskilled wage income, rich households based on semi-skilled and skilled wage income, and capitalist households based on profits. The protectionist effect of sanctions is calibrated as a tariff equivalent and with a peak in 1990. This allows the analysis of a counterfactual scenario without sanctions, with consequences for the relationship between adoption and innovation and consequently skill bias. The analysis separates between three time periods: pre-sanctions 1960-74, sanctions 1975-1993, and post-sanctions 1994-2010.

The paper presents the modelling of the productivity dynamics (section 2), the full intertemporal general equilibrium model (section 3), the calibration of South Africa's growth path (section 4), and offers a counterfactual analysis of sanctions (section 5). Section 6 concludes.

2. Productivity dynamics

Productivity growth is assumed to be generated through technology adoption and own improvements of technology (innovation). The understanding of innovations includes both modern R&D activities and other growth enhancing factors related to structural change and better organization, and in the model the innovation activity is assumed to follow the investment path. The adoption of foreign technology is related to the degree of openness in the economy measured by total trade. The dynamic specification of the productivity equations follows Jones (1995) and avoids the scale effect in endogenous growth models. He derives a relationship where the productivity growth rate is affected by the level of productivity, and with the equilibrium assumption that the growth rate of productivity is declining in the level.

Consistent with empirical evidence for South Africa offered by Harding and Rattsø (2004), the calibration will assume 'fishing out' dynamics whereby the change in productivity is declining in the level. The higher the level of productivity, the harder it is to raise productivity. This is consistent with the early analysis of Nelson and Phelps (1966), where the profitability of technology adoption declines as the economy catches-up with the frontier, due to less adoption opportunities.

While the productivity level in government services is assumed to grow exogenously, the rate of growth of labor augmenting technical progress in traditional (*A*) and modern (*M*) sector is specified as follows (time subscript is omitted):

$$\frac{\dot{A}_i}{A_i} = \lambda_i \frac{\left(\frac{\sum_i (EX_i + M_i)}{Se}\right)^{\theta_{1,i}} \cdot \left(\frac{I}{Se}\right)^{\theta_{2,i}}}{A_i^{1-\varphi_i}} \qquad i = A, M \qquad (1)$$

where EX_i and M_i are exports and imports of good *i*, *Se* total supply of semi-skilled labor, *I* total investment, and $\lambda_i, \theta_1, \theta_2, \varphi$ are constant parameters. The terms in the numerator represent the foreign and domestic channels of growth, respectively, where θ_1 and θ_2 are the elasticities of productivity growth with respect to technology adoption and innovation. The modern sector is assumed to be relatively more dependent on foreign technology in productivity improvements. The denominator captures the scale effect, and by assuming a negative value of φ, higher productivity level lowers productivity growth and also productivity expansion (fishing-out dynamics). To have constant rate of labor augmenting technical progress in the long run, the parameters must satisfy the following condition; $\theta_{1,i} + \theta_{2,i} = 1 - \varphi_i$. For simplicity the specification excludes explicit handling of the world technology frontier. A Ramsey growth model with technological catch-up and possible divergence is offered by Stokke (2004), and is applied to study the growth process in Thailand.

The economy-wide growth rate is determined endogenously by the productivity dynamics at the sector level and hence the long-run growth rate will endogenously change with sectoral TFP growth rates. An exogenously fixed interest rate, which is consistent with the assumption of perfect capital market, is therefore not suitable for the model. The interest rate has to be endogenously linked with the growth rate, and we apply a reduced form specification where the domestic interest rate is defined as a function of the world interest rate adjusted by the degree of openness in the economy. The understanding is that when openness (represented by the ratio of trade over GDP) stimulates sectoral TFP growth, the domestic interest rate will simultaneously adjust and will exceed the world market rate to attract more capital inflows.

The productivity dynamics enter as part of the production functions, which are defined as a Cobb-Douglas function of capital (*K*) and total efficient labor use (*L*):

$$X_i = K_i^{\alpha_i} L_i^{1-\alpha_i} \tag{2}$$

where i = *A*, *M*, *S* represents traditional sector, modern sector and government services, respectively. Efficient labor is a CES aggregate of unskilled (*Lu*), semi-skilled (*Se*) and skilled (*Ls*) labor:

$$L_i = \left[\gamma_{1,i} A_i^{v-\frac{1}{2}\beta} Lu_i^v + \gamma_{2,i} A_i^v Se_i^v + (1-\gamma_{1,i}-\gamma_{2,i}) A_i^{v+\frac{1}{2}\beta} Ls_i^v \right]^{\frac{1}{v}} \tag{3}$$

Labor and capital are mobile across sectors, but not internationally. γ_1 and γ_2 are the share parameters for unskilled and semi-skilled labor, respectively, and $\sigma = \frac{1}{1-v}$ ($v < 1$) is the elasticity of substitution between different labor types. Marginal productivity of skilled relative to unskilled labor is given as:

$$\frac{\partial X_i / \partial Ls_i}{\partial X_i / \partial Lu_i} = \frac{1-\gamma_{1,i}-\gamma_{2,i}}{\gamma_{1,i}} A_i^{\beta} \left(\frac{Ls_i}{Lu_i} \right)^{v-1} \tag{4}$$

Following from decreasing returns, an increase in the relative use of skilled labor reduces the relative marginal productivity. The direction and degree of technological bias is introduced through the parameter β, which gives the elasticity of the marginal productivity of skilled relative to unskilled labor with respect to labor augmenting technical progress. For β equal to zero, technical change is neutral and does not affect the relative efficiency of the three labor types. With a positive value of β technical change favors skilled workers and to a lesser extent semi-skilled workers (skill-biased technical change), while negative values imply that improvements in technology are biased towards unskilled labor.

