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From stabilization to a knowledge-based economy

A computable general equilibrium modelling approach

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Foreword

Over the past few decades, macroeconomic policies in Egypt have produced growth that has not been inclusive enough particularly in terms of reducing poverty or creating decent work for the hundreds of thousands of unemployed Egyptian youth. Thus, the foremost challenge is to shift to a more inclusive growth trajectory. How can this be done? The authors of this paper make a strong case for a knowledge economy. In fact, this is not a matter of choice. The fast-moving pace of change is constantly pushing the technological frontier, demanding significant efforts to catch the technological leaders and achieve levels of productivity and competitiveness that will allow effective participation in the global economy. Can this be achieved within the framework of Egypt's Sustainable Development Strategy?

The answer given by the authors of this paper is yes, but conditional on investment in indigenous technological capacity and knowledge-based assets leading to increased investment and productivity growth. However, knowledge-inducing policies cannot be implemented in the abstract. They have to be context-specific and within the realm of possibilities of existing macroeconomic policies and 'industrial policy space'. Hence, this paper's choice of a computable general equilibrium model specifically designed to capture these linkages as an appropriate tool to test base-case and knowledge-inducing economic growth scenarios.

The results have shown that a knowledge-inducing growth scenario is expected to increase GDP growth up to 2 per cent per year over and above to the GoE and IMF base-case scenario over the period from 2020-2030, which can increase the per capita real GDP by an additional 16%. These results are driven by improvements on the external balance, both the trade and capital accounts, labour market skill structure and overall productivity of the economy at large.

What should be done to realize this envisaged scenario? The authors argue this will take more than just increased investment in research and development and modern infrastructure. It will require incentivizing the State, private businesses and academic institutions to advance economic diversification and encourage private investment and FDI towards high value-added sectors, especially manufacturing and service sectors with high export growth potential and new technologically advanced sectors in renewable energy. It will also require targeting the employment of women and youth, two groups with high unemployment rates, and high potential productivity.

Conducted simultaneously, alongside other economic governance reforms and with an equitable taxation policy, these measures can have a positive quantitative and qualitative impact on the long-term performance of the economy, inducing higher crowding-in and productivity of public and private investments as it will on endogenous growth dynamics where knowledge sectors and technological change play a lead role in shifting the productivity of the economy.

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Abbreviations

CBE	Central Bank of Egypt
CES	constant elasticity of substitution
CET	constant elasticity of transformation
CGE	computable general equilibrium
DSGE	dynamic stochastic general equilibrium
ERSAP	Economic Reform and Structural Adjustment Programme
ESCWA	Economic and Social Commission of Western Asia
FDI	foreign direct investment
GDP	gross domestic product
IMF	International Monetary Fund
ISIC	International Standard Industrial Classification of All Economic Activities
LE	Egyptian pound
OECD	Organisation for Economic Co-operation and Development
RDI	research, development and innovation
R&D	research and development
SAM	social accounting matrix
SCGE	spatial computable general equilibrium
TFP	total factor productivity
SNA	The System of National Accounts

Introduction and motivation

After 2011, intensifying unrest led to a rapid deterioration of the economic situation in Egypt. Three years after the onset of the political transformation, economic fundamentals were extremely fragile. The budget deficit reached almost 13 per cent of gross domestic product (GDP), economic growth declined to 2.9 per cent,[1] inflation stayed at double digits, and the shortage in foreign currency was so severe it forced the Central Bank of Egypt (CBE) to undertake drastic measures, restraining imports and capital outflows as international reserves reached a dangerously critical level. The macroeconomic stance at the end of 2015 again called for a full-fledged stabilization and reform package. In November 2016, Egypt announced a home-grown reform programme that led to the approval of a three-year $12 billion loan.

The economic programmes have had two components: one for short-term stabilization, the other long-term structural reform. Stabilization primarily aims to reduce inflation and deficits (budget and balance of payments), and give flexibility to the exchange rate. Despite problems such as high inflation, a slowdown in the level of economic activity and reduction in the real income of some households, especially those already vulnerable, stabilization measures are relatively easy to implement. Adverse effects are usually short-lived, followed by a noticeable improvement in key economic fundamentals. The relative ease of implementing this component of economic programmes and the high success rate stems from the fact that these stabilization measures are related to the demand side of the economy, which can be manipulated in the short run. It comes as no surprise that in the economic programmes of 1991 and 2006, and the current one, the Government of Egypt has implemented these measures successfully.

More daunting, however, is the reform component. In the two previous economic programmes, few efforts were directed in this area, and those were never completed. There are several reasons for this. First, stabilization efforts are easier to implement because the macroeconomy, in the short-run, is determined by the demand side, which can be manipulated using appropriate fiscal and monetary policies. Second, structural reforms are targeted at the supply side, which determines the behaviour of the macroeconomy in the long run, and hence its growth trajectory. Structural reforms aim to affect quasi-rigid issues like long-term investment path, sectoral distribution, and factors and total factor productivity. Third, there are always costs and benefits associated with stabilization and reform. Policymakers continuously weigh these costs and benefits and dynamically optimize their decisions based on the net effect. Stabilization efforts in economic programmes usually come first where policymakers have the motive to ensure their success, since deviation from the planned action means failure and eminent crisis. In addition, the rewards of sticking to stabilization efforts arrive quickly and with a low probability of failure. On the other hand, structural reforms come with all kinds of qualification. They are neither well defined nor straightforward. Costly to implement, they usually oppose the interests of a few groups benefiting from the current structure of the economy with all its limitations and distortions. By definition, expected benefits will be realized in the long run since they are structural changes, but must be paid for in the short run, which makes policymakers more reluctant to pay, especially after the macroeconomic stance has stabilized following successful implementation of the programme's first phase. Even if policymakers were to implement these structural reforms and withstand its short-run costs, success is far from certain as it affects the supply side in the economy, which cannot be manipulated by government policies, at least directly.

