A Historical CGE Simulation of the South African Economy from 2006–2013: Analysing Changes in the Use of Primary Factors by Industries

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Abstract

This paper uses a dynamic CGE model to help explain some apparent contradictions between changes in the structure of the South African economy and movements in related variables over the 2006 to 2013 period. Most notably, an increase in the capital-labour ratio was identified, despite a relative increase in the price of capital rentals. To calibrate this result with conventional economic theory suggests that a change in the preferred capital-labour ratio of industries must have occurred. We quantify this change and comment on what this means for policymakers trying to reduce the country's high level of unemployment. Other changes to the economy over this period are also quantified and explained.

1 Introduction

This paper seeks to quantify and explain movements in the South African economy from 2006-2013 not directly observable or measurable through conventional methods. In doing so, we identify changes in the country's primary factor and trade profiles that are seemingly contradicted by relative prices changes observed over this period. To reconcile these observed movements with conventional economic theory suggests that changes in industry and consumer preferences must have occurred. We conduct our investigation into these events using the historical decomposition approach of Dixon & Rimmer (2002) in a dynamic computable general equilibrium framework.

The economic model used for this study is the dynamic version of the University of Pretoria's General Equilibrium Model (UPGEM). In addition to providing new quantitative evidence of trends in the primary factor and trade environments, two further benefits emerge from this research. First is the identification of other trends in the economy that may be used to inform baseline projections in the UPGEM model,[1] and second is the updating of the model's underlying supply-use database to improve the accuracy of policy simulation results.

The remainder of the paper is set out as follows: Section 2 describes the UPGEM model in broad detail. Section 3 describes the model closure for our historical analysis and summarizes the observed movements between 2006 and 2013. Section 4 presents the results of the simulation and Section 5 draws some conclusions.

2 The UPGEM Model

UPGEM is a recursive-dynamic computable general equilibrium (CGE) model of the South African economy. The theoretical specification of UPGEM is based on the MONASH model of Australia described in Dixon & Rimmer (2002). A complete exposition of the model code adopted in UPGEM is shown in Dixon & Rimmer (2005). The model's base year data is for 2006 and based on the supply-use tables published in StatsSA (2008). The UPGEM database distinguishes 33 industries and commodities, and in combination with the model's theoretical specification, describes the main inter-linkages in the South African economy.[2] The model is implemented and solved using the GEMPACK suite of programs (Harrison & Pearson, 1996).

Following the MONASH-style of implementing a CGE model, the general equilibrium core of the UPGEM model is made up of a linearized system of equations describing the theory underlying the behaviour of participants in the economy. It contains core equations describing: the nature of markets; demands for inputs to be used in the production of commodities; household demands; demands for inputs to capital creation and the determination of investment; government demands for commodities; and foreign demand for exported goods. The dynamic version of UPGEM contains additional equations describing: physical capital accumulation; lagged adjustment processes in the labour market; and government fiscal accounts.

The specifications in UPGEM recognize each industry as producing one or multiple commodities, using as inputs combinations of domestic and imported commodities, different types of labour, capital and land. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions. This nested production structure, shown in Appendix 1, reduces the number of estimated parameters required by the model. Optimising equations determining the commodity composition of industry output are derived subject to a CET function, while functions determining industry inputs are determined by a series of nests. At the top level, intermediate commodity composites and a primary-factor composite are combined using a Leontief or fixed

[1] See Dixon & Rimmer (2010) for an example of using historical simulations to inform baseline projections.

[2] Some of the 27 industries in the 2006 supply-use tables were further disaggregated to reach the 33 industry specification used in this study.

proportions production function. Consequently, they are all demanded in direct proportion to industry output or activity. Each commodity composite is a CES function of a domestic good and its imported equivalent. This incorporates Armington's assumption of imperfect substitutability for goods by place of production (Armington, 1969). The primary-factor composite is a CES aggregate of composite labour, capital and land, with composite labour itself a CES aggregate of different labour types. In UPGEM, all industries share this common production structure, but input proportions and behavioural parameters vary between industries based on available data and econometric estimates.

Demand and supply equations for industries and households are derived from the solutions to the optimisation problems which are assumed to underlie the behaviour of private sector agents in conventional neo-classical microeconomics. Each industry minimises cost subject to given input prices and a constant returns to scale production function. Households maximise a Klein-Rubin utility function subject to their budget constraint. Units of new industry-specific capital are determined as cost-minimising combinations of domestic and imported commodities. Imperfect substitutability between sources of commodities is modelled using the Armington CES assumptions. The export demand for any local commodity is inversely related to its foreign-currency price. The price of imports is exogenous, consistent with the assumption of South Africa being a small open economy. Government consumption and the details of direct and indirect taxation are also recognised in the model. Markets are assumed to be competitive which implies that the basic price and marginal cost of goods will be equal. The model also distinguishes trade and transport margin costs which are included in the purchaser's price, but not in basic price, of goods and services.