During transition the degree of technological bias is endogenously determined (see below), but to have balanced growth neutral technical change (β = 0) is a necessary long-run condition. With this assumption the production function can be written as:

$$X_i = K_i^{\alpha_i} A_i^{1-\alpha_i} \left[\gamma_{1,i} Lu_i^v + \gamma_{2,i} Se_i^v + (1-\gamma_{1,i}-\gamma_{2,i}) Ls_i^v \right]^{\frac{1-\alpha}{v}} \tag{5}$$

The long-run growth rate is determined by the endogenous rate of technical progress and the exogenous growth in labor supply. The relationship between sector total factor productivity (*TFP*) and labor-augmenting technical progress (*A*) is given by:

$$TFP_i = A_i^{1-\alpha_i} \tag{6}$$

It follows that the growth paths of sector TFP are:

$$\frac{T\dot{F}P_i}{TFP_i} = (1-\alpha_i)\frac{\dot{A}_i}{A_i} \tag{7}$$

The common understanding in South Africa is that trade liberalization and skill biased technological change are important to understand the development at the labor market. The specification of technological bias is linked to the relative importance of technology adoption and innovation as sources of productivity growth. The more dependent the economy is on adoption of foreign technology, the higher is the degree of skill-bias in technical change. The reduced form specification of technological bias is assumed to be an increasing and convex function of adoption relative to innovation:

$$\beta = b\left[\left(\frac{adop}{inn}\right)^2 - 1\right] \tag{8}$$

where b is a constant parameter, and *adop* and *inn* represent the technology adoption and innovation term, respectively, from equation (1). Given the dimension of the trade and investment level in South Africa, the specification does not need scaling to generate sensible values of technological bias. With adoption as the main source of productivity growth (*adop* > *inn*) technical change is skill-biased $(\beta > 0)$, while technology improvements driven by own innovations (*adop* < *inn*) are biased towards unskilled labor $(\beta < 0)$. Equal importance of technology adoption and innovation gives neutral technical change.

3. The intertemporal general equilibrium model

The productivity dynamics is built into a standard intertemporal Ramsey growth model for a small open economy. It follows that capital accumulation and technological growth do not influence world prices and interest rate, which are exogenously given. The model setup of Diao et al. (2002, 2005) is the starting point, but is extended to capture endogenous skill-bias and balance between innovation and adoption in productivity growth, and to analyze income distribution effects. As discussed above, the production structure allows technical change to be biased towards unskilled or skilled labor, and the degree of bias is endogenously determined by the relative importance of adoption versus innovation in productivity improvements. Detailed documentation of the intertemporal general equilibrium model is given in a separate model appendix.

Early applied Ramsey models include Goulder and Summers (1989), who study tax policy effects on investment in the US, and Go (1994), who applies the model framework on development issues. Our approach also relates to existing models of growth in dual economies. Stifel and Thorbecke (2003) model the dual character of an archetype African economy that is of relevance here. Irz and Roe (2001) develop a similar Ramsey model to analyze the interaction between agriculture and industry. Love (1997) analyzes industrialization in a dynamic general equilibrium model, also with an emphasis to the role of agriculture.

The Ramsey model describes an economy with macroeconomic stability, full employment of resources, and flexible allocation of resources between sectors according to profitability. The assumptions are certainly heroic, and it is a challenge to develop the model to include political and structural rigidities of the country. At this stage the model should be interpreted as representing the long run market adjustments expected to affect consumption demand and investment behavior, and with labor market adjustments faster than in reality.

The economy is disaggregated into three sectors: traditional, modern and government services. The division is based on skill-intensity, the traditional sector is unskilled-intensive and the modern sector is skill-intensive. The details are described in appendix A. The labor market formulation separates between unskilled, semi-skilled and skilled labor, and the relative wages are the key variables describing the income distribution. The model includes three household types according to income level and source of income: A poor household with unskilled wage income, a rich household with semi-skilled and skilled wage income, and a capitalist household with capital income. All savings are done by the capitalist household, which also pays interest on the foreign debt.

Except for government services, which are not traded internationally, we assume imperfect substitution between domestic and foreign goods, and the model then operates with two composite goods (traditional and modern). Imports are endogenously determined through an

Armington composite system, while exports are determined through Constant Elasticity of Transformation (CET) functions.

The aggregate capital stock is managed by an independent investor who chooses an investment path to maximize the present value of future profits over an infinite horizon, subject to the capital accumulation constraint. With a waste due to the adjustment costs in investment, net profits as returns to capital go to the capitalist household. Investments can be financed through foreign borrowing, and the decisions about savings and investment can therefore be separated. Domestic savings and investments do not have to be equal in each period, but a long-run restriction on foreign debt exists. Increase in foreign capital inflows (i.e., trade deficits) in the current period, together with interest payments on existing debt, augments foreign debt in the next period.

For each household the consumption of traditional good, modern good and services are constant shares of its total consumption. But aggregate consumption of each good as share of total consumption can change over time. The poor household is assumed to consume relatively more traditional goods, while the rich and the capitalist household spends a relatively higher share of its income on modern goods. While within period consumption patterns differ between the three households, there exists a common intertemporal allocation of total income to consumption and savings to maximize its intertemporal utility. The intertemporal utility function is maximized subject to a budget constraint, which says that discounted value of total consumption cannot exceed discounted value of total income. Assuming intertemporal elasticity of substitution equal to one we have the well-known Euler equation for optimal allocation of total consumption expenditure (*E*) over time:

$$\frac{E_{t+1}}{E_t} = \frac{1+r_t}{1+\rho} \tag{9}$$

where r_t is the domestic interest rate and ρ the positive rate of time preference. The growth in consumption depends on the interest rate, the time preference rate, and the price path. Higher interest rate or lower time preference rate motivate more savings and thereby higher consumption spending in the future.

4. Productivity growth and income distribution in South Africa

South Africa achieved remarkable high growth from 1960 to the mid-1970s, here called the pre-sanctions period, with an annual average of above 6%. The implication was that the whites enjoyed a living standard at the level of the richest countries of the world, but the majority lived in poverty. Then the economic growth shifted down in the mid-1970s with the liberalization struggle and the international isolation. Many developing and developed economies experienced economic stagnation because of the oil crisis. The growth process in South Africa also was affected by local economic and political factors. It is a common understanding that Apartheid labor policies came to be a constraint on growth in South Africa. While initially the discrimination of blacks may have stimulated growth by cheap labor, now shortages of skilled labor are building up. When the sanctions were tightened, at the same time political unrest and labor strikes affected the economic development. In the post-sanctions period the economic performance has been erratic, but with a low average. Fedderke (2001), Lewis (2001) and Gelb (2003) offer a nice record of the recent economic history.

