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# **The Macroeconomic Impact of Skilled Emigration from South Africa: A CGE Analysis**

Heinrich R Bohlman<sup>1</sup>

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<sup>1</sup> Centre of Policy Studies, Monash University

# The Macroeconomic Impact of Skilled Emigration from South Africa: A CGE Analysis

Heinrich Bohlmann\*

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## Abstract

South Africa faces the dual problem of large inflows of illegal immigrants and outflows of skilled emigrants. This situation potentially has serious implications for the domestic labour market and economy as a whole. In this paper we measure the impact of skilled emigration and the subsequent loss in primary factor productivity on the South African economy using a dynamic computable general equilibrium (CGE) model. Results indicate that skilled emigration in the absence of any programmes to counter this flow of workers has a generally negative effect on the economy. Industries with the greatest exposure to the investment and export sectors as well as those with the highest concentration of skilled workers are shown to be most affected. We also use simple and intuitive back-of-the-envelope equations to enhance our understanding of the mechanisms driving the model's macroeconomic results. These results justify the government's current efforts to retain and attract skilled labour as part of the ASGISA framework.

## 1 Introduction

The political and social discussion concerning international migration has been one of the most contentious issues in recent times. More people live outside their country of birth today than at any other time in history (United Nations, 2006; 2009). Both the positive and negative effects of this unabated movement of people have forced virtually every country in the world to carefully reconsider its migration policies.

South Africa is no different in this regard. Policymakers continually face the dual problem of how to best limit the inflow of illegal (and therefore mostly unskilled) immigrants, as well as the outflow of skilled emigrants. Given the nature of the South African economy it can hardly afford either scenario, let alone both. Despite being the largest economy on the African continent, many socio-economic problems still plague the country. Overall unemployment is above 30 per cent resulting in widespread poverty and inequality (StatsSA, 2009b). Sustainable economic growth and development is essential if South Africa is to overcome these problems, and the importance of human capital in this regard is unequivocal. However, the loss of skilled labour to popular emigration destinations such as the United Kingdom and Australia, the so-called 'brain drain', is thought to slow these growth efforts considerably. In addition, the inflow of illegal, and mainly unskilled, immigrants from Sub-Saharan Africa (SSA) increases the supply of labour in this segment of the market, further reducing the probability of unemployed South Africans finding a job.

The South African government's stance with regard to its population policies highlights the issue at hand. Whilst its view is that both immigration and emigration is too high in general, its policy stance with regard to the immigration of highly skilled workers is to raise the number of such immigrants. However, this was not always the case. In 1996 the same government held a satisfactory view

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\*Centre of Policy Studies, Monash University: Email: heinrich.bohlmann@buseco.monash.edu.au

of both immigration and emigration, and only recently changed its policy position with regard to skilled immigrants from ‘maintain’ to ‘raise’ (United Nations, 2007). The flow of illegal immigrants is linked indirectly to the policy stance on immigration, as unsuccessful but desperate applicants find alternative means of entering the country. This was particularly evident during the recent economic and political crises in Zimbabwe. With regard to skilled emigration, recent data availability is severely limited. Between 1990 and 2003, there were approximately 126,000 self-declared emigrants from South Africa, of which close to 86,000 emigrated between 1996 and 2003. The vast majority of these migrants were South African citizens who emigrated to developed countries, with the most popular destinations being Europe and Australasia (StatsSA, 2009b). However, in a recent population estimate, Statistics South Africa assumes a total outmigration of 500,000 whites between 1996 and 2008 (StatsSA, 2009a). This suggests that the official number of self-declared emigrants was thought to be considerably less than the actual numbers shown up to 2003 and that the rate of emigration may well be increasing. Given the nature of international migration, we can safely assume that most of these emigrants were at least semi-skilled or had considerable experience in their line of work.

This paper, whilst forming part of a much larger study on migration in South Africa, investigates only the macroeconomic impact of a jump in skilled emigration on the local economy. A new 2006 database is implemented on a dynamic computable general equilibrium (CGE) model of South Africa and solved using GEMPACK. Results from the different simulation scenarios are then reported and interpreted as percentage changes away from the baseline forecast of the model.