All the above may justify why the government has a good record in implementing stabilization efforts, but a bad one when it comes to enacting structural reforms. There is, however, significant cost associated with these missed reform opportunities. Lack of major development in the economy over decades and the reoccurrence of similar crises forcing the government and its citizens to pay additional costs are the negative outcomes of these missed opportunities.

[1] World Bank, "World Development Indicators". Available at https://datacatalog.worldbank.org/dataset/world-development-indicators.

With the current economic programme, there seems a determination not to repeat the same mistakes. The government realizes structural reform is the key to break the vicious cycle of crises. A good example is reform in the energy sector, where it launched an ambitious plan to phase out the energy subsidy by 2019. Despite its well-known distortionary effects on consumption and production patterns, and bias in favour of the rich, the subsidy has long been untouchable. The government has also enacted feed-in tariffs to encourage the supply of electricity from renewable sources such as solar and wind. Both of these reform measures have the potential to change the structure of the sector towards a more efficient use of energy, and the energy mix from traditional fossil fuel to more renewable green sources where the private sector is a principle player.

The country requires these types of reforms to structurally transform the economy and achieve its Sustainable Development Strategy (SDS): Egypt Vision 2030. One of the main goals of this strategy is that by 2030 the economy is a "balanced, knowledge-based, competitive, diversified, market economy". Not many would disagree with such a well-articulated aim. The more engaging debate relates to the genre of policies capable of achieving it, the task picked by this paper. High-tech goods and services are the most dynamic sectors in the world economy and trade, whereas specialization in commodities and unskilled labour intensive products is the surest path to immiserizing growth. Such goods and services are associated with innovation, the key determinant of productivity and competitiveness at global level. Enhanced productivity improves returns to firms and workers. This has a spillover effect on all sectors as overall demand tends to increase. The Republic of Korea underwent this transformation, focusing on innovation and development of high-tech goods and services as a means to move from the ranks of the poorest countries in the world to one of its richest economies. For instance, GDP per capita in the Republic of Korea increased from $6,508 in 1990 to $30,009 in 2017,[2] while high-tech exports increased from $11 billion in 1990 to $118 billion in 2016.[3]

The paper has two main objectives. First, it provides an overview of the Egypt's main macroeconomic and social indicators, highlighting the impact of economic reforms implemented since 2016 and arguing the case for a knowledge-based transformation targeting decent employment generation and productivity growth as necessary for sustainable, inclusive growth. Second, it provides a narrative of the economic and policy implications of such a transformation, based on a knowledge-based innovation-driven computable general equilibrium (CGE) model specifically designed for long-term analysis. Such a narrative is required as it can help policymakers design a road map with quantitative milestones, an integral part of Egypt Vision 2030.

The paper is organized as follows. Section I explores Egypt's last full-fledged economic programme, launched in the early 1990s, highlighting its stabilization and reform efforts. Section II presents the main elements of the 2016 programme and its short-term effects. Section III outlines the economic rationale, structural features and specification of the CGE model that depicts the transformation to a knowledge-based economy. In conclusion, Section IV provides policy implications and recommendations.

[2] Economist Intelligence Unit, "DataServices".

[3] World Bank, "World Development Indicators". Available at https://datacatalog.worldbank.org/dataset/world-development-indicators.

I. STABILIZATION NECESSARY BUT NOT SUFFICIENT: A LESSON FROM THE 1990S

Will macroeconomic stability translate into more investment and better-quality jobs? The answer offered by the Bretton Woods Institutions (the World Bank and the IMF) is a conditional yes. If accompanied by supportive medium- and long-term structural adjustment policies, such as the trade liberalization and regulatory/governance reforms, stabilization will lead to higher private sector and foreign investment, growth, employment generation and productivity gains. Poverty reduction and an expanding middle class are the final outcomes if the government works to "improve the business climate, reduce corruption, streamline the role of the state in the economy, strengthen competition, improve the governance and transparency of state owned enterprises, reduce barriers to trade, improve access to finance and land and facilitate better integration of women and young people in the labour market".[4] These structural reforms, the IMF suggests, will attract investment while increasing the country's credibility, supporting exports and promoting innovation.[5]

Does the theory work? Country experience shows that in the short run, restrictive monetary and fiscal policies can curb inflation, control budget deficit, stabilize the exchange rate market and restore imbalance in the external sector. The improvement in economic fundamentals often restores private sector confidence and brings positive expectations about the economy, spurring investment and growth. Historically, however, there is a dim part to these economic programmes, and Egypt's experience is no exception. These upbeat days are usually short-lived, and, after a few years, the economy reverts to its low state and the positive development trajectory is halted. Given this boom and bust cycle is well documented, many studies have questioned the reasons behind it.[6] A combination of short-lived reforms and credibility problems associated with the continuation of reforms is the most common justification. Regardless of the exact cause, a common denominator was that reforms – especially structural ones – stopped a few years after the onset of the reform programme, creating space for crony capitalism and socioeconomic inequality, aside from feeble rates of output and investment growth.

