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THE BRIDGE
AN ADRS SIMULATION POLICY BRIEF
SKILLS PLANNING SERIES
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Introducing LM-EM: The Linked Macro-Education Model of South Africa

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KEY QUESTIONS

What will be the impact on the economy and the demand and supply of skills *if:*

Public infrastructure investment increases?

Matriculation rates among Africans increase?

Labour force participation rates among youth increase?

College graduation rates for all races increase?

Emigration rates decline?

Retirement rates increase?

Oil price goes up again?

Foreign investment increases?

Rand significantly appreciates?

IN THIS ISSUE

Until recently, South Africa did not have a comprehensive system to produce consistent projections of skills and occupations. Through a project with the Department of Higher Education, the Linked Macro-Education Model (LM-EM) was built to provide a platform to design economic, labour force, and education policy scenarios, quantify their impact, and forecast trends in economic indicators and the demand and supply of skills.

LM-EM combines economic, demographic, and education data with state of the art statistical and modeling techniques to capture key interactions and interdependencies within the economy, including the behaviour of households, the private sector, and government, and the links between the labour market and the education sector.

LM-EM's user-friendly web platform allows policymakers, analysts, researchers, scholars, and others to have direct access to the model to design and quantify potential outcomes of alternative economic, labour force, and education policies.

This is the first issue of the ADRS Skills Planning Series of The Bridge. The aim of the series is to utilise the LM-EM to respond to economic, labour force, and education policy questions that relate to skills planning and HR strategies for the economy, economic sectors, and provinces by the public and private sector.

KEY FEATURES

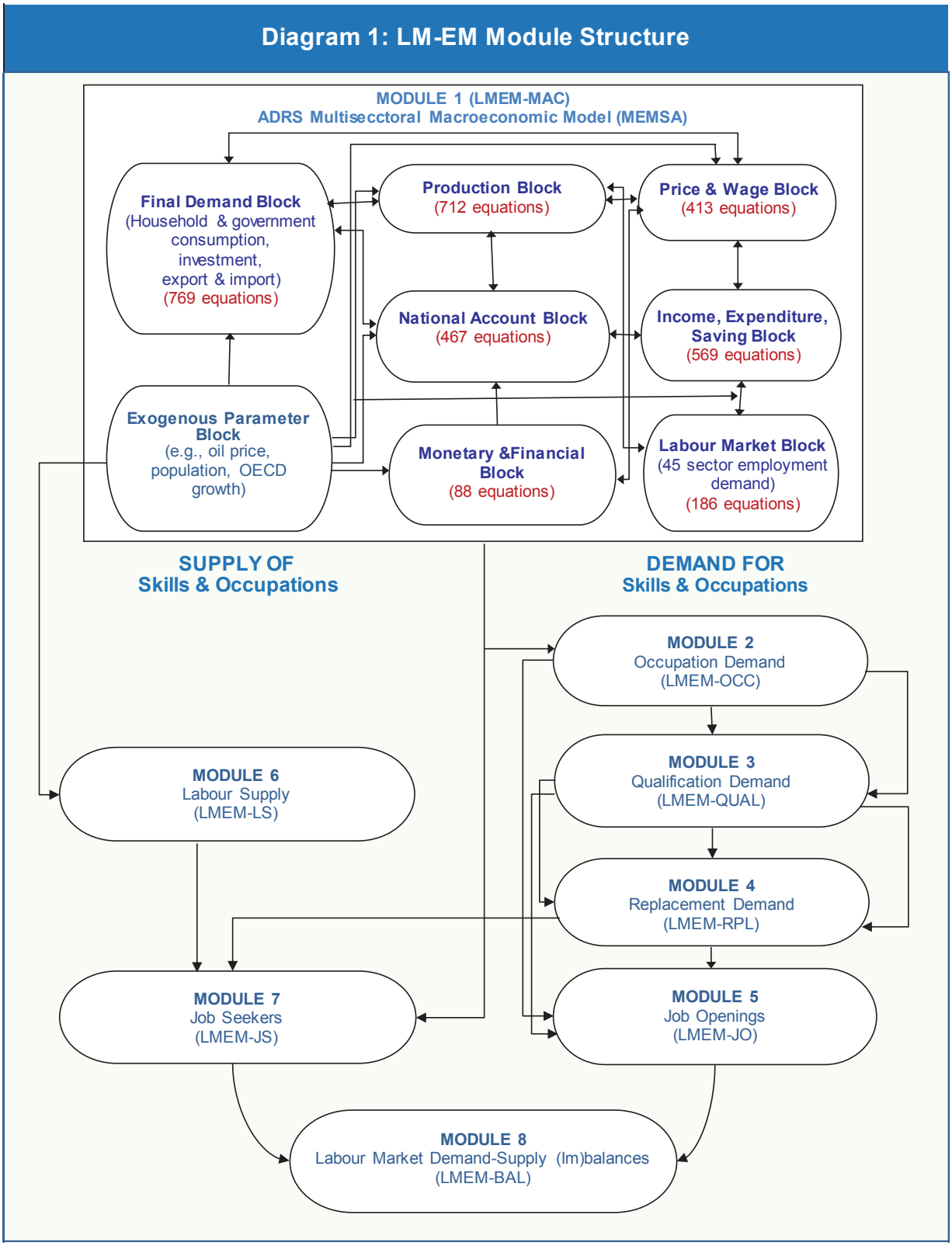
- Linked to a multi-sector macroeconomic model of South Africa
- Capacity to provide quantitative answers to many different simple and complex policy questions.
- Wide range of systematic and consistent forecasts
- Easy to use web-platform that makes designing and running scenarios simple and accessible
- Flexible architecture allows for future extensions
- Easy access 24/7