The dynamic elements of UPGEM allow for inter-temporal links describing: physical capital accumulation; lagged adjustment processes for labour; and government fiscal accounts. Capital accumulation is specified separately for each industry, and linked to industry-specific net investment in the preceding period. Investment in each industry is positively related to its expected rate of return on capital. For the government's fiscal accounts, a similar mechanism for financial asset/liability accumulation is specified. Adjustments to the national net foreign liability position of households are related to the annual investment/savings imbalance, revaluations of assets and liabilities, and remittance flows during the year. Changes in the public sector debt are related to the public sector deficit incurred during the year. In policy simulations, the labour market follows a lagged adjustment path where wage rates are allowed to respond over time to gaps between demand and supply for labour.

3 Model Closure and Observed Movements from 2006-2013

For detailed CGE models such as UPGEM the number of variables (n) will always exceed the number of equations (m). To close the model and compute a solution, $(n - m)$ variables must therefore be treated as exogenous. Alternatively stated, the number of endogenous variables must equal the number of equations for the model closure to be valid and represent a unique equilibrium. The selection of the $(n - m)$ exogenous variables is largely user-determined, but should be chosen to best describe the economic environment for which the simulation is run. For any simulation, endogenous variables are solved by the model with values for exogenous variables essentially 'assumed' or given.

UPGEM provides modellers with a significant amount of flexibility in the choice of closure. In comparative-static mode, UPGEM can set up to conduct policy simulations over a short-run or long-run time span depending, in principle, on the treatment of capital and labour. For example, in the long-run, a typical model closure may have aggregate employment and industry-level returns to capital set as exogenous, with real wages and capital stocks endogenously determined. Once the desired time span has been determined, further changes to the model closure can impose various behavioural assumptions on particular agents in the model. For instance, government consumption can be set to follow changes in household consumption, move in line with a desired budget position, or remain exogenous.

With the dynamic MONASH model, the idea of flexible closures was fully extended with the development of four functional closure categories: long-run decomposition, historical, forecasting and policy (Dixon & Rimmer, 2002:233-277). In MONASH-style dynamic CGE applications, the forecast and policy closures are the most widely used. The baseline forecast closure is used to produce a believable business-as-usual picture of the future evolution of the economy. This requires setting as exogenous all the variables we think we know something about in future, such as the components of GDP, the consumer price index or population growth. The choice of exogenous variables is therefore usually based on the availability of reliable macroeconomic forecast data, with little regard to causation. The policy closure is used to evaluate the impact of an exogenous shock to the economy relative to the unperturbed baseline scenario. The impact on macro variables, such as the components of GDP, is usually of particular interest to policymakers and must therefore be allowed to respond to the policy change or shock under consideration and set as endogenous again. Variables deemed to be unaffected or independently determined from the policy scenario are then set as exogenous, allowing no deviation between the policy and forecast simulation values for these variables.[3]

In CGE modelling, historical simulations have become a popular tool for estimating movements in factor productivity, technical change and preference variables that are compatible with observed data at both an industry and macro level. That is, historical simulations allow calibration of the model's parameters to observed data. For this study we use a historical model closure to conduct our analysis of the South African economy over the period 2006–2013. Historical closures include in their exogenous set two types of variables: observables and

[3] A simple exposition on setting up forecast and policy closures is shown in Bohlmann (2011).

assignables. Observables are those for which movements can be readily observed from data sources for the period of interest, such as real GDP, trade figures or employment numbers. Assignable variables are naturally exogenous and can be assigned a value without contradicting anything that we have observed about the historical period or wish to assume about that period. The choice of assignable variables is simulation specific, but may include various aggregate or industry-level technical change variables, or the position of foreign demand curves not set as endogenous in the application of the historical simulation.

Historical closures may appear, at first, as unusual in that many variables which we would consider naturally endogenous in policy modelling, such as the component of GDP, are now exogenously set at their historically observed values. A number of naturally exogenous variables, such as technical change or the positions of export demand curves, must therefore be allowed to move endogenously for the model to maintain its compatibility with the given observed values and various parameter estimates over the historical period. Using this closure to conduct historical simulations allows us to quantify the movements of many of these unobservable variables and analyse their trends in order to, ultimately, better understand changes that have occurred in the economy.

Table 1 shows the variables in UPGEM explicitly given non-zero exogenous year-to-year movements based on available historical data. Pseudo-exogenous variables, that is, variables whose net change in any given period are determined by exogenously set variables, are also included and shown in italics. Table 2 shows the same historical movements represented as cumulative percentage changes away from the 2006 base year values, or initial solution. With the components of GDP set at their observed values, real GDP growth of 20.2 per cent was achieved over this period, equivalent to an average annual growth rate of around 2.6 per cent. All values represent percentage point changes, unless otherwise stated.