Since Egypt witnessed an episode of similar reform in early 1991, it would appear pertinent to reflect on the legacy of its stabilization and the structural adjustments of the 1990s, which had an enduring impact on society and the economy. The macroeconomic stance leading to the Economic Reform and Structural Adjustment Programme (ERSAP) was disastrous. Chronic inflation was rampant, reaching 25 per cent in 1987. Budget deficit, mainly financed by seigniorage, reached the unsustainable level of 20 per cent of GDP in 1991-1992.[7] Foreign debt reached 150 per cent of GDP in 1991, rendering Egypt incapable of paying its debt services: a monetary policy characterized by fiscal dominance with no nominal anchor. A multiple overvalued official exchange rates system was installed with the black-market exchange rate premium reaching 0.7.[8]

ERSAP had two main complementary objectives: to stabilize the macroeconomy and to transform the Egyptian economy from an inward to an outward market-oriented one. Despite an initial major slowdown in the level of economic activity resulting from contractionary fiscal and monetary policy, economic fundamentals were stabilized within three years of starting ERSAP (figure 1). Reaching the second objective proved more troublesome. Indeed, the government enacted measures to open the economy, including privatization, financial sector reform and reducing trade barriers. As a result, the size of the private sector increased, and more investment was directed to modern sectors such as finance and communication.

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[4] IMF, 2018.

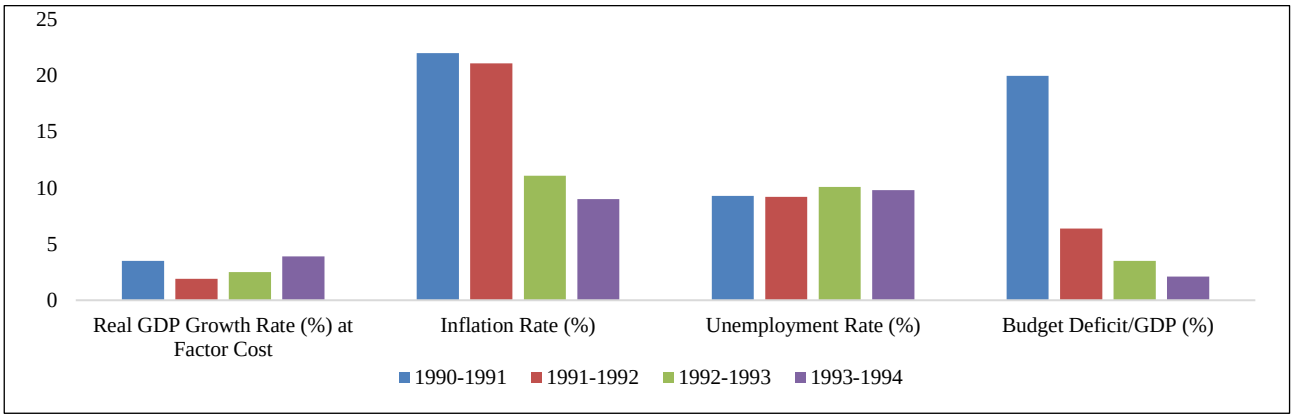
[5] Ibid.

[6] From the 1990s, the boom-bust cycle has been extensively documented. For example, Aaron Tornell and Frank Westermann, "Boom-Bust Cycles in Credit Constrained Economies: Facts and Explanations" (2001), and "Boom-Bust Cycles in Middle Income Countries: Facts and Explanation", CESifo Working Paper No. 755, Category 6: Monetary Policy and International Finance (2002).

[7] African Development Bank Group, 2000.

[8] Mohieldin and Kouchouk, 2002.

Figure 1. Evolution of economic indicators during Economic Reform and Structural Adjustment Programme



Source: African Development Bank Group, 2000.

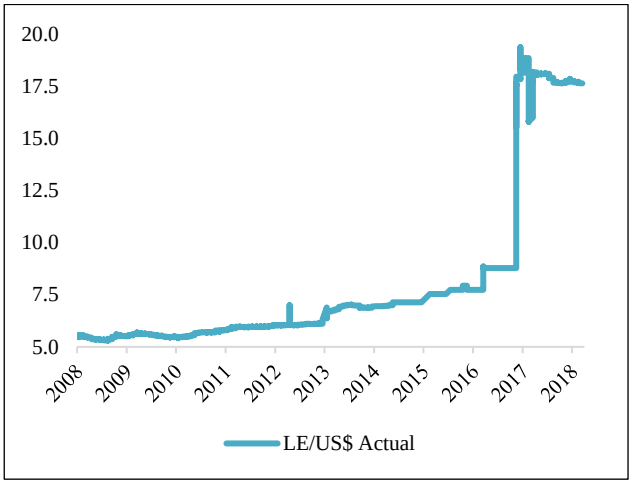
Fast forward to the beginning of the new millennium, and, after almost 20 years of ERSAP, it seems the 1990s programme failed to fundamentally change the structure of the economy. Productivity is low, private sector contribution and the investment rate are feeble, quality jobs are rare and informal employment and poverty rampant. The balance of payment inflows depend on unstable rentier-based sources and merchandise exports are low in quantity and value added. The Egyptian economy suffered from endemic structural fragilities even before political upheaval and uncertainty. As a result, with the onset of instability, the macroeconomy re-entered the intensive care unit and a new economic programme had to be administered.