## 2 Literature

### 2.1 *Theories of international migration*

Before investigating some empirical findings, a brief review of some of the most prominent theories of international migration is in order. Neoclassical theory has long been the most common theory used in explaining the international migration phenomenon. Differences in wage levels, in particular the expected earnings gap, and employment conditions between regions serve as the primary motivation for migration in this model (Todaro, 1976). A further proposition is that governments will require regulation and influencing of labour markets in order to control migration flows (Massey *et al.*, 1993). On a microeconomic level, the theory postulates that rational actors would migrate if their individual cost-benefit calculations yield positive net returns. Borjas (1990; 1994) states that migration will occur to where the expected discounted net returns are greatest over a given period of time. Gelderblom (2006) also points out that in most microeconomic applications, labour is considered mobile and, hence, should be able to allocate itself to where rewards are highest. In this scheme, international migration is viewed as a form of investment in human capital (Massey *et al.*, 1993).

Other theories of migration include the ‘new economics of migration theory’ and the ‘dual labour market theory’ (Massey *et al.*, 1993). In the former, migration decisions are assumed to be made by units of related people such as families or households who minimise risk, instead of individual actors attempting to maximise income. The latter argues that migration is driven by the intrinsic labour demands of modern industrial societies. International migration is therefore a direct result of this continued demand for cheap and abundant immigrant labour.

A number of theories have also been developed to explain the perpetuation of international migration. As Massey *et al.* (1993) suggest, the conditions that initiate migration may be quite different from those that allow it to continue. Factors that facilitate the movement of people have also played an important role. The decision to migrate, especially in the case of labour migrants, has been made considerably easier by improvements in transport and communication (United Nations, 2004). Indeed, these advances have created a modern category of global worker, often assigned to different projects across the globe for extended periods of time.

When surveying these theories of how migration begins and why it continues, it becomes evident that the different explanations are not necessarily contradictory. All factors motivating people to leave their country of birth can be linked to their effort of improving their own and their family's well being (United Nations, 2004). Giving up the comfort and familiarity of your home country usually requires substantial differences in compensation or living conditions. Complementary to this is the inherent demand for labour by multi-national corporations, which may include both skilled and unskilled labour.

Unfortunately, the need for basic survival has also been responsible for large migration flows in many parts of the world. Many refugees and asylum seekers, who are displaced during periods of war, political instability, or famine, never return to their home country, or only do so after an extended period of time (United Nations, 2004). Countries in close geographical proximity, or with friendly policies towards refugees, are therefore more likely to attract more such migrants.

## 2.2 *Empirical results of migration studies*

Most empirical studies of international migration use econometric models to estimate the impact of immigrants on the economy. Issues such as the assimilation, selection and earnings of immigrants, changes in cohort quality, and the general impact on the labour market have been analysed extensively by economists since the 1960s. Borjas (1999) however admits that in order to measure the full impact of migration on the economy, a model detailing how the various sectors of the economy operate and are linked together is required. Economy-wide computable general equilibrium (CGE) models fulfil these requirements.

The use of CGE models in analysing migration policy, especially regarding emigration, has been surprisingly rare. CGE models are generally well-suited to analysing a wide range of economic policy questions. One of the most comprehensive studies using a CGE model was by Dixon *et al* (2008) who investigated the impact of a reduction of illegal immigrants on the U.S. economy. Although our paper looks only at skilled emigration, the conclusions from Dixon *et al* (2008) should still be considered as part of the overall migration debate presented here.

The method in which policy proposals were implemented in the Dixon *et al* (2008) paper delivers arguably the most insightful set of results on illegal immigration to date. The USAGE-M model used in the study is a detailed and dynamic CGE model of the United States with a theoretical structure similar to that of the MONASH model of Australia (Dixon & Rimmer, 2002). Using various labour market extensions, they analyse the impact of two types of programmes to lower the number of illegal migrants employed in the United States over the period 2005 – 2019. The first represents policies restricting labour supply by increasing the costs of illegal immigration to the U.S. through, for example, increased border security, deportation, and improved conditions in sending countries. This is modelled as a shift in immigrant preferences towards staying in their home country, or alternatively, away from migrating to the United States. The second programme reduces labour demand for illegal migrants through policies designed to increase the cost of employing such labour. This is achieved by imposing taxes and fines on employers of illegal migrants. Under both scenarios, gross domestic product is expected to decrease by around 1.6 per cent.