Apart from the main macro variables, Table 1 and 2 also shows industry variables in the gold and electricity sector that were exogenously assigned their observed values. Both these industries are of special importance to the local economy. Despite falling output levels, South Africa remains one of the leading gold producers in the world, yielding significant export revenues. The electricity sector in South Africa is heavily regulated through the state-owned enterprise Eskom. Since 2007 and the commencement of Eskom's New Build Programme, electricity prices have been increased significantly in order to reach a cost-reflective level (Eskom, 2013). By combining available price and output data for these sectors, we are then able to endogenously estimate changes in productivity and shifts in demand curves required to reconcile these observations with relevant elasticity parameter values in the model.

Figure 1 and 2 displays the same information as Table 2 for selected variables in line chart form. Figure 1 shows the cumulative percentage change in import versus export quantities and of persons employed versus capital stock. South Africa's widening trade deficit and the impact of the global financial crisis in 2008/09 on trade are clearly evident, as well as the poor performance of the labour market, in terms of employment numbers, relative to the growth in the capital stock. Figure 2 shows the cumulative movement in important price variables.

Two interesting observations emerge when comparing the two figures. The first is the relative increase in the use of capital relative to labour (see Figure 1), despite increases in the relative price of capital rentals (endogenously determined here) to wages (see Figure 2). The second is the widening trade deficit (see Figure 1), despite the weakening of the Rand (see Figure 2). In the following section we discuss the solutions to various endogenous variables that help explain these apparent contradictions.

4 Endogenous Results for the Historical Simulation from 2006-2013

Given the choice of closure and 'historical' exogenous shocks to the model over the observed period, UPGEM determines the movement in a large number of endogenously set variables. Table 3 and 4 show the endogenously determined variables most relevant to our analysis of the selected macro and industry observations in Section 3: movements in overall factor productivity, preference twists between domestic and imported commodities used by industry, shift's in the rest of the world's demand for our exports, and preference twists between capital and labour reflecting changes in industry technology. We also show productivity change in the gold industry. Results in Table 3 are shown as annual percentage changes and in Table 4 as cumulative percentage changes.

The most striking result from our historical simulation relates to the changes in primary factor composites, that is, the combination of capital and labour, by industries. The historical data in Section 3 shows an increase in the observed capital-labour (K/L) ratio over the 2006–2013 period, despite an increase in the rental-wage (P_K/P_L) ratio. This result seems to defy conventional theory. To explain how the economy changed during this period to make this result possible, we introduce the concept of a cost-neutral preference twist from Dixon & Rimmer (2002; 2004).

4.1 Explaining the Observed Capital-Labour Changes

To calibrate the increase in the K/L ratio with the historical increase in effective cost of using capital relative to labour, a cost-neutral labour/capital preference twist, shown below as (TWLK), is introduced. Intuitively, the TWLK twist variable may be thought of as a variable capturing changes not explained through conventional substitution between capital and labour as a result of relative price changes.

Over the 2006–2013 period, a cost-neutral twist in preferences by users holding back labour in the primary-factor composite is generated by the model. The positive value of 30.0 per cent generated for TWLK (twist_i) over the period, as shown in Table 4, reflects this strong shift in preferences away from the use of labour required by the model to reconcile the seemingly incompatible exogenously given values of the K/L ratio and primary-factor prices in Table 1 and 2 with each other.

To better explain this result we must look at the theoretical specification of TWLK within UPGEM. Input demand equations by industries are derived subject to a CES aggregation function with substitution elasticities (σ) between primary factors set at 0.2. With $\sigma \neq 1$ in the linearized input demand equations, this allows cost-neutral preference twists (TWLK) accommodating exogenous historical data or forecasts in the primary-factor market to be introduced and converted into technical or taste changes.[4] Equations (E1) and (E2) show these linearized demand equations as they appear in the UPGEM model code.

$$cap = z - \sigma S_L(p_K - p_L) + S_L TWLK \quad (1)$$

$$\text{lab} = z - \sigma S_K(p_L - p_K) + S_K TWLK \quad (2)$$

Following the UPGEM notational convention, *cap* and *lab* represent the percentage change in industry demands for capital (K) and labour (L), respectively. We note that in the absence of any change in output (z) and relative factor prices ($p_K - -p_L$), this representation gives *[cap – lab = TWLK]* and $[S_K$**cap* $+S_L$**lab = 0]*. Thus, if the K/L ratio in UPGEM increases by 10 per cent beyond what is explained by relative factor price movements, then TWLK will equal 10. The twist is therefore equivalent to movements in a_K and a_L, the technical change associated with capital and labour, respectively, which satisfy equations (E3) and (E4).

$$S_L TWLK = a_{K-}\sigma S_L(a_{K-}a_L) \quad (3)$$

$$-S_K TWLK = a_{L-}\sigma S_K(a_{L-}a_K) \quad (4)$$

We can further show that by implementing the twist via the technical change variables, we are in effect assuming that:

$\left[a_K = \frac{S_L}{1-\sigma} * TWLK\right]$ and $\left[a_L = -\frac{S_K}{1-\sigma} * TWLK\right]$

With σ below one, a positive TWLK value is equivalent to a cost-neutral capital-using technical change combined with a labour-saving technical change.