The early growth episode followed by stagnation is clearly described by the relative performance of South Africa. GDP per capita relative to the US was about 0.21 in 1960 and reached a peak of 0.25 in 1974. By 1994 GDP per capita relative to the US has declined to 0.14, and the domestic level of real GDP per capita is lower than in 1970. The relative position to the US is further reduced to 0.13 in 2003. Overall the gap to the technology frontier, here defined as the US, is steadily rising since 1974. Domestic level of real GDP per capita is rising in the post-sanction period and reaches about the 1970 level in 2003. Table 1 presents some comparing statistics for the three periods.

Table 1 about here.

The growth model described above is calibrated to reproduce the main elements of the economic development during the three periods. The first step of the analysis is to calibrate a growth path that is close to the growth experienced in South Africa during 1960-2003 and projected to 2010. The model allows for a new measure of the protectionist effect of international sanctions. The empirical literature addressing foreign trade and trade policy faces the problem that sanctions cannot be measured directly. We calibrate a tariff-equivalent level that reproduces the actual development of the trade. Figure 1 reports the reproduction of the trade path. While tariffs are kept low (at 5%) during 1960-74, the slow growth of foreign trade during sanctions require a gradual increase of the tariff-equivalent after 1975, and with a peak in 1990 of about 80%. Interestingly, this tariff-equivalent measure of openness is consistent with the openness indicator for South Africa calculated by Aron and Muellbauer (2002) based on econometric estimation.

Figure 1 about here.

The economic growth of the period under study is of transitional character, but is consistent with a long run growth path. Figure 2 shows how we track the declining, but erratic, actual growth rate as a steady decline in the model growth rate. The long-run equilibrium growth rate is assumed to be 3 percent (1 percent technological progress rate and 2 percent labor growth). The parameters supporting the long-run equilibrium path are based on the 1998 social accounting matrix (SAM) documented in Appendix A. The original SAM includes 43 production sectors, which are aggregated into a traditional and a modern sector according to skill-intensity in production (except for government services which are treated as a separate sector). The calibration assumes that the SAM represents long run balanced growth, i.e. the savings-investment balance can support a sustainable growth path, the structure of the economy is stable, and the trade surplus with interest payments balances the projected development of foreign debt.

Starting from the base year 1998, we calibrate backward a growth path that is close to the observed real GDP growth for the previous four decades and then allow this to project the post-sanctions growth through 2010. To reproduce the actual GDP of 1960, the initial level of the capital stock is reduced to about 10 percent of the base year level. Supply of skilled, semi-skilled and unskilled labor are also scaled down, and the skill-ratio (defined as skilled and semi-skilled relative to unskilled) is calibrated to increase from 0.62 in 1960 to about 0.8 at the end of the period studied (broadly consistent with data in Fedderke et al., 2003). The share of unskilled labor in total labor force declines from 0.62 to 0.56 during five decades, with a corresponding increase in the skilled labor share from 0.06 to 0.12. Sectoral TFPs are reduced according to the long run growth rate and foreign debt is adjusted to reproduce the initial year. The scaling back serves as an exogenous shock that takes the economy outside the equilibrium long run path in 1960. The initial capital stock is below the long run path and economic growth is driven by endogenous adjustment back to equilibrium growth. The calibrated economic growth rate during the pre-sanctions period 1961-74 is 5.8% on average, while the growth rate during sanctions (1975-1993) averages 3.8%. The post sanctions period has an increasing model growth rate with an average of about 3.7%.

Figure 2 about here.

The pre-sanctions period broadly observed the prediction of the model with high, but declining, growth. The understanding is that the best profit opportunities encouraged high investment and were exploited first, and that the marginal return to capital consequently was reduced over time. This is the core of the neoclassical convergence mechanism. In the beginning of the growth period studied the low level of the capital stock gives high marginal return to investment with consequent high investment growth and capital accumulation (Figure 3). Part of the investment must be imported from abroad with imperfect substitution between foreign and domestic goods. Technology spillovers embodied in foreign capital goods stimulate productivity growth, and contribute (together with domestic improvements of technology) to the increasing productivity growth path (see Figure 4). The capital and GDP growth rates decline over time due to decreasing returns to investment.

During the sanctions period the negative growth trend is strengthened. The international isolation represented by an increasing tariff-equivalent affects productivity growth directly by increasing the barriers to technology adoption and limiting the transfer of foreign spillovers. A possible scenario for South Africa would be to compensate the reduced openness with higher domestic investments. As seen from Table 1, this did not happen. Our understanding is that the cost of investment increases as imports of capital goods became more expensive with sanctions, and lower productivity growth further reduces the profitability of investments. The fall in capital growth strengthens the negative effect on productivity growth by reducing the growth in total imports and holding back domestic innovations. The growth path of the model is consistent with the low level of investment and the declining growth rate of productivity during the sanctions period.

As seen from Figure 4, productivity growth is relatively higher in the traditional sector. This follows from the assumption that the modern sector is more dependent on foreign technology, while the traditional sector takes more advantage of own innovations. In the early period, local improvement of technology is the main source of productivity growth (driven by high investment growth), and this benefits the traditional sector the most. The importance of own innovation in productivity growth declines over time as capital accumulation slows down, but the forced protectionism during sanctions limits the transfer of foreign technology and contributes to the continued low productivity growth rate in the modern sector. As the economy opens up in the post-sanction period, the modern sector gradually catches-up with the traditional sector, and in the long run the sectoral productivity growth rates are equal.

Figure 3 and 4 about here.