It follows from the Dixon *et al* paper that policymakers' preference towards supply or demand restrictions in reducing illegal immigrants should be determined by the impact on consumer welfare. Simulation results show that supply restrictions such as tighter border control and policing will impose much greater welfare losses on legal residents compared to demand restrictions such as fines or taxes. The study recognises that any limiting policy will increase costs to the employers of those foreign illegals who remain in the country. However, the policies differ significantly with respect to the nature of these additional costs. In the case of supply restricting policies, the extra costs are generated by an increase in the wage rates of remaining illegal migrants, with no benefit to the legal residents. In the case of criminal prosecutions, the extra costs can be linked to the use of lawyers, administrators, and other professionals involved in these actions. By comparison, the taxes and fines

generated through demand oriented policies are a transfer to the U.S. Treasury which can be used to benefit legal citizens through increased public spending or tax breaks.

Dixon *et al* highlight the advantages of using a detailed CGE model in such simulations. In addition to being able to quantify readily anticipatable effects, the CGE approach allows identification of effects that were initially unexpected, yet once identified, quite significant and explainable. The occupational-mix effect which shows how a reduction of foreign illegal employment reduces welfare by lowering the average skill level of local employment is perhaps the most insightful of these. The argument here is that a reduction of illegal workers who usually fill lesser-skilled jobs would now create relatively more job opportunities in this segment of the market. New entrants and those returning to the job market would then have more of their offers directed to and accepted in these occupations at the lower end of the market. Over time, this would lead to reduction in the average skill level of native workers as they become entrenched in lower-paying unskilled jobs previously done by foreign illegals.

### **2.3 *The South African context***

The results in Dixon *et al* (2008) naturally depend on the structure of the US labour market. The ability of workers to re-align their skills and job preferences is crucial in this model. The case of South Africa is rather different given the characteristics of its labour market. High levels of structural unemployment, no doubt a legacy of South Africa's apartheid past, have led to widespread poverty and inequality. The ability of these unemployed to align their skills with the requirements of a modern economy is therefore likely to be diminished. The same holds true for new entrants to the labour market who may have faced social and economic constraints in their education. The large stock of unemployed natives in the lower-skilled segment of the market, in addition to their reduced ability to offer to higher-skilled jobs should more vacancies arise there, must therefore be considered when comparing the results from Dixon *et al* (2008) to a similar study of South Africa. Accordingly, unlike the results in Dixon *et al* (2008) which suggest that illegal immigrants may benefit the US economy to some extent, this scenario would most likely not hold for South Africa.

To fully understand the problem within a South African context requires a closer look at some of the literature specific to the region. In an attempt to rid the economy of a number of binding constraints, a new macroeconomic framework for South Africa was introduced in 2005. The Accelerated and Shared Growth Initiative for South Africa (ASGISA) formally recognised constraints such as a shortage of skilled labour and suitable infrastructure, and proposed several interventions to help solve these problems (Presidency, 2006). The origins of the current skills shortage goes back many decades. In addition to the regime change that occurred in 1994, the South African economy has also undergone major structural change since 1970 with, for example, the primary sector shedding more than 1 million jobs (Bhorat, 2000). Skills-biased technological change in particular has been identified as having major implications on employment (Kraak, 2008).

Increased growth and investment since 2000, facilitated by a more open economy, was much more capital-intensive than, for example, the high growth experienced during the 1960s. In addition, the sluggish economy preceding 2000 led to a decline in the demand and subsequent training of certain professions. Kraak (2008) states that this new growth path has required a different set of skills than before, and has created a misalignment of education and training output with economic needs. This left the economy with inappropriate skills, creating a bottleneck effect and serious skills shortages in various occupation groups. Combined with the already severe impact of apartheid, the inability of many workers to adapt their skills to the requirements of the modern economy has left them structurally unemployed. This has prompted the need for a multi-dimensional approach to the problem, requiring both closed- and open-economy solutions to the skills shortage (Daniels, 2007; Du Toit *et al*, 2007).

Unfortunately, discrepancies in the definition of scarce skills between the Department of Labour (DoL), and the Department of Home Affairs (DoHA) have led to disputes over the precise numbers

and areas of occupational skill shortages (Daniels, 2007). New legislation previously forward by the DoHA was actually considered more restrictive than before with regard to the importing of skills, and therefore, as Daniels points out, counterproductive to its stated objective. Clearly, there is a need to better coordinate these types of legislation, and although the current administration has started to address these problems, much work remains to be done.