To provide additional insight into the composition of our K/L movements, we use the two 'back-of-the-envelope' equations shown in (E5) and (E6).[5] Assuming competitive conditions, the marginal products of capital and labour would equal

[4] This method of implementing cost-neutral preference twists eliminates a problem arising with these variables when set as exogenous in policy simulations. The same method is used to implement cost-neutral import/domestic preference twists.

[5] The two BOTE equations in (E5) and (E6) are easily derived by maximising economy-wide profits, $P_y.Y$ – (W.L + Q.K), subject to a Cobb-Douglas production function where Y = $A[L^{\beta}.K^{(1-\beta)}]$

their respective factor payments. In our exposition of (E5) we recognise that the marginal product of capital (F_K) is negatively related to the K/L ratio. In (E6) we recognise that the marginal product of labour (F_L) is positively related to the K/L ratio. In determining (E5) we assume that the rate of return on capital can be expressed as (Q/P_i) with Q the factor payment to capital and P_i the price index for new investments. We then assume Q is determined by the value of the marginal product of capital, written as (F_K*P_y). With (F_K) a function of the K/L ratio, and technical change (A) and (P_y/P_i) a function of the terms of trade (TofT), we are able to summarise this relationship through equation (E5). In similar fashion, we are able to write (E6) linking the real wage (W/P_c) to the K/L ratio, technical change, and the terms of trade effect.

$$F_K A\left[\frac{(K/_{A_K})}{(L/_{A_L})}\right] \approx \frac{Q}{P_i} * \frac{P_i}{P_y} \tag{5}$$

$$F_L A\left[\frac{(K/_{A_K})}{(L/_{A_L})}\right] \approx \frac{W}{P_c} * \frac{P_i}{P_y} \tag{6}$$

Given the implementation of our labour/capital twist via the technical change variables, we are now able to use our 'back-of-the-envelope' equations to help interpret the results for TWLK. In (E5), a preference twist affecting capital will therefore be transmitted via the technical change variable (A_K). In (E6), a preference twist affecting labour will similarly be transmitted via the technical change variable (A_L).

Our simulation results using UPGEM show strong primary-factor technical change in favour of capital and against labour between 2007 and 2013. This is reflected in the positive value of 30.0 per cent generated for TWLK (twist_i). We may equate this result to an increase in A_K in (E5) which will decrease the marginal product of capital requiring a rise in the relative amount of capital used. For labour, this may be equated to a decrease in A_L in (E6) which will increase the marginal product of labour requiring a fall in the relative amount of labour used. In the absence of this cost-neutral preference twist, captured via the technical change variables, exogenous 'shocks' related to the K/L ratio and relative primary-factor payments as applied here, could not have been accommodated simultaneously.

What this result suggests is that industry technology on average changed so that at any given ratio of the real wage to real rental price of capital, industries would choose a K/L ratio 30 per cent higher in 2013 than in 2006. This change may also be interpreted as a change in 'preferences' by industry for how their primary-factor composite looks. More capital is now preferred relative to labour in the production process, all other things equal. Speculation on the exact reasons for this change in industry technology or preferences towards the use of capital requires further research. However, it is no secret that the number of industrial action cases in recent years has cooled employers' attitudes to hiring labour. This result further suggests that industries certainly have the ability to substitute labour for capital. Labour unions should therefore be careful when pushing for higher real wages and going on protracted strikes, as these actions may well be part of the reason why industries have shifted towards investing in capital rather than labour over this period.

With employment (emp_jobs) exogenous and capital growth (x1cap) linked to investment expenditure (x2tot) via the capital accumulation mechanism, the model determined that economy-wide technical change (ff_a1prim) of 11.6 per cent occurred over this period. That is, the model calculated that a cumulative productivity increase of 11.6 per cent was required to calibrate the observed GDP figures with changes in use of capital and labour inputs.

Given the exogenous export demand (x4tot) and terms of trade (p0toft) settings, a cumulative shift in world demand for exports (f4gen) of 26.9 per cent over the period is endogenously determined by the model. The shift in export demand reflects the general growth in the world economy and demand for locally-produced exports, consistent with the exogenous trade data imposed on the model. This result is equivalent to an annual average growth rate, or outward shift, of around 3.5 per cent in the export demand curve (f4gen) over the 7 year period. To explain this result, recall from Section 2 that the export-demand curve is downward sloping in the theoretical specification of UPGEM. A large shift in (f4gen) is therefore required for the model to reconcile the exogenously given increase in real exports (x4tot) of 2.6 per cent with the increase in the terms of trade (p0toft) of 18.1 per cent. The result produced here also reflects the given export elasticities in UPGEM of between 1.5 and 3 for all commodities.