While economic sanctions have negative effects on economic growth, the income distribution improves. Driven by increasing skill-ratio, the relative wage between unskilled and skilled labor increases in the pre-sanction period. Figure 5 shows how this positive distributive effect is strengthened during sanctions. Our understanding of the increased relative wage for unskilled labor is related to the development of technological bias. Increased tariffs have a negative effect on both technology adoption and innovation through higher barriers and lower capital accumulation, respectively. In our simulations the first effect dominates, and the relative importance of technology adoption decreases during the sanction period. The economy is forced to rely more on own improvements of technology, and the degree of skill-bias in technical change declines from 0.31 to 0.25. As explained in section 2, the degree of skill-bias is the elasticity of the marginal productivity of skilled relative to unskilled labor with respect to labor augmenting technical progress. Positive values imply bias towards skilled labor. Since technical change is relatively less skill-biased under sanctions, the relative marginal product of unskilled labor increases. The relative demand for unskilled workers is stimulated, and the relative wage gradually increases to meet the higher demand.

The change in income distribution generates shifts in the consumption pattern that strengthen the positive effect on the relative wage. Relative higher income for the poor household increases relative demand for traditional goods, which further increases the demand for unskilled labor (since the traditional sector uses unskilled labor relatively more intensively). The relative unskilled to skilled wage rate is 0.15 in 1975, but increases to 0.18 during the sanction period. Declining skill-bias improves the income distribution, but the increase in the relative wage is held back due to a shortage of skilled labor. Larger expansion of the skill-ratio would keep skilled wages down and contribute to the reduction of the wage gap between skilled and unskilled labor.

In the post-sanction period trade liberalization reduces the barriers to technology adoption, and the degree of skill bias increases gradually from 0.25 to 0.35. The increase in the skill-ratio is not sufficient to meet the higher skill demand and the wage gap widens over time. The relative wage between semi-skilled and skilled labor follows a similar pattern, increasing from 0.29 in 1960 to about 0.36 at the end of the period studied. According to Fedderke et al. (2003), the relative wage for semi-skilled labor increases from 0.32 in the 1970s, via 0.34 in the 80s, to about 0.37 in the 90s. Similar figures for the unskilled wage rate are 0.10, 0.16 and 0.25, respectively. The relative wage paths generated by the model are broadly consistent with this observed pattern.

Economic research in South Africa has addressed the relationship between wage inequality and skill bias. Edwards (2001) argues that skill bias has contributed to increased skill employment in South Africa. Abdi and Edwards (2002) address the puzzle that relative wages of unskilled has gone up, while unskilled employment has gone down since the mid-1970s. Since this is hard to explain in a standard labor market model, appeal to political and institutional factors to understand this is common, including increased union power. In our setting we emphasize a different channel of effects. The degree of skill-bias is reduced with sanctions and the higher demand for unskilled labor increases the relative wage of unskilled. Institutional factors are not built into our analysis and are hard to handle in this context.

Figure 5 about here.

The post-sanctions period shows increasing growth rate with our assumptions. The elimination of sanctions reduces the costs of imported investment goods and opens the economy to more technology adoption. Again the investment and productivity effects strengthen each other, but now in a positive direction. The increasing growth rate is closely related to the increased openness and assumes that reduction of protectionism continues steadily. Also the projection is the result of favorable conditions for investment allocation to take advantage of the improved profitability. Finally, the higher growth rate is driven by technology adoption, in practice associated with foreign direct investment. The actual growth has increased according to Table 1, but not fully at the potential indicated by the model projections. This can be due to macroeconomic disturbances excluded from the model. But it is more realistic to assume that the structural conditions of the economy are different from the flexible adjustments assumed in the model. The limited foreign direct investment observed may indicate that technology adoption has been below the projection shown.

5. Counterfactual analysis of sanctions

The model allows for counterfactual analysis of the role of international sanctions in South Africa. As explained above, we have calibrated a tariff-equivalent growing from 1974 and with a peak in 1990 to reproduce the actual trade and growth path. Eliminating this rise in the tariff-equivalent during the sanctions period, we can simulate the economic development in an open economy without sanctions. In the experiment, the import tariff-equivalent is kept at a constant low level (5%) for the entire period studied. The new GDP growth path is shown in Figure 6 below. The main message is that South Africa could have avoided some of the decline in the growth rate. Sanctions have contributed to more costly investment goods and less technology adoption and consequently held back economic growth. The growth effect adds up to a rather large permanent and increasing income gap between the two scenarios. Without sanctions the 1998 level of real GDP would have been about 15 percent higher than its actual level in that year.

Figure 6 about here.

More openness reduces the cost of adopting foreign technology by limiting the barriers to technology transfer, and productivity growth increases over time (Figure 4). While the productivity growth in the reference path is declining after the mid-1970s, the productivity growth now is increasing with steadily higher trade. The growth rate effect of higher trade is decreasing over time since the magnitude of the spillover effect and the return to own innovations gradually decline. The learning potential is reduced as the productivity level increases. This is assumed by the negative value of φ in the sectoral productivity growth functions. Decreasing returns to investment is counteracted, and capital growth is kept high over time (Figure 3). The profitability of capital accumulation is stimulated both by less expensive foreign capital goods and higher productivity growth. High capital growth generates domestic innovations and implies more imports, generating further technology spillovers from abroad. This productivity-investment interaction stimulates growth and contributes to the large growth differential between the two scenarios. During the early pre-sanction period (1961-74) both capital and GDP growth are slightly higher along the calibrated South Africa path compared to the counterfactual path. This follows from intertemporal adjustment with perfect foresight, since expected higher tariffs (more expensive capital goods) in the future gives an incentive to increase current capital accumulation.