Closed-economy solutions focus heavily on Sectoral Education and Training Authorities (SETAs), which are mandated to provide skills training primarily to the unemployed, but have not produced the desired results as of yet (Daniels, 2007). Coordination problems such as the link between providing suitable skills training and accrediting individuals with a qualification, have also been identified. As implied by the literature, any closed-economy solution should not only be concerned with training new workers or re-training old workers, but also with where these workers apply their skills once qualified (Lucas, 1988; Massey *et al*, 1993; Page & Plaza, 2006; Daniels, 2007).

### 3 Methodology

The model used in this application is a recursive-dynamic CGE model of the South African economy, based on the ORANIG-RD model developed by Horridge (2000; 2002). An extension of the comparative-static ORANI model (Dixon *et al*, 1982), the RD version adds dynamic elements arising from various stock/flow accumulation relations. This includes equations describing capital accumulation, investment allocation, and real wage adjustments over time. This model, as well as more advanced versions such as MONASH, is solved using the GEMPACK software package (Harrison & Pearson, 1994).

The main purpose of the ORANIG-RD model is to provide projections of the effects of various economic policy changes on a wide variety of economic variables. To accomplish this, a baseline scenario incorporating available forecast data is first simulated. A perturbed scenario incorporating the policy shocks is then run and compared to the outcome of the base run, with deviations reported in percentage change. ORANIG-RD recognises that the simulation results of any policy change depend on the macroeconomic environment in which it takes place. This is reflected by the model closure used in the particular simulation, which users must specify according to the environment for which their projections apply.

Models such as ORANIG-RD belong to the Walras-Johansen class of multisectoral models with the added advantage of having incorporated several extensions to the usual framework. Johansen-type models postulate neo-classical production functions and price-responsive demand functions, linked around an input-output matrix in a general equilibrium model that endogenously determines quantities and prices.

A Johansen-style model is therefore essentially non-linear. For a detailed model the number of equations ( $m$ ) and variables ( $n$ ) can be very large. To avoid the computational problems involved in solving a large non-linear system, Johansen (1960) approximated his model by a system of linear equations in changes or percentage changes of the variables. This linear system was then solved by matrix manipulations, giving the approximate effects on the ( $m$ ) endogenous variables of changes in the ( $n - m$ ) exogenous variables. In GEMPACK, the linearisation error that arises through this method is eliminated through use of the Euler method with Richardson extrapolation. This technique essentially breaks up the imposed shock into a number of smaller changes, or multiple steps, thereby significantly improving the accuracy of simulation results involving large changes. More in-depth detail concerning the CGE methodology and ORANI-style models can be found in Dixon *et al* (1982), Horridge (2000; 2002) and Dixon & Rimmer (2002).

The accompanying database to the model used in this application represents the South African economy for the base year 2006 and was developed using both the 2002 and 2006 supply-use tables (StatsSA, 2006; 2008), 2006 national accounts data (SARB, 2007) and 2006 labour force survey results (StatsSA, 2007). Accordingly, it features 27 industries and commodities, and 11 different

occupations groups. The database was set up according to the structure of the absorption matrix shown in Horridge (2000, p.9). Initial capital stock data for industries in the model was calibrated to reflect gross rates of return of between 10 and 14 per cent. Substitution elasticity and other parameter values in the model were taken from the UPGEM model (Van Heerden *et al*, 2006) where no more recent data were available. Additional sources used in the development of the database were United Nations (1999) and Roos (2010).

## 4 Simulations

The simulation attempting to show the impact of skilled emigration can effectively be broken into two parts. The first part captures the direct impact of skilled workers leaving the domestic workforce, simulated as a reduction in the employment of these category workers. The second part captures the indirect effects through a reduction in primary factor productivity, which is consistent with a situation of skill shortages in a country. This strategy enables a clearer understanding of each component and subsequently the overall impact as well. For the purpose of this paper, the two simulations are run over an eight year period from 2007 to 2014. The third simulation reported on combines the two above scenarios.

The shocks performed on the current model can be summarised as follows:

1. Simulation 1 reduces employment in the two skilled labour categories, ‘legislators, senior officials, and managers’ and ‘professionals’ by 3 per cent in 2007, 2 per cent in 2008, and 1 per cent in 2009. This reflects the emigration of skilled labour as a result of a negative shock to their preferences for working in South Africa, and the inability of the labour market to find suitable replacements in the short-run. The size of these shocks is relatively large when compared with the average outmigration witnessed over the past two decades, but aim to simulate a more severe shift in skilled-labour preferences than before. We also assume that these emigrants do not send remittances.
2. Simulation 2 reduces primary factor productivity (which affects both labour and capital inputs proportionally) by 1 per cent in 2007 and 2008. This reflects the impact of the skills shortage created in simulation 1 on the economy’s productivity.
3. Simulation 3 combines the two above simulations to reflect the overall impact of skilled emigration.