The lower levels of trade relative to GDP (x0gdpexp) in the 2008/09 period reflects the impact of the Global Financial Crisis on imports (x0cif_c) and exports (x4tot). The terms of trade (p0toft) is shown to have improved between 2007 and 2013. This is defined as an increase in export prices relative to import prices. A natural shift towards relatively cheaper imports in the local import/domestic sales mix should therefore occur. However, the observed values for imports and exports do not suggest any significant change in the import/domestic mix relative to the given change in the terms of trade. To calibrate the historical values for the trade balance with the terms of trade, a cost neutral import/domestic preference twist (twist_c) is introduced in a similar fashion to the capital/labour twist. Over the 2006–2013 period, a cost-neutral twist in preferences by users holding back imports in the local/import domestic mix of sales is generated by the model. The negative value of 20.7 per cent generated for the import/domestic preference twist (twist_c), as shown in Table 4, reflects this shift in preferences away from the use of imports required by the model to reconcile the different exogenously given values of imports, exports and terms of trade in Table 1 and 2 with each other. One reason for this shift may be attributed to changes in government procurement policies favouring locally produced goods.

5 Conclusions

South Africa's GDP growth and unemployment problems have been well documented in the literature. This paper seeks to quantify some of the factors underlying the country's struggles in this regard using a historical CGE simulation. Results show that there has been a significant shift in preferences away from labour towards capital, despite primary factor prices movements that would suggest the opposite. In essence, what this result suggests is that industry technology on average changed so that at any given ratio of the real wage to real rental price of capital, industries would choose a K/L ratio 30 per cent higher in 2013 than in 2006. Other findings include a slight improvement in overall primary-factor technical change, but a significant deterioration in productivity in the gold sector, perhaps as a result of the increasing difficulty associated with deep underground mining. A slight preference twist towards the use of domestically produced goods relative to imports was also found. The findings from this paper lay the groundwork for improved baseline forecasts for the UPGEM model and a better understanding of recent trends in the economy.

References

[1] Aghion, P., Braun, M. and Fedderke, J. (2008) Competition and Productivity Growth in South Africa. Economics of Transition, 16:741-768.

[2] Armington, P.S. (1969) A Theory of Demand for Products Distinguished by Place of Production. International Monetary Fund Staff Papers, XVI:159-178.

[3] Banerjee, A., Galiani, S., Levinsohn, J., McLaren, Z. and Woolard, I. (2008) Why Has Unemployment Risen in the New South Africa? Economics of Transition, 16:715-740.

[4] Behar, A. (2010) Would Cheaper Capital Replace Labour? South African Journal of Economics, 78:131-151.

[5] Bhorat, H. (2012) Six Possible Policy Suggestions for Employment Creation in South Africa. DPRU Working Paper 12/150. Development Policy Research Unit, University of Cape Town.

[6] Bhorat, H., Goga, S. and Van der Westhuizen, C. (2012) Institutional Wage Effects: Revisiting Union and Bargaining Council Wage Premia in South Africa. South African Journal of Economics, 80:400-414.

[7] Bohlmann, H.R. (2011) Labour and Migration Policy in South Africa. PhD Thesis. Centre of Policy Studies, Monash University.

[8] Boratynski, J. (2012) Historical Simulations with a Dynamic CGE Model: Results for an Emerging Economy. Paper prepared for the 2012 Ecomod Conference, Seville.

[9] Dixon, P.B. and Rimmer, M.T. (2002) Dynamic General Equilibrium Modelling for Forecasting and Policy: A Practical Guide and Documentation of MONASH. North-Holland, Amsterdam.

[10] Dixon, P.B. and Rimmer, M.T. (2004) A Problem with Exogenous Twists in Policy. CoPS Archive Item TPPB0053 Available Online at www.monash.edu.au/policy

[11] Dixon, P.B. and Rimmer, M.T. (2005) Reducing the Barriers to Entry in Dynamic CGE Modelling. Paper Prepared for the 8^{th} Annual Conference on Global Economic Analysis. Lübeck, Germany.

[12] Dixon, P.B. and Rimmer, M.T. (2010) Validating a Detailed, Dynamic CGE Model of the USA. The Economic Record, 86:22-34 (Special Issue).

[13] Dixon, P.B., Koopman, R.B. and Rimmer, M.T. (2013) The MONASH Style of CGE Modeling. In Handbook of Computable General Equilibrium Modeling. (Edited by Dixon, P.B. and Jorgenson, D.W.) North-Holland, Amsterdam.