Given our model specification, there is a trade-off between economic growth and income distribution. While the aggregate economy benefits from a more open economy, the difference between poor and rich households increases. With lower tariffs the cost of technology transfer is kept low, and the economy takes advantage of foreign technology. Falling capital growth rate reduces the ability to generate local improvements of technology, and the relative importance of technology adoption increases over time. The new technology favors skilled workers, and the degree of skill-bias in technical change increases gradually from 0.33 in 1960 to 0.41 at the end of the period studied. This generates an increase in the relative demand for skilled labor, which counteracts the increasing skill supply and gives about constant relative wage over time. Changes in the consumption pattern following relative larger wage gap strengthen the negative effect on the income distribution. The rich household with semi-skilled and skilled wage income consumes relatively more modern goods, which uses skilled labor more intensively. This increases the demand for skilled labor and widens the wage gap even more. The economy is stuck in a vicious circle, where skill-biased technical change and demand-side effects of changing consumption pattern work together to worsen the income distribution. On average the unskilled wage, both relative to semi-skilled and skilled wage, drops about 2 percentage points compared to the sanction scenario (see Figure 5). But even though the relative unskilled wage rate is lower, the absolute income level for the poor household is eventually higher than along the calibrated path due to higher growth.

6. Concluding remarks

The analysis addresses the interaction between economic growth, openness and income distribution in South Africa. With a standard intertemporal Ramsey growth model as a starting point, we have introduced endogenous skill-bias and productivity growth related to openness. The economy is disaggregated to capture interactions between traditional and modern industrial sectors and adjustments at the labor markets for skilled, semi-skilled and unskilled labor. The main focus is on the linkage between openness and distribution generated by skill bias and productivity growth determined by innovation and adoption. The degree of openness influences the degree of adoption and skill-bias.

The model reproduces the declining growth rate since 1960 and separates between the pre-sanctions, sanctions and post-sanctions periods. The high and declining growth during pre-sanction 1961-1974 is consistent with neoclassical convergence, the exploitation of profit opportunities with declining return. To understand the low growth during sanctions, 1975-1993, additional assumptions of protectionism are needed. The isolation of the economy implies higher costs of investment and reduced foreign productivity spillover. Interestingly, this period shows increase in the relative wage of unskilled labor. The protected economy has less skill-bias in technology. The model projects an increasing growth rate in the post-sanctions period, driven by cheaper investment goods and technology adoption with openness. Policies to encourage investment and foreign spillover can raise the actual growth to these projections.

The analysis reveals a trade off between economic growth and income distribution. Openness stimulates growth (spillovers, less expensive capital goods and productivity-investment interaction), but worsens the income distribution because foreign technology is skill-biased. The development of relative wages depends on the sources of productivity growth. While adoption of foreign technology generates skill-biased technical change, local improvement of technology through innovation can be directed towards unskilled labor. The impact of openness on income distribution also works through demand-side effects (changes in the consumption pattern). Since the poor household consumes relatively more traditional goods, a worsening of the income distribution shifts consumption away from unskilled-intensive goods and reduces the demand for unskilled labor. The general equilibrium model puts this demand story in a broader context.

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

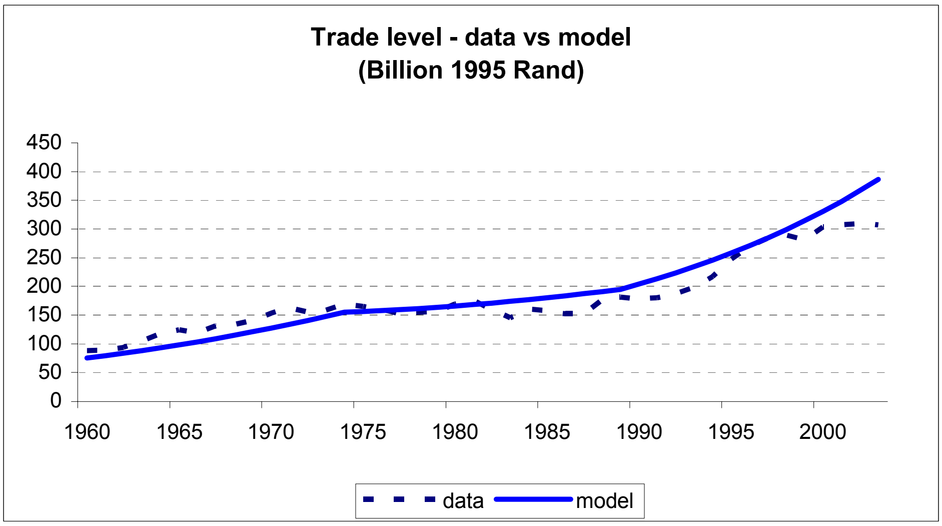

Figure 2. Real GDP growth rate: Calibrated path of model versus actual growth (measured as 5-year moving average)