LM-EM
Linked Macro-Education Model

Structure of LM-EM

LM-EM has a modular architecture based on a functional partitioning of the model. Each module is designed to carry out a particular set of functions within the larger system, using inputs from other modules and feeding generated outputs into the rest of the system. The model has eight modules, including ADRS' multi-sector macroeconomic model of South Africa (MEMSA™).

Diagram 1: LM-EM Module Structure



Distinguishing Features of LM-EM

Link to a Multi-Sectoral Macroeconomic Model

Statistical analysis of demand for skills relies heavily on the estimation of the demand for occupations that are derived from sector employment projections. In effect, skills projections require access to a multi-sectoral macroeconomic model that can provide such employment projections. LM-EM's link to ADRS' disaggregated Macroeconometric Model of South Africa (MEMSA™), which provides sector level projection of employment, is an important feature of the model.

Sound Analytical and Empirical Foundations

Both the macroeconomic model and skills demand and supply modules of LM-EM have strong analytical and empirical foundations. The macroeconomic model component of LM-EM captures the working of the economy. Its analytical approach follows the pluralistic tradition in economics and uses modern time-series specification and estimation methods to estimate the parameters of the model's behavioural equations.

Internationally, most skills supply and demand forecasts are based on simple extrapolations of past trends, mainly due to significant data limitations. In South Africa, access to the Quarterly Labour Force Survey and Census data makes possible the use of regression techniques to establish the statistical links between the occupational and skills structures within economic sectors and economic and demographic factors. An important advantage of using regression analysis is that its underlying statistical techniques are designed to identify and establish the relationship between explanatory variables and the dependent variable, while enabling forecasts of future outcomes of the dependent variable. For LM-EM, the analyses of demand for occupations, demand for educational qualifications, and supply of labour were conducted by the multinomial logistic regression technique (Hosmer and Lemeshow, 2000; Long, 1997; Agresti, 2002). This approach allows estimating the probabilities of different possible outcomes of a categorically distributed dependent variable (e.g., several educational qualifications), given a set of independent variables (e.g., age, gender, occupations).

Wide Scope of Outputs

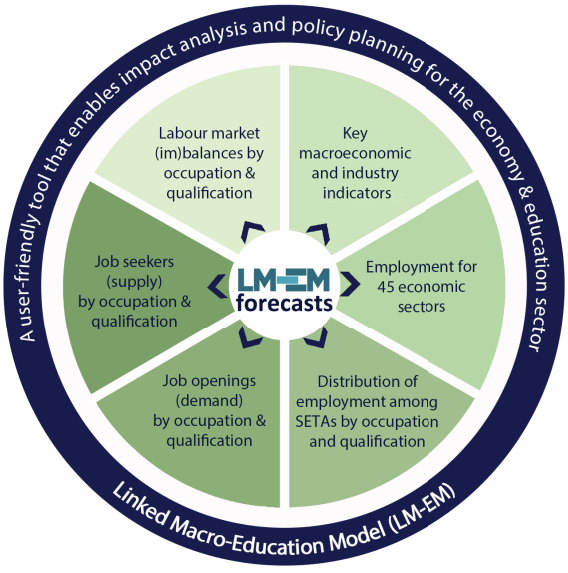
LM-EM forecasts key macroeconomic and industry indicators, employment for 45 economic sectors, distribution of employment among SETA's, job openings, job seekers, and labor market balances - all by occupation and qualification (Diagram).