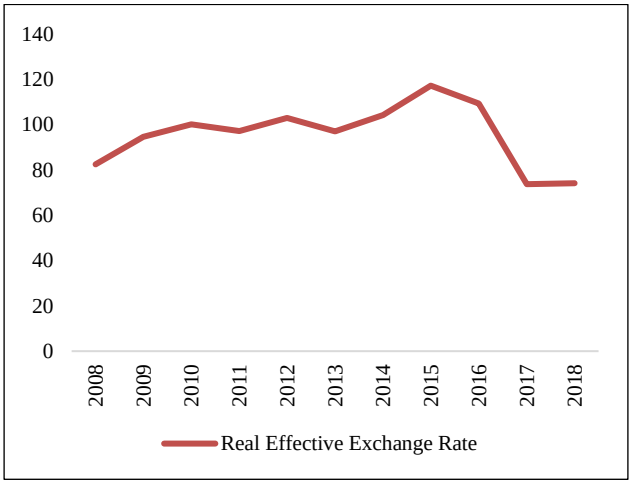
II. 2016 ECONOMIC PROGRAMME AND ITS SHORT-TERM EFFECTS

A. STABILIZATION RESTORES CONFIDENCE

The economy is on its way to recovering from the shock of the currency devaluation of November 2016 (by approximately 50 per cent). The first positive sign is stability in the foreign currency market, with an improvement in the real effective exchange rate (figure 2), indicating Egypt's tradable goods may become more competitive on international markets, reinforcing its external position. The second success is bringing inflation closer to its pre-devaluation average rate (10-15 per cent). It declined from a near record high of 32 per cent in April 2017 to 13 per cent in April 2018. This will pave way for further reductions in key interest rates, including the yield on the treasury bonds, which have declined since July 2017.

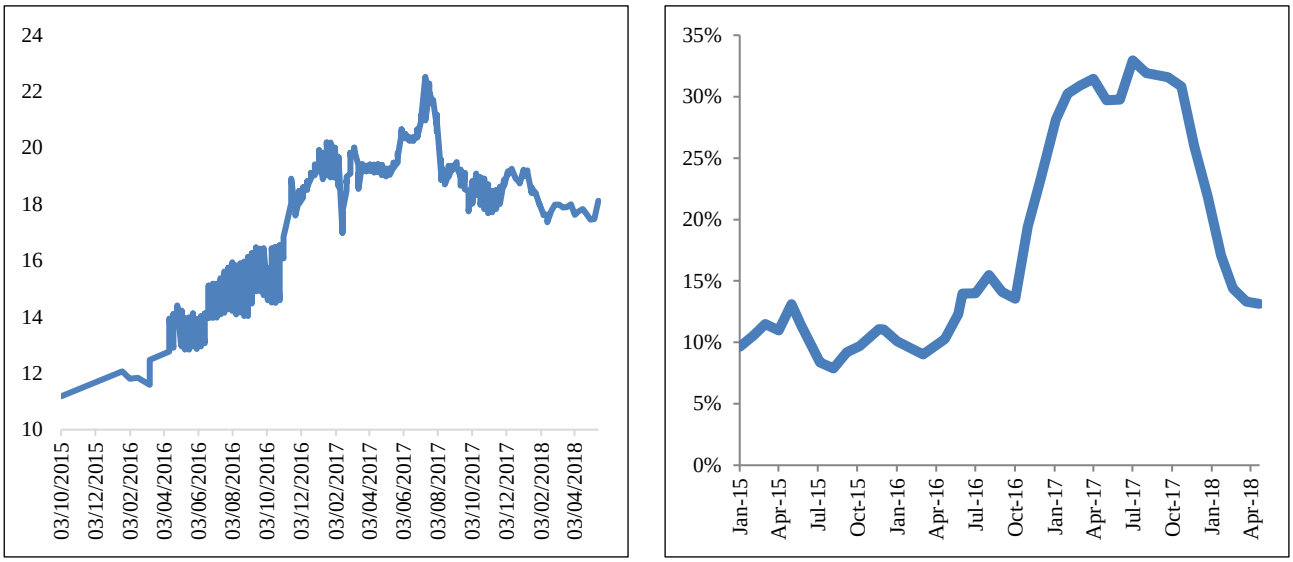
Figure 2. Official exchange rate (Egyptian pounds/US dollars) and real effective exchange rate





Source: CBE, 2018 and World Bank, 2018.