[14] Dixon, P.B. and Rimmer, M.T. (2013) Validation in CGE Modeling. In Handbook of Computable General Equilibrium Modeling. (Edited by Dixon, P.B. and Jorgenson, D.W.) North-Holland, Amsterdam.

[15] Du Plessis, S. and Smit, B. (2007) South Africa's Growth Revival after 1994. Journal of African Economies, 16:668-704.

[16] Eskom. (2013) Tariff & Charges Booklet 2013/14. Available at www.eskom.co.za/tarrifs

[17] Fedderke, J. (2012) The Cost of Rigidity: The Case of the South African Labor Market. Comparative Economic Studies, 54:809-842.

[18] Harrison, W.J. and Pearson, K.R. (1996) Computing Solutions for Large General Equilibrium Models using GEMPACK. Computational Economics, 9:83-127.

[19] International Monetary Fund. (2012) IMF Country Report No 12/247. Staff Report for the 2012 Article IV Consultation. International Monetary Fund, Washington D.C.

[20] Klein, N. (2012) Real Wage, Labor Productivity and Employment Trends in South Africa: A Closer Look. IMF Working Paper 12/92. International Monetary Fund, Washington D.C.

[21] Mai, Y. (2007) The Chinese Economy From 1997-2015: Developing a Baseline for the MCHUGE Model. CoPS/IMPACT Working Paper G-161. Centre of Policy Studies, Monash Univeristy.

[22] National Treasury, Republic of South Africa. (2013) Medium Term Budget Policy Statement 2013. National Treasury, Pretoria.

[23] The Presidency, Republic of South Africa. (2012) National Development Plan 2030: Our Future – Make It Work. National Planning Commission, The Presidency, Pretoria.

[24] Pollin, R., Epstein, G., Heintz, J. and Ndikumana, L. (2006) An Employment-Targeted Economic Program for South Africa. United Nations Development Programme, New York.

[25] South African Reserve Bank. (2013) Quarterly Bulletin, September 2013. South African Reserve Bank, Pretoria.

[26] Statistics South Africa. (2008) Gross Domestic Product, Fourth Quarter 2007. Statistical Release P0441. Statistics South Africa, Pretoria.

[27] Statistics South Africa. (2013) Labour Market Dynamics in South Africa 2012. Statistics South Africa, Pretoria.

[28] Statistics South Africa (2013) Quarterly Labour Force Survey, Third Quarter 2013. Statistical Release P0211. Statistics South Africa, Pretoria.

[29] Statistics South Africa. (2013) Gross Domestic Product, Third Quarter 2013. Statistical Release P0441. Statistics South Africa, Pretoria.

[30] Verick, S. (2012) Giving Up Job Search During a Recession: The Impact of the Global Financial Crisis on the South African Labour Market. Journal of African Economies, 21:373-408.

[31] The World Bank. (2012) World Development Report 2013: Jobs. World Bank, Washington D.C.

Table 1: Annual percentage change to selected exogenous variables (2007–2013)

Macro variables	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
Real GDP (x0gdpexp)	*5.5*	*3.6*	*-1.5*	*3.1*	*3.6*	*2.5*	*2.0*
Real Consumption (x3tot)	5.5	2.2	-1.6	4.4	4.8	3.5	2.4
Real Investment (x2tot_i)	14.0	14.1	-3.2	-2.0	4.5	5.7	4.1
Real Government (x5tot)	3.9	4.5	4.6	5.0	4.6	4.2	3.3
Real Imports (x0cif_c)	9.0	1.5	-17.4	9.6	9.7	6.3	7.2
Real Exports (x4tot)	6.6	1.8	-19.5	4.5	5.9	0.1	6.0
Govt/Consumption Ratio (f5tot)	*-1.5*	*2.2*	*6.3*	*1.1*	*-0.5*	*0.5*	*1.0*
Consumer Price Index (p3tot)	6.1	9.9	7.1	4.3	5.0	5.7	5.9
Real Wages (real_wage_c)	1.0	2.5	2.5	3.0	1.0	1.5	1.5
Terms of Trade (p0toft)	1.6	-0.1	8.0	7.2	2.3	-2.2	0.5
Nominal Exchange Rate (phi)	-4.6	-13.4	-2.3	14.0	1.3	-11.9	-10.0
Labour Employed (emp_jobs)	0.4	2.0	-3.0	-1.5	1.5	0.5	0.5
Capital Stock (x1cap)	*1.7*	*2.9*	*4.0*	*3.5*	*3.0*	*3.1*	*3.4*
Industry variables	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
Gold Price (p4)	31.0	4.0	25.0	30.5	7.5	8.5	-15.0
Gold Output (x4)	-5.5	-15.0	-6.0	-4.0	-4.0	-10.0	-5.0
Electricity Price (p0dom)	5.1	27.5	31.3	24.8	25.8	16.0	8.0
Electricity Output (z)	4.0	-1.0	-2.0	4.0	2.0	2.0	4.0