High Level of Consistency

LM-EM forecasts economic and labour market indicators that are systematic and consistent. The range and consistency of results across the economy, sectors, and SETAs, by occupations and educational qualifications, makes LM-EM a reliable tool.

Efficient and Sustainable

Despite the complex nature of LM-EM, its web-based platform makes policy design, impact analysis and forecasting relatively simple and widely accessible to users. It also frees institutions and individuals from spending valuable resources to design, build, administer, manage and maintain models to create policy scenarios that address challenges, run simulations, and forecast results. LM-EM thus increases the analytical and forecasting capability of its users and significantly boosts their productivity, effectiveness and value-chain contributions.



LM-EM

Modules	Purpose	Data
1. Macroeconomic Model	To capture the structure of the South African economy including the behaviour of households, private sector, and the government, To allow design and analysis of macroeconomics and industrial policies.	Reserve Bank's electronic time series National Income and Product Account, 1970 to 2015. Quantec's industry database 1970 to 2015. For the model's exogenous variables various international databases are used, such as the electronic databases and publications of the International Monetary Fund, the World Bank, the OECD, the European Union, the African and Asian Development Banks, OPEC, and other similar sources.
2. Occupational Demand	To capture the links between LM-EM's macro module and the occupational structure of economic sectors. To capture occupational composition of new job opportunities due to the expansion of the economy (i.e., expansion demand). To provide projections of the occupational composition of the employment share of 21 SETAs.	A pooled dataset composed of three Quarterly Labour Force Survey data from 2009 to 2011. A detailed population forecast for 2015-2025 provided by Statistics South Africa.
3. Qualification Demand	To capture the educational qualification structure within occupations. To capture qualification composition of new job opportunities due to the expansion of the economy (i.e., expansion demand). To provide projections of future allocations of skills (educational qualifications) among 21 SETAs.	A pooled dataset composed of three Quarterly Labour Force Survey data from 2009 to 2011. A detailed population forecast for 2015-2025 provided by Statistics South Africa.
4. Replacement Demand	To provide projections of the number of employees in each occupation that will be replaced due to labour turnover related to retirement, migration, mortality or through career changes	Quarterly Labour Force Surveys for 2008 to 2012. OECD immigration database.

MODULES

Empirical Approach	Projections
The model is built on a broad pluralistic theoretical foundation and uses the Autoregressive Distributed Lag (ARDL) cointegration procedure, developed by Pesaran (1997) and Pesaran et al.(1996, 1999), to estimate its more than 400 bahavoural equations, including 7 estimated variables for 41 economic sectors, designed to empirically capture the behaviour of the private and household sectors as part of capturing the working and dynamics of the economy from its production, expenditure and income perspectives. Recent examples of using cointegration techniques in the construction of macroeconomic models are Pesaran et al. (2004), Dees et al. (2007), Di Mauro et al. (2013), Chudik and Pesaran (2014), and Garrett et al. (2006). A transition matrix was used to allocate LM-EM's annual sector employment projections among 21 SETAs.	Macroeconomic indicators including GDP, employment, balance of payments, inflation, wage rate, investment, consumption, trade, government expenditure, debt and deficit GDP ratios, exchange rates, money supply, and income and expenditure of households, incorporated businesses, and government. Industry indicators including projections of employment, output, investment, exports, imports, prices, and wage rates for 45 economic sectors.
Multinomial logistic regression technique (Hosmer and Lemeshow, 2000; Long, 1997; Agresti, 2002) was used to establish the economic and demographic factors that are associated with employment in 9 main occupational categories in South Africa. In total, twelve versions of the MNL model were estimated for the occupational demand. Examples of using multinomial logistic regression techniques for analyses of occupational demand are: Schmidt and Strauss (1975), Polacheck (1981), Peeters (1990), Garnaut and Huang (2001), Briscoe and Wilson, (2003), Chiswick and Taengnoi (2007), and CEDEFOP (2009). A transition matrix was used to translate LM-EM's demand for 9 main occupational categories to demand for 398 disaggregated occupational categories.	Annual projection of employment by 9 main occupation categories. 21 SETA employment allocation by occupation. Projection of annual job opening due to the expansion demand by occupation. Projection of demand for 400, 4-digit, occupations. Demand for scarce occupations.
Multinomial logistic regression technique (Hosmer and Lemeshow, 2000; Long, 1997; Agresti, 2002) was used to establish the economic and demographic factors that are associated with 9 main educational qualification categories of employed in South Africa. In total, ten versions of the MNL model were estimated for the qualification demand. The final MNL regression for the qualification demand includes nine estimated equations for the 9 categories of educational qualifications. The final model estimates the likelihood of having various levels of education among workers given the determining factors. Examples of using multinomial logistic regression techniques for skills demand analyses are: Muller et. al. (1995), Andrews and Bradley (1997), Jackson, Goldthorpe, and Mills (2005), Wilson (2008), CEDEFOP (2009), and Unni and Sarkar (2013). A transition matrix was used to translate LM-EM's 9 qualification demand projections to demand for 27 educational qualifications categories.	Annual projection of employment by 9 main categories of educational qualifications. Annual projection of employment by 27 categories of educational qualifications. 21 SETA employment allocations by qualification. Projection of annual job opening due to the expansion demand by educational qualification.
Used the cohort component approach (Hamilton & Perry, 1962, Pittenger 1976, Isserman (1993), Shryock et al (1986), George et al (2004)) to estimate the numbers of leavers from various population cohorts at two different points in time.The methodology used is based on the pioneering work of Willems and de Grip (1993) and has been used to calculate the net replacement demand in the Netherlands (Willems and de Grip, 1993), Australia (Shah and Burke, 2001), Ireland (Sexton et al., 2001), and the United States (Eck, 1991, and Bureau of Labour Statistics, 2006), and CEDEFOP (2009).	Annual projections of retirement, mobility, migration, and mortality among workers by occupation. Projection of annual job openings due to the replacement demand by occupation and educational qualification.