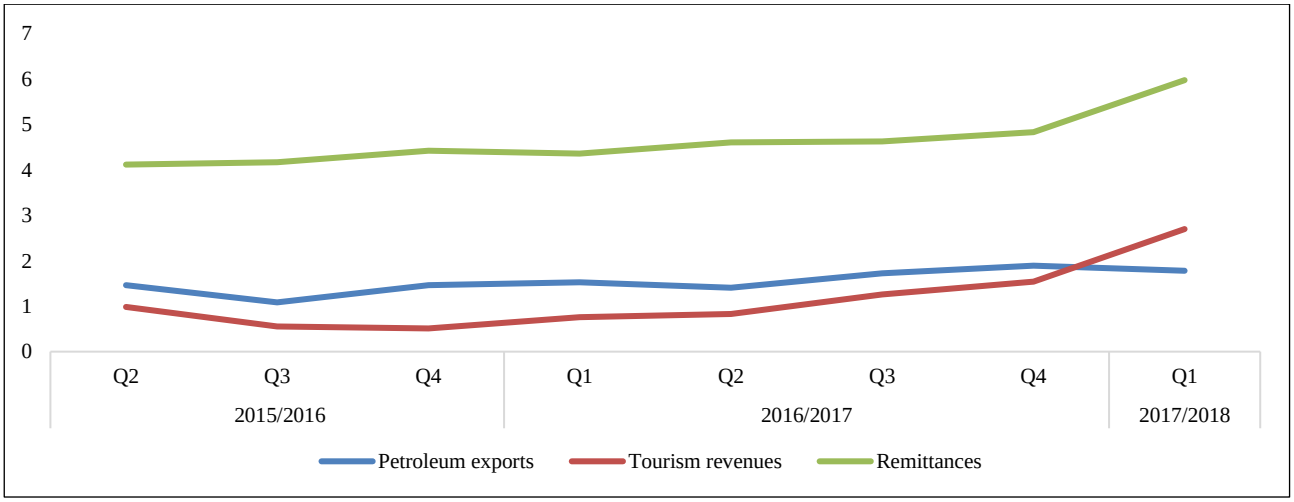
Figure 3. Yield on treasury bills in Egyptian pounds and inflation rate, 2015-2018



Source: CBE, 2018.

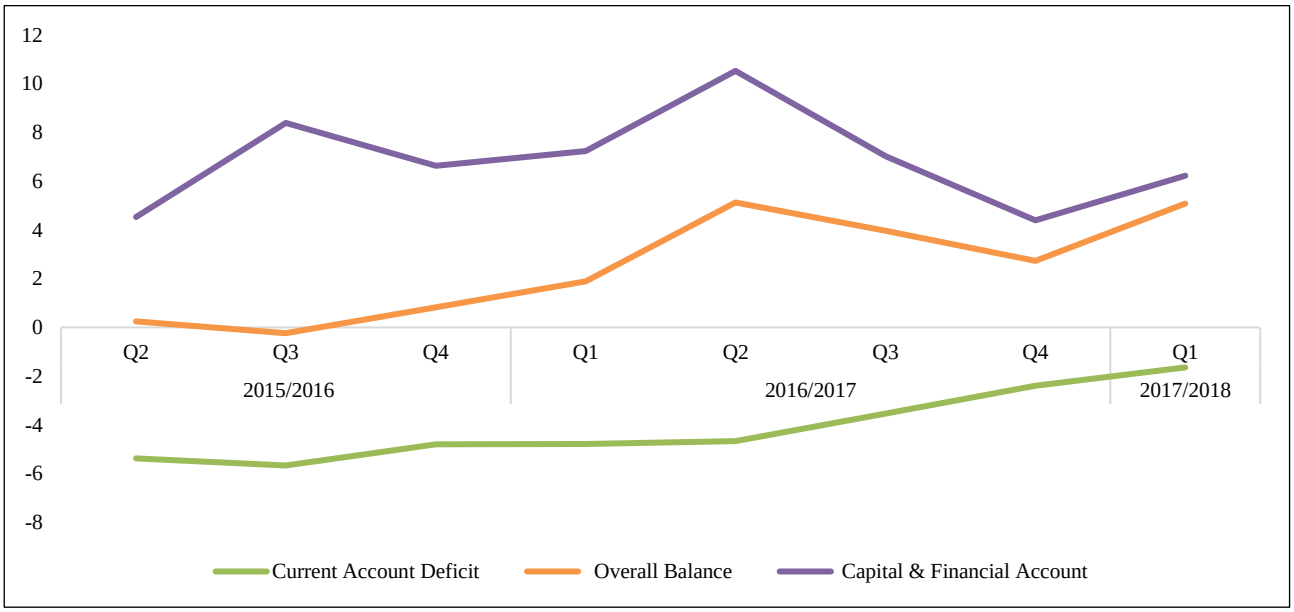
The improvement in the current account (from a $19.8 billion deficit in 2016 to a $15.6 billion deficit in 2017) was driven to some extent by higher petroleum exports, and slightly increased remittances from Egyptians working abroad (figure 4). The quarterly evolution, and a significant increase in remittances in the first quarter of 2018, is evident. The major relief, however, came from capital and financial accounts. Exchange rate stability, aided by an attractively high interest rate on Egyptian treasury bills, induced a significant rise in speculative capital inflows (figure 6) due mainly to a notable increase in the share of foreign holdings of treasury bills. At the same time, there was a notable rise in foreign direct investment (FDI) from $6.9 billion in 2016 to $7.9 billion in 2017 (mainly in the oil sector). Thus, the capital and financial account increased from $21.3 billion to $29 billion (figure 5). As a result, the overall balance of payments reached a surplus of $13.7 billion in 2017, from a deficit of $2.8 billion in 2016, which translates into reserves rising from a historic low of $13.6 billion in January 2013 to $38.2 billion in January 2018 (approximately six to seven months of import coverage).