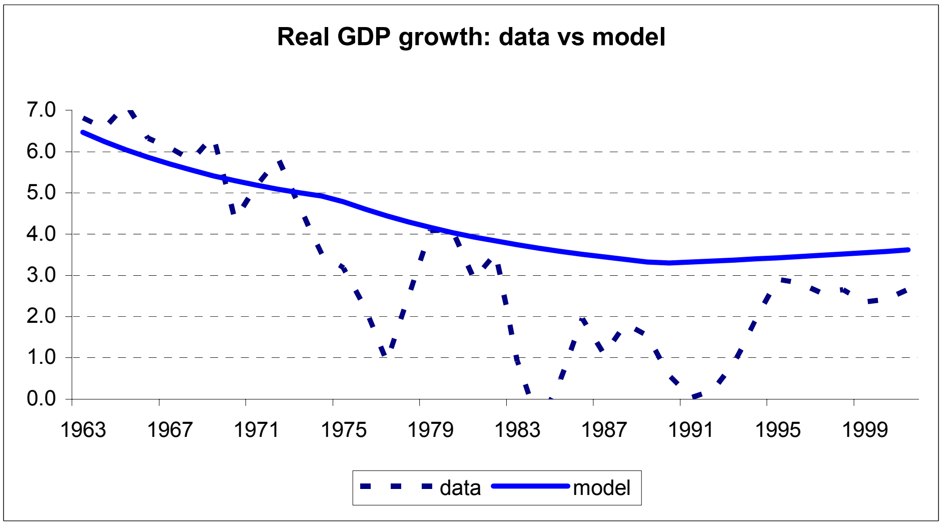

Figure 3. Growth rate of capital: calibrated path versus counterfactual path

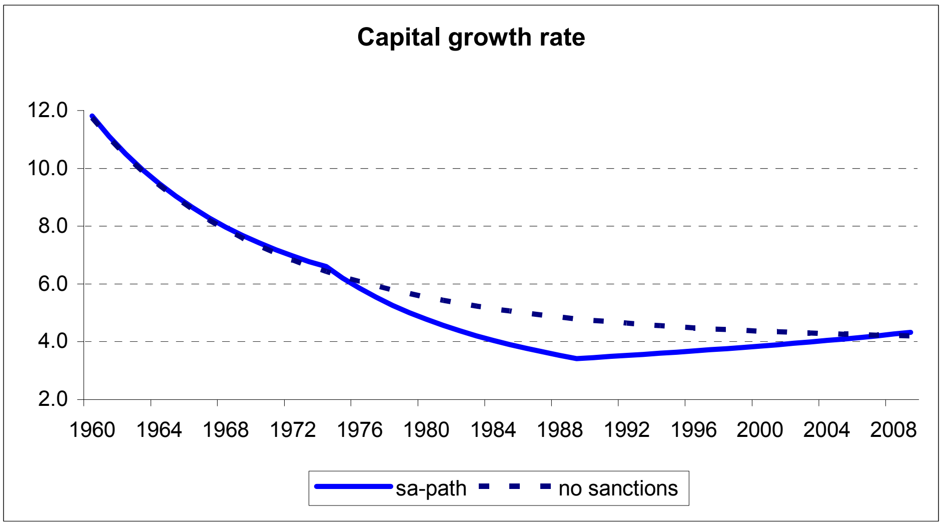

Figure 4. Sectoral labor augmenting technical progress: calibrated path versus counterfactual path

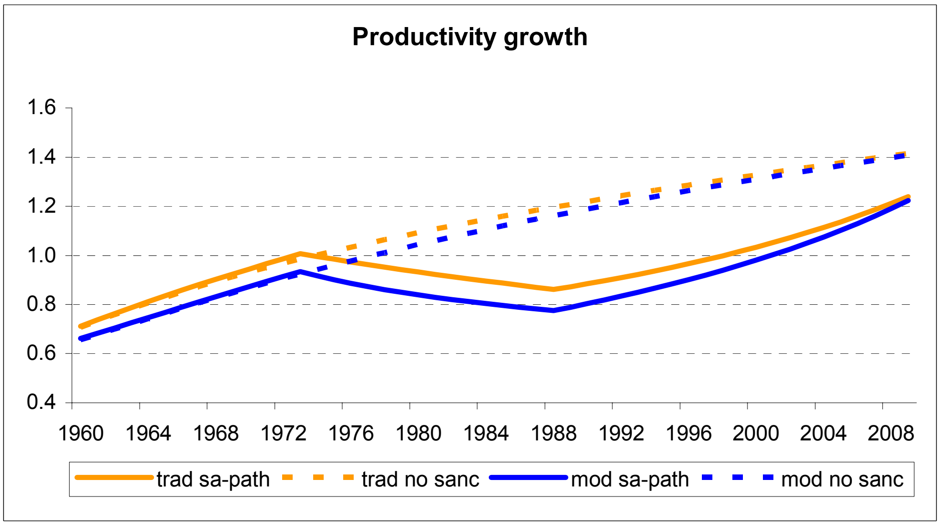

Figure 5. Unskilled wage rate relative to skilled wage rate: Calibrated path versus counterfactual path

Figure 6. Real GDP growth: Calibrated path versus counterfactual path

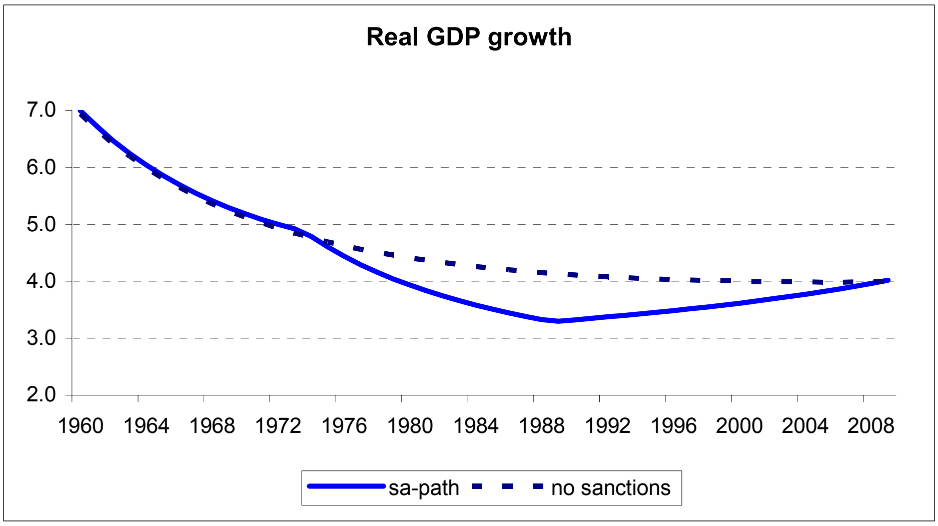

Table 1. South Africa growth experience 1961 – 2003

	1961 – 74 Pre-sanctions	**1975 – 93 Sanctions**	**1994-2003 Post-sanctions**
GDP growth rate	6.1 %	1.3 %	2.7 %
Growth in total trade	4.9 %	1.0 %	4.6 %
Growth in gross fixed capital formation	8.1 %	-0.2 %	3.9 %

Source: World Bank Development Indicators 2004

Appendix A: 1998 Social Accounting Matrix

The original SAM is developed by Thurlow and van Seventer (2002) and includes 43 sectors, 14 household types and three labor categories: unskilled, semi-skilled and skilled. We aggregate this micro-SAM into a three-sector framework with three household types. To capture the dual structure of the South African economy, we distinguish between a modern sector using semi-skilled and skilled labor intensively and a traditional unskilled-intensive sector. In addition, government services are treated as a separate sector.