LM-EM MO

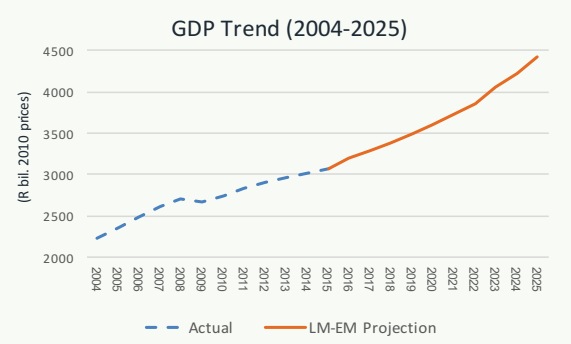
Modules	Purpose	Data
5. Job Openings	To provide projection of total job openings in the economy.	Projections generated by occupation, qualification and replacement demand modules of LM-EM.
6. Labour Supply	To produce annual projections of the labour force by qualification (skills supply) and occupation, using expanded definition of unemployment.	The initial set of estimations used the pooled three-year Quarterly Labour Force Survey that was used for other modules of LM-EM. However, for the final run, the 10 percent sample of the Census 2011 was used. The number of learners that obtained a National Senior Certificate in 2011 and the number of graduates from higher education and training institutions in 2011, broken down by race. Demographic input data included the annual projections of population by gender, race, age groups and provinces, provided by the Statistics South Africa.
7. Job Seekers	To produce annual projections of the size of job seekers in the economy and its breakdown by qualification of unemployed and their occupational preference.	LM-EM projections of the labour force, employment, and replacement demand by occupation and qualification.
8. Labour Market Imbalances	To estimate the extent of labour market imbalances, skills gap, and unemployment rates over time.	LM-EM projections of Job Openings, Job Seekers, and labour force by occupation and qualification.