Figure 4. Petroleum exports, tourism revenues, remittances 2015-2018
(*Billions of US dollars*)



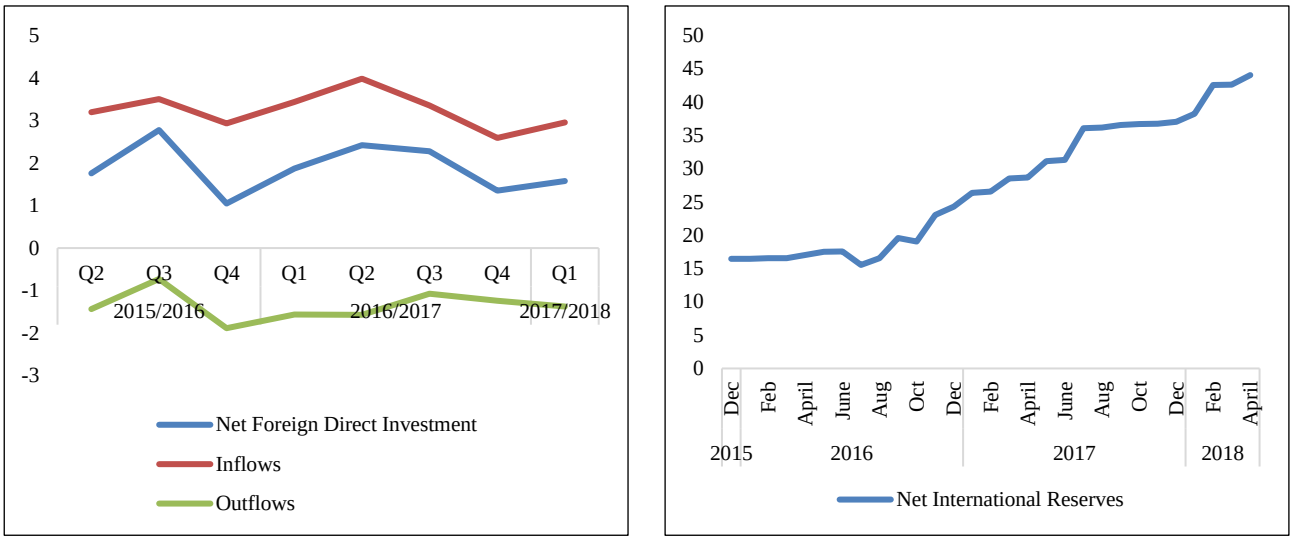
Source: CBE, 2018.

Figure 5. Balance of payments 2015-2018
(Billions of US dollars)



Source: CBE, 2018.

Figure 6. Net FDI, inflows and outflows, and net international reserves
(Billions of US dollars)



Source: CBE, 2018.

The ramifications of stabilization can also be detected in the growth rate of GDP, which was projected to be 5.2 per cent in 2017/2018. As shown in table 1, major expenditure items contributing to the growth rate between 2017 and 2018 are capital formation, at 23.5 per cent, and exports, which grew at a phenomenal 127.4 per cent. But net exports removed 11.2 per cent from GDP during the same period, as imports grew by 62.2 per cent. Private consumption expenditure, the largest component of GDP, experienced only a slight growth in 2018 (1.1 per cent), compared with the rates in 2016 and 2017.

TABLE 1. GDP GROWTH RATE BY EXPENDITURE

	2016	2017	2018
1. GDP at market prices (2+5-6)	4.3	4.2	5.2
2. Total domestic expenditure (3+4)	5.5	5.0	3.9
3. Final consumption	4.6	4.0	1.4
Final private consumption	4.7	4.2	1.1
Final government consumption	3.9	2.5	4.6
4. Gross capital formation	11.2	11.3	23.5
Investments	13.0	12.2	24.1
Change in stock	-19.5	-9.2	8.1
5. Exports of goods and services	-15.0	86.0	127.4
6. Imports of goods and services	-2.2	52.5	62.2
7. Domestic resources gap (5-6)	18.4	13.7	-11.2

Source: CBE, March 2018.

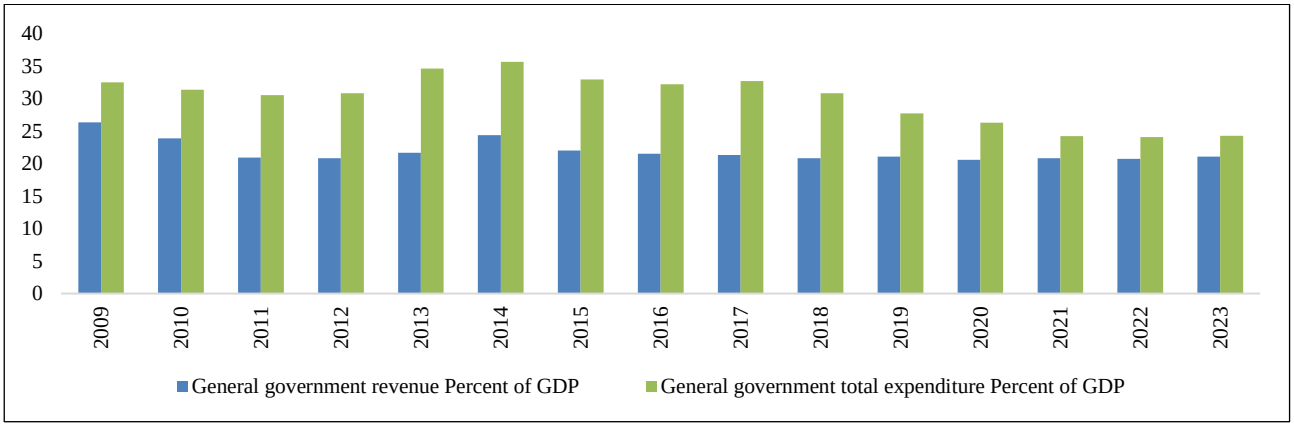
In short, stabilization has restored confidence in the economy, and gradual monetary easing is expected to deepen this recovery. In this base case scenario, portfolio investment should stabilize – given the expected decline in returns in the local currency – and direct investment should continue strongly, buoyed by good prospects for the energy sector. Policymakers may need to turn their attention to the following medium- to long-term challenges.