Traditional sector	**Modern sector**
Agriculture, forestry and fishing	Beverages & Tobacco
Coal mining	Paper and paper products
Gold and uranium ore mining	Printing, publishing and recorded media
Other mining	Coke and refined petroleum products
Food	Basic chemicals
Textiles	Other chemicals and man-made fibers
Wearing apparel	Rubber products
Leather and leather products	Non-metallic minerals
Footwear	Basic non-ferrous metals
Wood and wood products	Machinery and equipment
Plastic products	Electrical machinery and apparatus
Glass and glass products	Television, radio and communication equipment
Basic iron and steel	Professional and scientific equipment
Metal products excluding machinery	Motor vehicles, parts and accessories
Furniture	Other transport equipment
Building construction & civil engineering	Other manufacturing
Wholesale and retail trade	Electricity, gas and steam
	Water supply
	Catering and accommodation services
	Transport and storage
	Communication
	Finance and insurance
	Business services
	Medical, dental, veterinary & other services
	Other products

Based on average relative wages for the manufacturing sector during the 1990s given by Fedderke et al. (2003), the relative wage between unskilled and skilled labor is assumed to equal 0.25, and the relative wage between semi-skilled and skilled labor is set to 0.37. With the labor income data from the SAM this means that the total labor force consists of 52% unskilled workers, 41% semi-skilled and 7% skilled workers. Both the traditional and the modern sector employ 34% of the labor force, while the remaining 32% works in government services. Appendix table 2 gives further characteristics of the three sectors.

The model includes three household types according to income level and source of income: A poor household with unskilled wage income, a rich household with semi-skilled and skilled wage income, and a capitalist household with capital income. All savings are done by the capitalist household, which also pays interest on the foreign debt. Income from sales taxes and import tariffs are transferred to the household sector lump sum. The distribution between the three household types is made according to income shares. The poor and the rich households do not save, and all income is used on consumption goods. The poor household is assumed to consume relatively more traditional goods, while the rich and the capitalist households spend a relatively higher share of its income on modern goods. This is consistent with the consumption pattern in the original SAM. The consumption share of government services is assumed to be relatively lower in the capitalist household. The income gap between the two wage-earning households (measured as the income of the poor household relative to the income of the rich household) equals 0.57. According to household wage income data in the original SAM, the poor household corresponds to more than the seven lowest income deciles (the 70 percent poorest of the population). Appendix table 3 gives further characteristics of the three households.

Except for import tariffs (which is an important parameter in the modeling of economic sanctions), we ignore transfers between the rest of the world and domestic agents. Capital and wage income going abroad are included as income to the capitalist and the rich household, respectively. We do not adjust total export and import, and the current account therefore differs from the original SAM. The adjustments give negative foreign savings (trade surplus). In intertemporal models the SAM is assumed to represent long-run balanced growth, and a trade surplus is consistent with growing foreign debt (as opposed to growing assets in the case of long-run trade deficit).

Appendix Table 1: 1998 SAM SOUTH AFRICA (3 sectors, 3 households, 3 labor categories)

(Measured in Millions of Rand)

	ACT_A	ACT_M	ACT_S	COMD_A	COMD_M	COMD_S
ACT_A				446 541		
ACT_M					683 580	
ACT_S						197 431
COMD_A	182 706	125 330	5 106			
COMD_M	164 071	294 073	26 404			
COMD_S		167	10 494			
UNSK	56 896	25 291	52 590			
SEMI-SK	37 699	77 551	42 057			
SKILLED	22 276	47 517	9 886			
CAPITAL	91 193	185 206	50 186			
POOR HH						
RICH HH						
CAP HH						
MTAX				2 234	4 408	
ATAX	2 830	7 479	708			
SAV-INV						
RoW				41 159	140 441	
TOTAL	557 671	762 614	197 431	489 934	828 429	197 431

Note: The table continues on the next page.

Appendix Table 1 continues:

	UNSK	SEMI-SK	SKILLED	CAPITAL	POOR HH	RICH HH
ACT_A						
ACT_M						
ACT_S						
COMD_A					71 829	21 628
COMD_M					13 813	130 100
COMD_S					52 490	91 262
UNSK						
SEMI-SK						
SKILLED						
CAPITAL						
POOR HH	134 777					
RICH HH		157 307	79 679			
CAP HH				326 585		
MTAX						
ATAX						
SAV-INV						
RoW						
TOTAL	134 777	157 307	79 679	326 585	138 132	242 990

Appendix Table 1 continues:

	CAP HH	MTAX	ATAX	SAV-INV	RoW	TOTAL
ACT_A					111 130	557 671
ACT_M					79 034	762 614
ACT_S						197 431
COMD_A	53 070			30 265		489 934
COMD_M	116 753			83215		828 429
COMD_S	42 450			568		197 431
UNSK						134 777
SEMI-SK						157 307
SKILLED						79 679
CAPITAL						326 585
POOR HH		1 262	2 093			138 132
RICH HH		2 258	3 746			242 990
CAP HH		3 122	5 178		-8564	326 321
MTAX						6 642
ATAX						11 017
SAV-INV	114 048					114 048
RoW						181 600
TOTAL	326 321	6 642	11 017	114 048	181 600	

Note: ACT_A = Traditional activity, ACT_M = Modern activity, ACT_S = Government service activity, COMD_A = Traditional commodity, COMD_M = Modern commodity, COMD_S = Government service commodity, UNSK = Unskilled labor, SEMI-SK = Semi-skilled labor, SKILLED = Skilled labor, POOR HH = Poor household, RICH HH = Rich household, CAP HH = Capitalist household, MTAX = Import tariffs, ATAX = Sales taxes, SAV-INV = Savings/Investments, RoW = Rest of world.