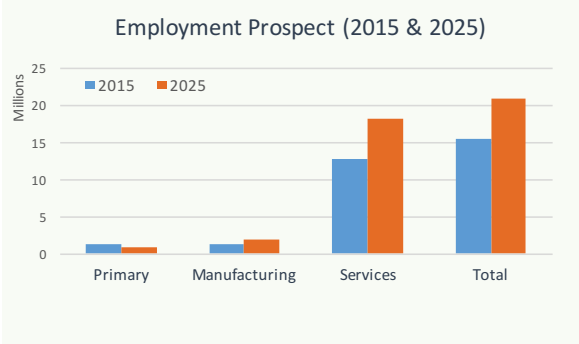
DULES CONT'D

Empirical Approach	Projections
Combines job openings due to economic growth (i.e., the expansion demand) and job openings due to the replacement demand.	Annual projections of total job openings by occupation and skill (i.e., educational qualification).
Utilised the multinomial logistical regression technique (Hosmer and Lemeshow, 2000, Long, 1997, Agresti, 2002) to establish the demographic, socio-economic and education factors (e.g., age, gender, race, province, matric and higher education graduation rates) that are associated with participation of individuals with different skill levels (i.e., educational qualifications) in the labour force. Overall, more than 10 versions of the MNL model were estimated for the skills supply. The multinomial logistic model estimated 10 equations for 11 educational qualifications. Examples of using multinomial logistic regression techniques for estimating supply of labour are: Hill (1989), Daly et. al. (1995), Winkelmann and Winkelmann (1997), Cerrutti (2000), van Soest (2002), Glauben et. al. (2008), and Flippen (2014).	Annual projections of the total labour force. Annual projections of labour force for 11 educational qualifications. Annual projections of the labour force for 9 occupation groups.
Takes annual projections of labour force, employment and replacement demand to calculate annual estimates of job openings by occupation and qualification.	Produces annual projections of job seekers (unemployment) by 9 educational qualifications and 9 occupation groups.
At the aggregate level, the module produces an annual estimate of labour market imbalances as the difference between the model's estimates of job seekers and job openings, i.e., unemployment or excess supply of labour. Skills gaps, i.e., imbalances by qualification, are estimated for all educational qualification categories by calculating the difference between the model's projection of job seekers and job openings for all the main educational qualification categories. Finally, the model estimates the imbalances by occupation by calculating the difference between the number of job seekers with different occupational preference and the number of job openings by occupation.	Projections of indicators of labour market (im)balances by educational qualification and occupation Annual projection of total unemployment rate, and unemployment rate by qualification. Annual projection of skills gap, i.e., imbalances between job seekers and job openings for each educational qualification. Annual projection of occupation gap, or preference mismatch, i.e., imbalances between job seekers and job openings in various occupational cohorts.

Sample Results

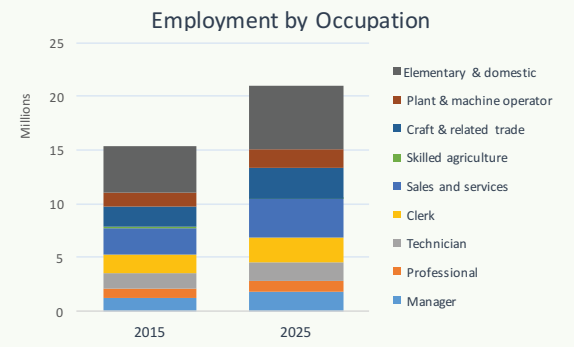
Macroeconomic

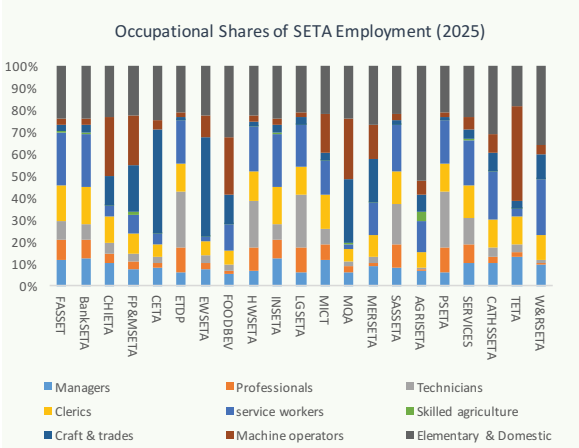




These graphs of LM-EM forecasts for a hypothetical economic scenario illustrate GDP growth across the total economy from 2015-2025 and increases in employment in the manufacturing and service sectors. LM-EM generates annual forecasts of output and employment for 45 economic sectors.