Source: SARB, StatsSA, National Treasury, Eskom, UPGEM simulation results

Table 2: Cumulative percentage change to selected exogenous variables (2007–2013)

Macro variables	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
Real GDP (x0gdpexp)	*5.5*	*9.3*	*7.6*	*11.0*	*15.0*	*17.9*	*20.2*
Real Consumption (x3tot)	5.5	7.8	6.1	10.7	16.1	20.1	23.0
Real Investment (x2tot_i)	14.0	30.1	25.9	23.4	28.9	36.3	41.9
Real Government (x5tot)	3.9	8.6	13.5	19.2	24.7	30.0	34.2
Real Imports (x0cif_c)	9.0	10.6	-8.6	0.2	9.9	16.8	25.2
Real Exports (x4tot)	6.6	8.5	-12.6	-8.7	-3.3	-3.2	2.6
Govt/Consumption Ratio (f5tot)	*-1.5*	*0.7*	*7.0*	*7.6*	*7.5*	*8.1*	*9.2*
Consumer Price Index (p3tot)	6.1	16.6	24.9	30.2	36.7	44.5	53.1
Real Wages (real_wage_c)	1.0	3.5	6.1	9.3	10.4	12.0	13.7
Terms of Trade (p0toft)	1.6	1.5	9.6	17.5	20.2	17.5	18.1
Nominal Exchange Rate (phi)	-4.6	-17.4	-19.3	-8.0	-6.8	-17.9	-26.1
Labour Employed (emp_jobs)	0.4	2.4	-0.6	-2.1	-0.7	-0.2	0.3
Capital Stock (x1cap)	*1.7*	*4.7*	*8.9*	*12.7*	*16.0*	*19.5*	*23.4*
Industry variables	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
Gold Price (p4)	31.0	36.2	70.3	122.2	138.9	159.2	120.3
Gold Output (x4)	-5.5	-19.6	-24.5	-27.5	-30.4	-37.4	-40.5
Electricity Price (p0dom)	5.1	34.0	75.9	119.6	176.2	220.4	246.0
Electricity Output (z)	4.0	2.9	0.9	4.9	7.0	9.1	13.5

Source: SARB, StatsSA, National Treasury, Eskom, UPGEM simulation results

Table 3: Annual percentage change to selected endogenous variables (2007–2013)

Endogenized macro variables	2007	2008	2009	2010	2011	2012	2013*
Factor productivity (ff_a1prim)*	5.0	3.3	-2.0	1.3	2.1	1.4	0.8
Import/domestic pref (twist_c)	2.5	-8.1	-31.1	5.8	4.9	8.0	2.0
Export demand shift (f4gen)	6.1	-1.8	-7.5	20.7	10.2	-5.9	5.3
Labour/capital preference (twist_i)	3.2	1.0	11.2	5.6	0.8	2.3	2.9
Endogenized industry variables	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
Gold export demand shift (f4q)	20.6	-25.4	41.4	31.5	-5.3	-8.9	-34.5
Gold factor productivity (f_a1prim)*	16.7	18.9	4.3	10.3	10.8	13.8	-1.1