As noted before, the model closure is designed to best describe the economic environment under which the simulation is run. The base run imposes shocks on the main macroeconomic variables for which reliable forecasts exist. These variables must therefore be set as exogenous in the base closure. In the policy closure most of these macro variables are made endogenous, as we are interested in evaluating the impact of the shock in question on these variables.

In our base-run simulation, the consumer price index is set as the numeraire. The exogenous setting of the CPI allows us to incorporate available inflation forecasts into our baseline scenario. For the policy closure, the CPI is made endogenous with the nominal exchange rate set as the numeraire. Because of the nature of the simulation shocks in the policy closure, employment by occupation type must be set as exogenous during the first three periods. For the remaining periods labour is allowed to move between occupation groups, but is fixed in total, i.e. total employment does not deviate from its baseline forecast. Labour’s ability to respond and move between these occupation groups is controlled by elasticities set in the model database. Real wages are endogenous which effectively allows us to interpret the shocks in simulation 1 as an inward shift in the supply of skilled labour.

Sectoral capital is allowed to move endogenously in the long run. In this model, changes in investment determine changes in capital, with investment being driven by expected rates of return. For the first period, change in capital stock is predetermined from the model’s database values

for initial capital stock, investment, and depreciation. For the policy run, this lagged relationship between capital, investment, and expected rates of return effectively fixes capital to its baseline projection in the first period. This is consistent with the idea that any policy change in the economy would not affect capital in the short run. Other assumptions include fixed or exogenous import prices, and export prices moving together with the price of domestically produced goods.

## 5 Results and Interpretation

The main macroeconomic results of the three simulations described in the previous section are shown in the following tables. All results are reported in percentage change as cumulative deviations from the baseline scenario.

The first-round impacts of both simulations are diagrammatically shown using a simple production function in Figure 1. We shall first examine the results for simulation 1. The immediate impact of the reduction in labour, with capital held fixed in the short run and technical progress set as exogenous, is to reduce the level of output. The reduction of labour employed increases the marginal product of labour, and therefore the average real wage.

The following two back-of-the-envelope equations capture the most important mechanisms driving the supply side of the model in a simple and intuitive manner.<sup>1</sup>

$$\frac{W}{P_y} = MP_L \left( A, \frac{K}{L} \right)$$

or alternatively

$$\frac{W}{P_c} \cdot \frac{P_c}{P_y} = MP_L \left( A, \frac{K}{L} \right) \quad (1)$$

$$\frac{Q}{P_y} = MP_K \left( A, \frac{L}{K} \right)$$

or alternatively

$$\frac{Q}{P_i} \cdot \frac{P_i}{P_y} = MP_K \left( A, \frac{L}{K} \right) \quad (2)$$

where  $W$  and  $Q$  are factor payments, the nominal wage rate and rental rate of capital;  $P_c$  and  $P_i$  the purchasers' prices of a unit of consumption and a unit of investment;  $P_y$  the economy-wide price level reflected by the GDP price index;  $A$  the level of technical progress or productivity; and  $MP_L$  and  $MP_K$  the marginal products of labour and capital, respectively.

The first part of Equation (1) shows that the real cost of labour should be equal to the marginal product of labour, which is positively related to the capital-labour ratio and level of productivity. To enhance our analysis, we then split the real cost of labour into two components or effects. The first is the real consumer wage  $\left(\frac{W}{P_c}\right)$  and the second is the terms of trade effect  $\left(\frac{P_c}{P_y}\right)$ . Thus, any changes to the real cost of labour as a result of changes to its marginal product could be explained by a combination of these two effects. We do the same for capital in Equation (2) by linking changes in the marginal product of capital, which is positively related to the labour-capital ratio, to a combination of the rate of return on capital investment  $\left(\frac{Q}{P_i}\right)$  and the terms of trade effect  $\left(\frac{P_i}{P_y}\right)$ . From Equation

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<sup>1</sup>These two BOTE equations are easily derived by maximising economy-wide profits,  $P_y \cdot Y - (W \cdot L + Q \cdot K)$ , subject to a Cobb-Douglas production function where  $Y = A[L^\beta \cdot K^{(1-\beta)}]$



(1) we can again see that a reduction in  $L$ , with  $K$  and  $A$  held constant in the short-run, would increase the  $MP_L$  and therefore the average real wage.