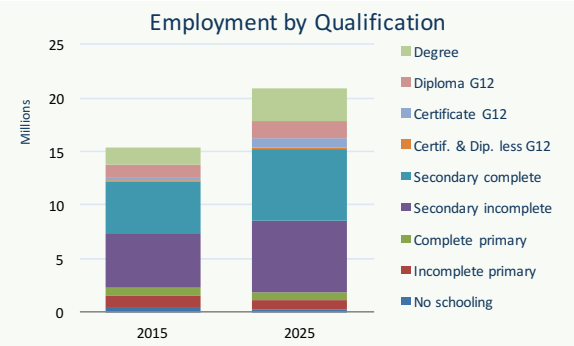
Occupational Demand

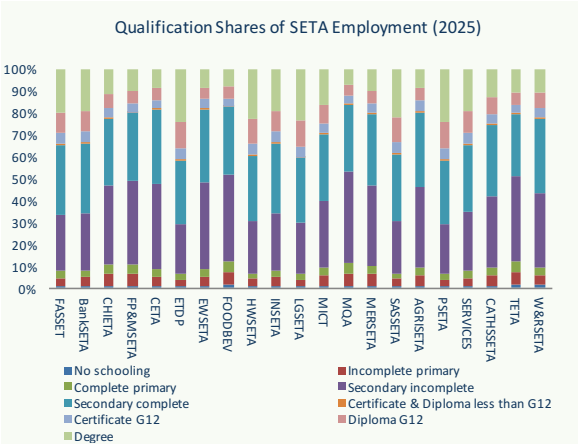




For the same hypothetical scenario, LM-EM forecasts a significant increase in employment across all occupations in the total economy except for skilled agricultural workers. LM-EM forecasts annual demand for various occupations and their allocation among 21 SETAs.

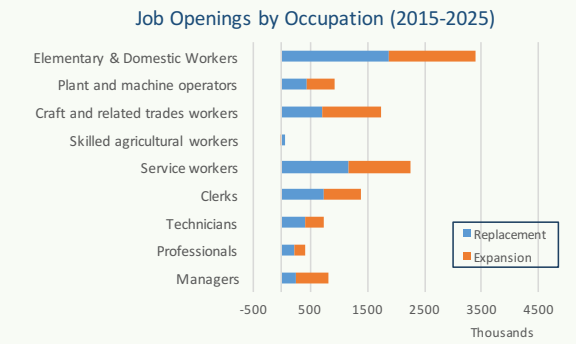
Qualification Demand

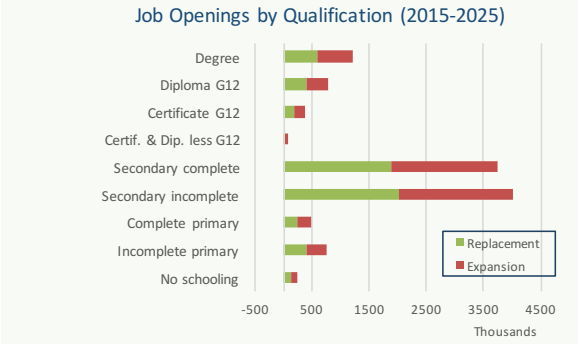




For every economic, labour force, and education policy scenario, LM-EM projects employment by education qualification across the economy and for the 21 SETAs. The above forecasts compare qualification composition of employment in 2015 with the results for 2025 and show qualification shares of SETAs in 2025.

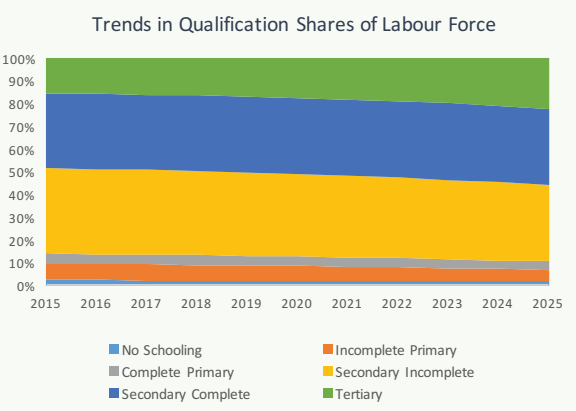
Job Openings

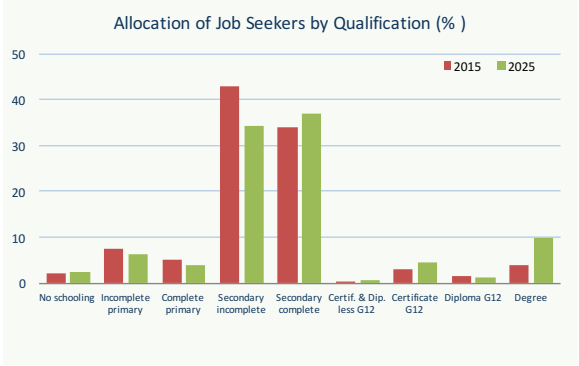




The above forecasts demonstrate occupation and qualification distributions of total job openings between 2015 and 2025. They also show the extent to which job openings in various occupations and qualifications are due to expansion demand and replacement demand.