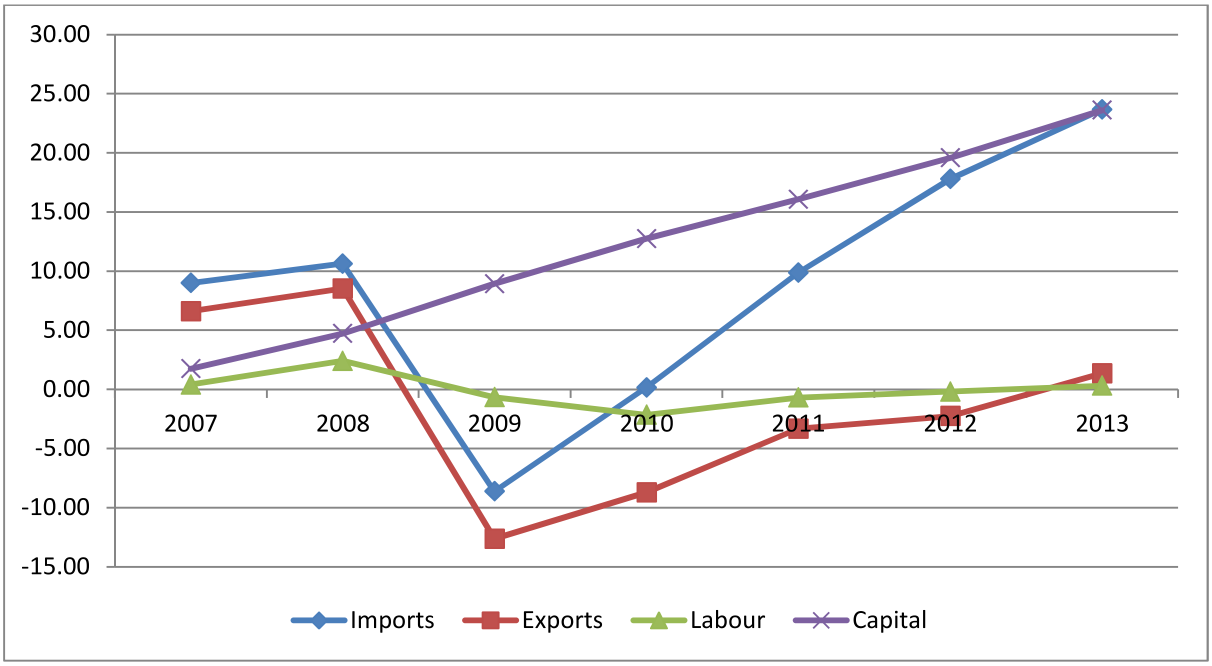
Source: UPGEM simulation results

Table 4: Cumulative percentage change to selected endogenous variables (2007–2013)

Endogenized macro variables	2007	2008	2009	2010	2011	2012	2013*
Factor productivity (ff_a1prim)*	5.0	8.3	6.4	7.6	9.6	10.9	11.6
Import/domestic pref (twist_c)	2.5	-5.8	-35.1	-31.3	-27.9	-22.2	-20.7
Export demand shift (f4gen)	6.1	4.2	-3.6	16.3	28.1	20.5	26.9
Labour/capital preference (twist_i)	3.2	4.2	15.9	22.4	23.4	26.4	30.0
Endogenized industry variables	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***
Gold export demand shift (f4q)	20.6	-10.8	27.1	67.3	58.4	44.2	-5.5
Gold factor productivity (f_a1prim)*	-16.7	-38.7	-44.7	-59.6	-76.9	-101.2	-99.0

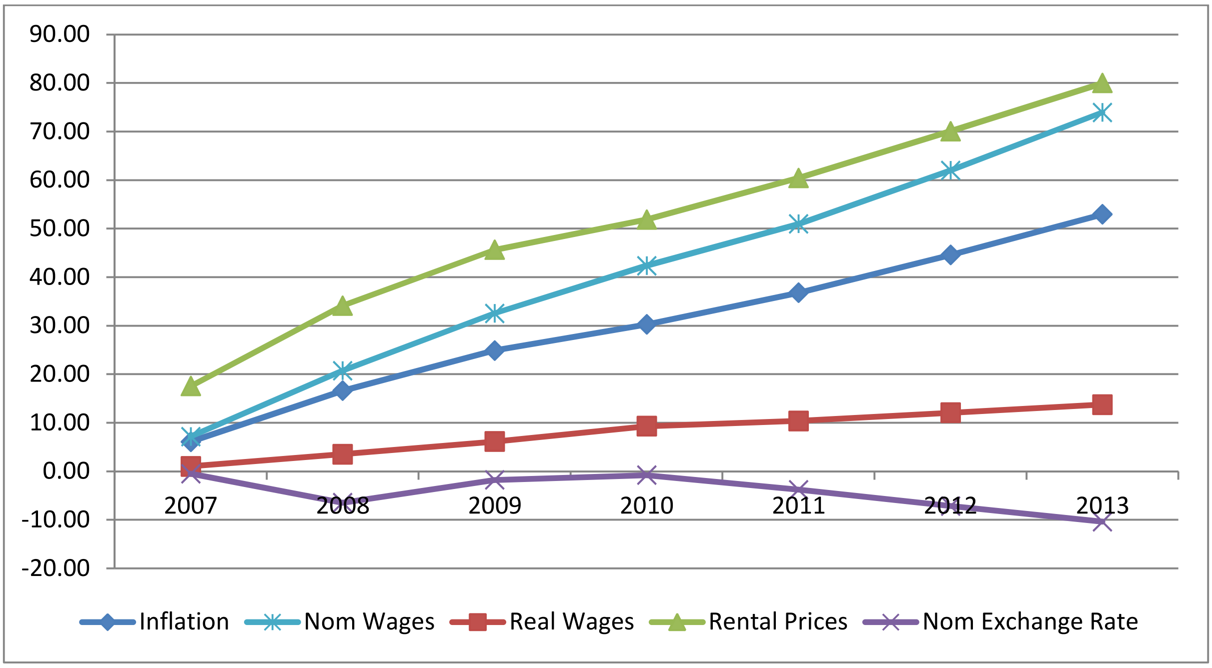
Source: UPGEM simulation results

Figure 1: Cumulative percentage change to trade, capital and labour variables (2007–2013)



Source: SARB, StatsSA

Figure 2: Cumulative percentage change to selected price variables (2007–2013)



Source: SARB, StatsSA, UPGEM simulation results

Appendix 1: Nested Production Structure of a Representative Industry in UPGEM