In the long run, the level of employment and rate of return on capital investments are implicitly fixed or exogenous, that is, they will remain unchanged from their baseline projection. From Equation (2) we can see that with the reduction in  $L$ , this would require a similar reduction in  $K$  to keep the rate of return constant in the long run. In the first period however,  $K$  is fixed and cannot start to fall to its desired level immediately. This results in a relatively large fall in the rental price of capital, and therefore the rate of return, as well as expected rate of return on capital investments. Since investment decisions are based on expected rates of return in the model, this explains the rather large drop in investment witnessed initially. It can also be shown that in order for  $K$  to fall to its desired level, a substantially larger fall in investment expenditure is required.

Simple back-of-the-envelope equations and identities are often the most straightforward method of understanding model results. Using the factor and expenditure shares in GDP, we can closely approximate the results of the simulation using basic arithmetic. Skilled labour is shown to make up about 26 per cent of the wage bill in the initial database.<sup>2</sup> For the first period, 2007, a 3 per cent reduction in skilled labour would therefore reduce total employment by about 0.8 per cent. Given that labour factor payments contribute around 50 per cent of GDP from the supply side, and capital and land are fixed in the short-run, we would expect a fall of around 0.4 per cent in GDP. This is confirmed by the model results shown for 2007 in simulation 1.

The demand or expenditure side of the economy can be explained in similar fashion. Starting from the standard GDP accounting identity and ignoring the contribution of inventories, we can write

$$Y = C + I + G + (X - M) \quad \dots \quad (3)$$

from where writing equation (E3) in percentage-change form would yield

$$y = S_c.c + S_i.i + S_g.g + S_x.x - S_m.m \quad \dots \quad (4)$$

which we could alternatively write as

$$y = S_c.c + S_i.i + S_g.g + S_x(x - m) \quad \dots \quad (5)$$

where  $y$ ,  $c$ ,  $i$ ,  $g$ ,  $x$  and  $m$  are the percentage change in their respective macroeconomic aggregates, and  $S$  their respective shares in GDP (assuming that  $S_x \approx S_m$ ).

From our supply-side calculations, we showed that GDP should decrease by around 0.4 per cent in 2007. We know that household consumption expenditure ( $C$ ) is closely linked to GDP, and that government expenditure ( $G$ ) follows  $C$  in the model. Also, imports ( $M$ ) are closely linked to GNE. Therefore, the fall GDP leads us to comfortably predict declines in  $C$ ,  $G$  and  $M$ . With the shock to  $L$  described before, we also expect  $K$  to fall in the long-run, which would necessitate a relatively large fall in investment ( $I$ ). The movement in exports ( $X$ ) can now be treated as a residual. Because we are reasonably sure about the size of the changes to  $C$ ,  $G$  and  $M$  given their ties to GDP, it follows that the size of the movement in  $I$  will largely determine the change in  $X$ . The contribution of investments to the identity shown in (E4) depends on the share of investment in the database ( $S_i$ ) and the actual size of the percentage change in investment ( $i$ ), which in turn is influenced by the sensitivity of investment to changes in the rate of return. We can therefore not be sure in which direction  $X$  will move without looking at the actual model database and parameters influencing investment.

Looking at the actual simulation results for 2007 confirms many of our predictions. The fall in consumption expenditure ( $C$ ) of 0.16 per cent can at first be considered lower than expected, given the fall in GDP of 0.39 per cent. This result is due mainly to the terms of trade effect, which is closely linked to investment in this simulation. With the share of investment in GDP ( $S_i$ ) below 20

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<sup>2</sup>Aggregate employment figures are wage-bill weighted in the model.

per cent and a fairly modest parameter value describing its sensitivity towards changes in rates of return, it turns out that the overall contribution of  $I$  to the change in GDP was not large enough to necessitate an increase in the balance of trade. Using the database shares and model results for  $C$ ,  $I$ , and  $G$  we can update equation (E5) as follows

$$(-0.39) = (-0.25) + S_x(x - m) \quad \dots \quad (6)$$

From here we can easily see that the fall in exports would have to be larger than the fall in imports for the balance of trade to be negative and equation (E6) to hold. It follows from this result that the large fall in export quantities required must be accompanied by an increase to export prices given a downward-sloping export demand curve. This would in turn lead to an increase in the terms of trade, that is, the ratio of export prices to import prices. This is confirmed by the model results shown for 2007 in simulation 1.