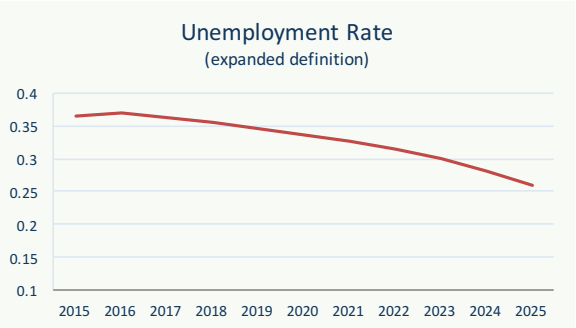
Labour Supply / Job Seekers

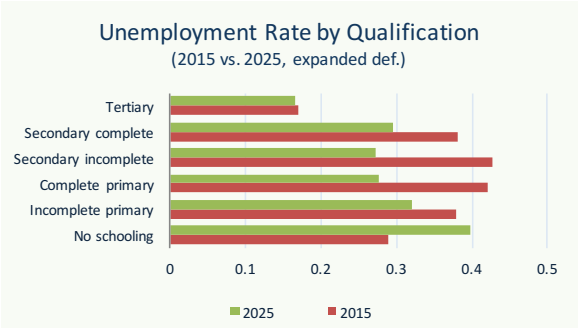




LM-EM projects labour supply by occupations and educational qualifications and job seekers by preferred occupation and qualifications. The above LM-EM forecasts illustrate an overall decrease in the lower educational qualification categories and a corresponding increase in the higher categories over the period.

Imbalances





For the same hypothetical scenario, LM-EM projects a decreasing unemployment rate in the total economy as well as a decrease in the rate across most qualification categories. LM-EM forecasts annual labour market imbalances by occupations and educational qualifications.

Easy Public Access to LM-EM

LM-EM's internationally unique web-platform is built to make the model accessible to the public. It is a cloud based system that is centrally hosted and is made available to the public on a subscription basis. As a SaaS system (Software as a Service), the model's security, uptime, upgrades and updates are attended to by ADRS. Moreover, users of the model have no need to purchase hardware or software, nor download files. The model is kept up-to-date, ready-to-use, and accessible on all devices anytime, anywhere.

All public and private organisations that conduct research and/or are responsible for skills planning and HR strategy can use LM-EM to design 'what if' questions about the economy, labour force, and the education sector and to obtain corresponding effects on future trends in demand and supply of skills and occupations for the economy, SETAs, provinces and economic sectors.

The LM-EM website is highly efficient. It takes less time to forecast the 10 year impact of a policy scenario than it takes Usain Bolt to run 200 meters!

LM-EM Resources

There are many resources available to users of LM-EM. The model has a full Technical Report, a User-Guide, an introductory You Tube video (https://youtu.be/dH0j1aUasAg), a library of practice questions, and several informational power point presentations about different aspects of the model. ADRS also offers technical and hands-on training workshops and provides online technical support to users of the model.

> *"Effective skills planning requires credible quantitative foresight on future trends in the macroeconomy and the demand and supply of skills.*

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APPLIED DEVELOPMENT RESEARCH SOLUTIONS

ADRS is an independent economic consultancy organization with extensive experience in economic model building, capacity building, policy research, and advisory services in Africa. Our innovative web-based interface gives users the power to design policies and test their impact prior to embarking on implementation.

THE BRIDGE

The Bridge is an ADRS policy brief designed to present the main findings of policy simulations on key development challenges. With each issue we present the quantification of policy options in order to support evidence-based policy decision-making and to contribute to current economic policy analysis and debate.

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ADRS MODELS OF THE SOUTH AFRICAN ECONOMY

BRIDGING RESEARCH AND DEVELOPMENT

Applied Development Research Solutions (ADRS) has developed six economic models of South Africa that interested individuals and institutions can use for projections, policy design and impact analyses. The models include a highly disaggregated macroeconometric model, two tax and transfer microsimulation models of households, a linked macro-micro model, and two linked national-provincial models of South Africa. Following is a brief description of each model:

MACROECONOMETRIC MODEL OF SOUTH AFRICA (MEMSA)™

This model captures the complex inter-linkages that exist between and within industrial sectors of the economy, macro-economic variables, policy variables, and income and expenditure of government, labour, and business. MEMSA is a bottom up disaggregated model with 7 estimated variables for 41 sectors of the economy. It is most suitable for forecasting and simulating the impact of domestic and international shocks, macroeconomic and industrial policy changes, major public expenditure projects, as well as policies that affect private businesses, government and household income and expenditure. MEMSA is hosted at the ADRS website and is accessible through its user-friendly platform.