B. MEDIUM- TO LONG-TERM POLICY CHALLENGES

1. *Fiscal and monetary policy*

To ensure fiscal and debt sustainability, the economy must generate increased domestic savings to finance investment in health, education and infrastructure. The challenge lies in raising tax revenue to GDP – as recommended in ESCWA's report on rethinking fiscal policy in the Arab Region – and limiting short-term speculative capital. Figure 7 depicts a downward trend in fiscal expenditures and an upward trend in fiscal revenues. The trajectory change is due to newly implemented reforms that targeted improving public financial management and enforcing additional transparency and accountability measures. According to the IMF Fiscal Monitor (April 2018), Egypt will achieve a primary budget surplus in 2018 and debt as a percentage of GDP is expected to decline for the first time in decades. This reduction in debt to GDP and the higher growth in income (expected at 5.2 per cent in 2018) will have a positive impact on debt sustainability. Further examination is needed to identify the impetus behind the increase in fiscal revenues.

Figure 7. General government revenue and expenditure as per cent of GDP



Source: IMF estimates.

The objectives of Egypt's tax reform include widening the tax base and increasing collections and advancing progressive taxation. These measures are aimed at increasing fiscal space for additional spending on infrastructure, health, education and additional social safety nets. At this stage, the ESCWA recommendation for compulsory income reporting might be appropriate to implement successful tax reforms. In addition to tax reforms, shifting expenditures would have a significant impact, particularly further reducing energy subsidies. This reduction, however, may induce further inflation, put a brake on monetary easing and thus pose a challenge to debt sustainability in the medium term. The biggest challenge will be avoiding financial fragility with further increases expected in short-term speculative capital inflows. A willingness to keep the nominal exchange rate fixed, or close to pre-determined, combined with few barriers to capital flows and the existence of wide "spreads" between returns on home assets and borrowing rates from abroad, will push the system towards being long on domestic assets and short on foreign holdings.[9] "Stock-flow repercussions through the balance of payments and the financial system's flows of funds and balance sheets may then set off a dynamic macro process which is unstable".[10]

2. *Productivity and employment*

The economy is vulnerable to many exogenous shocks. Other than the obvious geopolitical risk factors, worker remittances, still the main source of foreign exchange inflows, are not expected to rise and may well decline given the increasing pressure on fiscal space in the Cooperation Council for the Arab States of the Gulf (GCC), and the Kingdom of Saudi Arabia especially. Further, Suez Canal and tourism revenue generally has increased slightly but tourism receipts are historically volatile. Third, Egypt is still a net importer of oil, and until this changes (driven by a surge in revenues from the newly discovered natural gas fields), the gap between local and international fuel prices will remain a determining force in the macroeconomic and fiscal policy landscape.

Responding to these challenges will require major improvements in productivity, which will not be easy. There have been some changes in economic structure over the past three decades, mainly resulting from the movement of labour from agriculture to lower value-added service sectors. The share of manufacturing in GDP has remained low and sluggish, and trade concentrated around oil and low to medium volumes of value-added products. Egypt's manufacturing sector is considered highly energy and capital intensive, facilitated by energy subsidies. The share of services in total output increased but remained mainly concentrated at the low end of the value-added chain in the informal sector, resulting in low-paid, low-quality and low-productivity jobs.

According to the IMF,[11] the biggest challenge in the short, medium and long term is creating more jobs. Egypt needs 700,000 new jobs annually. Undertaking a transformation within sectors and towards areas with a higher knowledge component therefore becomes the main challenge. Any diversification plan will not be attained without unleashing the potential of the private sector to create productive employment. Improving the regulatory framework is essential to induce the private sector to fulfil this role.

3. *Poverty and distribution*

According to the Central Agency for Public Mobilization and Statistics (CAPMAS), 28 per cent of Egyptian families were extremely poor in 2015, their average spending falling below the poverty line of LE 1,800 per month. Another 25 per cent were vulnerable to extreme poverty, with average spending ranging between LE 1,800 and 3,000 per month. That means that in 2015, more than half the population was either extremely poor or vulnerable to poverty. The middle classes, or households spending more than LE 3,000 but less than the LE 4,500 spent by the economically affluent, were estimated at about 40 per cent of the population. But one of Egypt's fundamental challenges is that its lower-middle class – the majority of this 40 per cent –

[9] Taylor, 1998.

[10] Ibid.

[11] IMF, 2018.

are located just above the vulnerability line in that they spend between LE 3,000 and 3,500 per month. Even a small price increase will cause them to fall into moderate poverty and thus become vulnerable to extreme poverty in the future.

What does this imply for current poverty and inequality profile? When the impact of recent price changes on real income and expenditure is factored in, estimates would indicate that the extremely poor population may have reached up to 32-35 per cent of the population and the vulnerable population may now border on 30 per cent. The implication is that Egypt's middle class may have already shrunk by one third, to about 30 per cent of the population, since 2015. To further grasp the magnitude of this, it is useful to recall that in 2011 the size of the middle class was estimated by ESCWA to be approximately 60 per cent. Paradoxically, Egypt's income inequality may have declined since 2015 because a higher share of the population is more equally deprived. The growth process from 2000 to today has been neither pro-poor nor pro-middle class. The challenge is to turn a historically anti-poor growth pattern to a pro-poor, pro-middle-class one.