In the policy closure of the model, the average propensity to consume (APC) is held constant, or set exogenously. We can write this as

$$\frac{P_c \cdot C}{P_y \cdot Y} = APC \quad (7)$$

or alternatively

$$\frac{C}{Y} = APC \cdot \frac{P_y}{P_c}$$

where  $P_c$  is the consumer price index and  $P_y$  the GDP deflator (which includes export prices).

With  $Y$  falling, APC held fixed, and the terms of trade improving as described before (represented by the term  $\frac{P_y}{P_c}$ ), we can see from equation (7) that the fall in  $C$  would have to be less than the fall in  $Y$ .

In the model, government expenditure is set to follow household consumption expenditure. This is based on the simple assumption that households will alter their demand for government services in line with all other goods as their income rise or fall. We have already established that investment would need to decline rather substantially in order to allow capital stocks to fall to their desired long-run level. As can be seen, investment falls by 0.66 per cent in 2007, and more than 1.2 per cent in total up to 2009.

Using this simple combination of BOTE equations and identities helps us to understand the macroeconomic results produced by the model. Results for later years can be interpreted using the same logic applied here for 2007.

In simulation 2, the economy's production function shifts downward as productivity declines in the first two periods, thereby reducing GDP growth. Because employment is held constant relative to its baseline projection, and capital is fixed in the short run, both the real wage and rental price of capital is forced to decline in the short run as their marginal products decline. Equation (1) and (2) again help us to better understand and anticipate these results. The 1.97 per cent reduction in GDP by 2008 clearly reflects this decline in primary factor productivity. The adjustment to a smaller economy with declining rates of return is reflected in domestic absorption, with household consumption, investment and government expenditure declining. The balance of trade again can be treated as a residual with exports required to fall more than the drop in imports. Export prices, and indeed the GDP price index, rises with the economy's supply curve shifting to the left and downward sloping demand curves.

The combined scenario shows the overall effect of skilled emigration on the South African economy. Over an eight-year period it is shown that GDP would be 3.06 per cent less than under the baseline scenario. Once the shock to employment is incorporated in the first couple of years, it steadies at 1.58 per cent below the base scenario. After the initial increase in real wages due to the sudden reduction in labour, real wages start to drop as the impact of lower productivity is felt.

The increase in the terms of trade is important to understanding results on both a macro and micro level.

Although not discussed in this paper, micro or industry-specific results often yield the most interesting results. Understanding industry results requires an intimate knowledge of the initial model database. The movement in the macroeconomic variable linked closest to the destination of an industry's sales is of critical importance. The capital-labour ratio of industries and share of skilled labour employed should also be considered. In this particular simulation, the mining and tourism sectors are typical losers because of their link to the severely declining export sector. The decline in the investment sector hurts the construction sector most. The textile and footwear industry is hurt both by the decline in household consumption and export demand. Some industries that employ a large share of now relatively more expensive skilled labour such as financial and business services are also typical losers.

Proper interpretation of the results – drawing only on values in the database, the underlying theory and model closure, or results explained earlier – helps to validate the model and give credibility to the results. It would be near impossible to analyse and think about all the different economic impacts without the help of a CGE model. In general, these results show that skilled emigration has a predominantly negative effect on a macroeconomic level.

## 6 Conclusion

This paper simulates the impact of an increase in skilled labour emigration on the South African economy. It also serves as an illustrative example to test a new 2006 database implemented on a dynamic computable general equilibrium (CGE) model of South Africa. In the current model it is shown that real GDP would be around 3 per cent lower over an eight year period as a result of skilled emigration. The resulting loss in competitiveness severely curtails export oriented industries, with declining rates of return hurting the investment sector. With a relatively smaller population compared to the baseline scenario, GDP per capita does not decline as much, but households are still left worse off.

Skilled emigration, especially where permanent, is therefore shown to reduce economic growth and welfare over the long term. Such emigration represents a loss of investment in human capital, which most developing countries such as South Africa can ill afford. Conversely, temporary migration of workers to further enhance their skills and experience could potentially benefit both parties a great deal. Remittances are also usually of great importance to families of such workers. It is therefore essential that authorities create a suitable environment and policies that manage and protect their human capital investments.