SOUTH AFRICAN TAX AND TRANSFER SIMULATION MODEL (SATTSIM)™

ADRS has built this microsimulation model of South Africa for the projection of costs and benefits of current and future tax and transfer policies. Users of the model can design simple or complex tax and transfer policies for the next 15 years and assess their budgetary, poverty and income distribution effects. Model results are presented in aggregate and disaggregated forms, i.e., by gender, family type, quintile, province, and locality. In addition to a direct and an indirect tax modules, the model includes modules for current social security programmes (i.e., old age grant, child support, disability grant, and care dependency grant), and five additional grant programmes (i.e., care giver support, the basic income grant, youth grant, unemployment grant and adult grant) that are not currently part of the social security system in South Africa but can be used to develop 'what if' scenarios. SATTSIM is hosted at the ADRS website and is accessible through its user-friendly platform.

MEMSA

SATTSIM

ADRS MODELS

- **MEMSA™: Macroeconometric Model of South Africa**
- **SATTSIM™: South African Tax and Transfer Simulation Model**
- **SATTSIM-Plus™: Augmented South African Tax and Transfer Simulation Model**
- **DIMMSIM-SA™: Dynamically Integrated Macro and Micro Simulation Models of South Africa**
- **LNP-Macro™: Linked National-Provincial Macroeconometric Model of South Africa**
- **LNP-MM™: Linked National-Provincial Macro-Micro Model of South Africa**

SATTSIM Plus

DIMMSIM-SA

LNP-Macro & LNP-MM

AUGMENTED SOUTH AFRICAN TAX AND TRANSFER SIMULATION MODEL (SATTSIM-PLUS)™

This model is an extension of SATTSIM. It allows users to produce projections of the tax revenue, social security beneficiaries and cost, and poverty and income distribution under alternative scenarios for the performance of macroeconomic indicators (e.g., growth, employment, inflation, and wage rate) over the next 15 years. Or, for a given scenario for the future performance of the South African economy (e.g., low or high economic growth during next three years), users can make changes to the social security and tax system and simulate their impact on the rate of poverty and income inequality. SATTSIM-Plus is hosted at the ADRS website and is accessible through its user-friendly platform.

DYNAMICALLY INTEGRATED MACRO AND MICRO SIMULATION MODELS OF SOUTH AFRICA (DIMMSIM-SA)™

This model integrates the ADRS macroeconomic model (MEMSA) with its household microsimulation model (SATTSIM) to capture the dynamic interactions between the macroeconomic performance and the poverty and income distribution at household level. The model is most suitable for the analysis of poverty and inequality and for the impact analyses of alternative macro and micro policies for growth and development. It includes two-way interactions between its macro and micro components such that (a) changes in macroeconomic variables (e.g., prices, employment, wage rates, benefits, transfers, etc.) influence the welfare of individuals and families, and (b) changes in household level economic conditions (e.g., poverty, inequality, consumption, taxes, eligibility for social grant, etc.) influence macroeconomic outcomes. DIMMSIM-SA is hosted at the ADRS website and is accessible through its user-friendly platform.

DIMMSIM-SA is most suitable for the impact analyses of alternative macro and micro policies for growth and development.

LINKED NATIONAL-PROVINCIAL MACROECONOMETRIC MODEL OF SOUTH AFRICA (LNP-MACRO)™

The purpose of the ADRS provincial macroeconomic model is to produce projections of growth, investment, and employment for 27 sectors of each of the nine provinces in South Africa. The model captures the economic structure of nine provinces using econometric estimations of sectors of provincial investment, output and employment and nine linked national-provincial input-output tables. The latter captures sector linkages within provinces and between provinces and the rest of the South African economy. The model is most suitable for forecasting the impact of national level policies on provincial economies or the impact of provincial initiatives on the province and the rest of the country. A second version of the model, **LINKED NATIONAL-PROVINCIAL MACRO-MICRO MODEL OF SOUTH AFRICA (LNP-MM)™**, allows additional assessments of the impact of policy scenarios on national and provincial poverty and income distribution.

For more information on ADRS models, visit the ADRS website or send your enquiries to adelzadeh@adrs-global.com.