Appendix Table 2: Sector characteristics (based on the SAM in Appendix Table 1)

	Traditional	Modern	Govm. service
Value added share	0.30	0.48	0.22
Within sector distribution of labor:			
Unskilled	0.65	0.28	0.63
Semi-skilled	0.29	0.59	0.34
Skilled	0.06	0.13	0.03
Between sectors distribution of labor:			
Unskilled	0.42	0.19	0.39
Semi-skilled	0.24	0.49	0.27
Skilled	0.28	0.60	0.12
Total	0.34	0.34	0.32
Capital/Total capital	0.28	0.57	0.15
Export/Output	0.20	0.10	0.00
Export/Total export	0.58	0.42	0.00
Import/Supply	0.08	0.17	0.00
Import/Total import	0.23	0.77	0.00

Note: Within sector labor shares are calculated based on the assumption that the relative wage between skilled and unskilled equals 0.25 and the relative wage between skilled and semi-skilled equals 0.37.

Appendix Table 3: Consumption pattern (based on the SAM in Appendix Table 1)

	Poor household	Rich household	Capitalist household
Share traditional good	0.52	0.08	0.25
Share modern good	0.10	0.54	0.55
Share govm services	0.38	0.38	0.20
Income share	0.20	0.34	0.46
Income share (without capitalist household)	0.36	0.64	

Appendix B: Calibration

The parameters in the production, demand, and trade functions are set according to the method adopted in most static computable general equilibrium models and are based on the 1998 social accounting matrix (SAM) documented in Appendix A. The long run growth path calibrated as supply side response to sectoral investment and productivity adjustments must be made consistent with the macroeconomic equilibrium as represented by the Euler equation ($r = (1+\rho)(1+g+n)-1$). Given a time preference rate of 9.2 percent and long-run growth rate of 3 percent, the long run domestic interest rate is equal to 12.5 percent. Then, with the long run assumptions, most parameters of the intertemporal part of the model can be calibrated from the SAM. Given marginal product of capital, the initial capital stock is calculated based on capital income. Investment is calibrated from the long-run constraint on capital accumulation, for given values of depreciation rate and long run growth rate. The shadow price of capital equals the firm value relative to the capital stock, and follows when we know the interest rate. The coefficient *a* in the capital adjustment cost function is determined by the no-arbitrage long run condition. The initial level of foreign debt is set by the long-run constraint on debt accumulation, given data about trade deficit/surplus together with the long-run growth rate and interest rate. To have 'fishing out' productivity dynamics φ is assumed to be negative and is set to –0.1 in both sectors. The θ values allocate the effects of the two sources of productivity growth, and θ_1 is set to 0.8 in the modern sector and 0.3 in the traditional sector, while θ_2 is calculated consistent with the balanced growth restriction ($\theta_1 + \theta_2 = 1 - \varphi$). Based on the long run technological progress rate, initial values of the adoption and innovation variables, and the initial level of productivity, the parameter λ follows as a residual. To have balanced growth the skill-bias variable (β) is set equal to 0 in the calibration. The elasticity reflecting the effect of increased openness on the domestic interest rate is set to 0.2, while the constant parameter in the interest rate function is calibrated to give equality between domestic and world market interest rate for the base-year level of the trade share. The elasticity of substitution in both the Armington and CET functions are assumed to be 2, in accordance 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). The elasticity of substitution between different labor categories is important for the adjustment of relative wages, and is set equal to 2, which implies that unskilled, semi-skilled and skilled labor are substitutes. Overview of the calibrated parameters and initial values of the intertemporal variables are shown in Appendix table 4 below.

Appendix Table 4: Values of selected parameters and initial values of endogenous variables

Definition	Symbol in the model	Value
Parameters		
Share of capital in value added for traditional sector	α_A	0.44
Share of capital in value added for modern sector	α_M	0.55
Share of capital in value added for government services	α_S	0.32
Elasticity of substitution between different labor types	σ	2
Distribution parameter in CES labor function, traditional sector	$\gamma_{1,A}$	0.31
Distribution parameter in CES labor function, modern sector	$\gamma_{1,M}$	0.17
Distribution parameter in CES labor function, services	$\gamma_{1,S}$	0.34
Distribution parameter in CES labor function, traditional sector	$\gamma_{2,A}$	0.31
Distribution parameter in CES labor function, modern sector	$\gamma_{2,M}$	0.36
Distribution parameter in CES labor function, services	$\gamma_{2,S}$	0.37
Parameter in technological bias function	b	0.05
Elasticity of adoption in traditional technical progress function	$\theta_{1,A}$	0.3
Elasticity of innovation in traditional technical progress function	$\theta_{2,A}$	0.8
Fishing out parameter in traditional technical progress function	φ_A	-0.1
Elasticity of adoption in modern technical progress function	$\theta_{1,M}$	0.8
Elasticity of innovation in modern technical progress function	$\theta_{2,M}$	0.3
Fishing out parameter in modern technical progress function	φ_M	-0.1
Parameter in technical progress function, traditional sector	λ_A	0.23
Parameter in technical progress function, modern sector	λ_M	0.10
Distribution parameter CET function traditional sector	mc_A	0.67
Distribution parameter CET function modern sector	mc_M	0.75
Distribution parameter Armington function traditional sector	ma_A	0.24
Distribution parameter Armington function modern sector	ma_M	0.32
Elasticity in Armington function	σ_{m}	2
Elasticity in CET function	σ_{e}	2
Coefficient in adjustment cost function	a	4.17
Time preference rate	ρ	0.092
Depreciation rate	δ	0.035
Elasticity in interest rate function	ε	0.2
Parameter in interest rate function	d	1.3
Endogenous variables		
Marginal returns to capital	$Rk + a \cdot P_M \left(I/K \right)^2$	0.20
Marginal product of capital	Rk	0.18
Derivative of adjustment cost w.r.t capital	$-a \cdot P_M \left(I/K \right)^2$	-0.02
Shadow price of capital	q	1.24
Adjustment cost per unit of investment	$a \cdot P_M \, I/K$	0.27
Unskilled wage rate	Wu	0.25
Semi-skilled wage rate	Wse	0.37
Skilled wage rate	Ws	1