These results justify the government's current efforts to retain and attract skilled labour as part of its ASGISA macroeconomic framework. In future work on this topic, a more sophisticated labour supply mechanism will be implemented to allow simulation of policy options available to government to slow the tide of both skilled emigration and illegal immigration.

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*Simulation 1 (reduction in employment of skilled labour)*

<b>Variable</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
CPI	0.26	0.47	0.60	0.63	0.66	0.69	0.70	0.72
GDP price index	0.49	0.86	1.05	1.07	1.08	1.09	1.10	1.10
GNE price index	0.43	0.74	0.90	0.92	0.93	0.93	0.94	0.93
Real Wages	1.45	2.38	2.78	2.66	2.54	2.43	2.34	2.24
Employment	-0.79	-1.32	-1.58	-1.58	-1.58	-1.58	-1.58	-1.58
Rental Price	-0.62	-0.94	-1.00	-0.85	-0.71	-0.59	-0.49	-0.40
Capital	0	-0.04	-0.11	-0.18	-0.25	-0.32	-0.38	-0.43
Price of Invest	0.19	0.33	0.41	0.43	0.44	0.45	0.46	0.46
Priv. Consump	-0.16	-0.28	-0.37	-0.41	-0.46	-0.50	-0.53	-0.57
Investment	-0.66	-1.08	-1.28	-1.25	-1.23	-1.22	-1.20	-1.19
Gov. Consump	-0.16	-0.28	-0.37	-0.41	-0.46	-0.50	-0.53	-0.57
Exports	-0.82	-1.44	-1.78	-1.83	-1.87	-1.90	-1.92	-1.93
Imports	-0.32	-0.54	-0.65	-0.66	-0.67	-0.69	-0.70	-0.71
Terms of Trade	0.18	0.31	0.39	0.40	0.41	0.42	0.43	0.43
GDP	-0.39	-0.67	-0.82	-0.85	-0.87	-0.90	-0.92	-0.94

*Simulation 2 (reduction in primary factor productivity)*

<b>Variable</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
CPI	0.34	0.70	0.72	0.73	0.74	0.75	0.76	0.76
GDP price index	0.44	0.90	0.90	0.90	0.90	0.90	0.90	0.89
GNE price index	0.34	0.71	0.71	0.71	0.71	0.70	0.70	0.69
Real Wages	-0.83	-1.71	-1.81	-1.91	-2.00	-2.08	-2.16	-2.23
Employment	0	0	0	0	0	0	0	0
Rental Price	-0.56	-1.04	-0.95	-0.86	-0.78	-0.71	-0.65	-0.60
Capital	0	-0.03	-0.10	-0.16	-0.22	-0.28	-0.33	-0.38
Price of Invest	0.28	0.58	0.59	0.60	0.60	0.60	0.60	0.60
Priv. Consump	-0.88	-1.78	-1.82	-1.86	-1.90	-1.94	-1.98	-2.01
Investment	-0.60	-1.20	-1.20	-1.20	-1.20	-1.20	-1.21	-1.22
Gov. Consump	-0.88	-1.78	-1.82	-1.86	-1.90	-1.94	-1.98	-2.01
Exports	-1.28	-2.60	-2.64	-2.68	-2.72	-2.75	-2.77	-2.80
Imports	-0.77	-1.54	-1.56	-1.58	-1.59	-1.61	-1.63	-1.65
Terms of Trade	0.28	0.57	0.58	0.59	0.60	0.60	0.61	0.61
GDP	-0.98	-1.97	-2.00	-2.03	-2.06	-2.09	-2.12	-2.15

*Simulation 3 (combined scenario)*

<b>Variable</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>
Real Wages	0.63	0.68	0.96	0.74	0.53	0.35	0.17	0.01
Employment	-0.79	-1.32	-1.58	-1.58	-1.58	-1.58	-1.58	-1.58
Capital	0	-0.08	-0.21	-0.34	-0.47	-0.59	-0.71	-0.81
Priv. Consump	-1.03	-2.04	-2.17	-2.26	-2.34	-2.41	-2.48	-2.55
Terms of Trade	0.46	0.89	0.98	1.00	1.02	1.04	1.05	1.06
GDP	-1.37	-2.62	-2.81	-2.86	-2.92	-2.97	-3.02	-3.06



Figure 1 (first-round impacts of simulation shocks)