III. MODELLING TRANSFORMATION TO A KNOWLEDGE ECONOMY

This section reports the results of applying a knowledge-based innovation-driven multisectoral computable general equilibrium simulation model to Egypt. The objective is to chart potential long-term scenarios that mimic the initial conditions and policy decisions discussed in the previous section (technical details of the model's structure are explained in the annex).

The main features of the model are covered in subsection A. In subsection B, data requirements and defining policy choices are reviewed. Subsection C looks at assumptions invoked in the closure rules. Section 5 explains the two scenarios that were formulated, one base case scenario and another pro-innovation scenario. Finally, Section 6 shows the results of applying this model to those two specific scenarios.

A. AN OVERVIEW OF KNOWLEDGE-BASED INNOVATION-ORIENTED DYNAMIC COMPUTABLE GENERAL EQUILIBRIUM MODEL

The relation between research and development (R&D) investment and productivity growth was first formalized by Griliches[12] and Terleckyj[13] and has been widely accepted since. Yet markets are likely to underprovide R&D due to the wedge between the private returns of innovator and social returns for the economy overall.[14] To address this potential market failure, government can design an array of policy interventions to stimulate innovation and realign public and private interests. The impact assessment of such policies, however, requires that an adequate modelling framework be developed to capture the specific characteristics of research and innovation.

The literature records four conceptually different traditions in RDI-based modelling: macroeconometric models, computable general equilibrium (CGE) models, spatial computable general equilibrium (SCGE) models, and dynamic stochastic general equilibrium (DSGE) models.

The main characteristic of macroeconometric models is their reliance on long-run time series data, econometrically estimated parameters and a solid empirical base. CGE models rely on the Arrow-Debreu framework, where markets are always in equilibrium, balancing supply and demand through the system of prices. Policies altering the equilibrium are considered shocks that induce new equilibriums into the interaction between consumers and producers in the different markets. SCGE models are similar to CGE models in their structure but they explicitly model regional economies and spatial linkage connecting them, such as trade of goods and services, factor mobility, income flows and knowledge spillovers. Finally, DSGE models follow

[12] Griliches, 1973.

[13] Terleckyj, 1974.

[14] Griliches, 1995; Jones and Williams, 1998; Klette, Møen and Griliches, 2000; Bye, Faehn and Grünfeld, 2011.

the rigorous market equilibrium concept of CGE models but derive agents' decision rules explicitly from intertemporal optimization under technological, institutional and budgetary constraints, the main difference with respect to the two other model types. The internalization of intertemporal considerations from economic agents makes DSGE modes particularly valuable instruments for knowledge and innovation-related policy analysis.

The overall structure of the knowledge and innovation-oriented dynamic CGE simulation modelling system for Egypt is schematically represented below. The system is composed of three specific models. The first is the static (within-period) model generally used to generate the equilibrium solution per year. Based on the CGE tradition, this model includes three main modules: (i) the consistency accounting relations reflected in the social accounting matrix (SAM) structure; (ii) the independent behavioural rules of economic agents such as producers, consumers, importers and exporters; and (iii) the model closure rules or market clearing mechanisms such as the macroeconomic saving-investment balance, the commodity markets equilibrium, government income and expenditure clearing rule. To ensure the dynamic path of the system, the second model provides dynamic adjustment relations, such as physical capital stock adjustment mechanisms, breakdown of labour supply by skill category, investment allocation between domestic and FDI flows and wage rates dynamic adjustment relations.

Given its specific orientation towards knowledge creation and dissemination, research and innovation enhancement, the third dynamic adjustment model derives the mathematical relations pertaining to the knowledge economy transformation process based on R&D, innovation, creative outputs and investment in intangible assets policy instruments. These represent the main contribution to the traditional CGE modelling process. In principle, knowledge stock, software development, creative outputs and other intangible assets need to have their capital stock updating mechanisms. Here, a similar approach to update physical capital was used, founded on base year capital stock, consumption of fixed capital, investment spending in these intangible assets and expected return on capital. The process of identifying knowledge stock and intangible assets from the industrial classification system of the United Nations (ISIC, or International standard industrial classification of all economic activities) is explained below. Further, in this third model, the impact of dynamic changes in knowledge and other intangible assets on total factor productivity, and labour and capital efficiencies by sector, is mathematically formulated based on the concept of elasticity of spillover effects. Finally, mathematical specification of labour movement across skill categories due to efficiency enhancement is also developed in this third model.

TABLE 2. ISSUE-ORIENTED COMPUTABLE GENERAL EQUILIBRIUM SIMULATION MODELLING SYSTEM FOR EGYPT

Issue-oriented computable general equilibrium simulation model for Egypt		
Inter-period dynamic submodel	**Within-period static submodel**	**Knowledge economy/innovation dynamic**
Physical capital stock adjustment	Accounting and consistency within-period relation	Knowledge stock updating mechanism
Population and labour force supply adjustment	Behavioural decisions of economic agents (producer/consumer/exporter)	Software, creative output and intangible assets updating mechanism
Labor supply by skill category	Closure rules and market clearing mechanisms (macroeconomic/commodity markets/government)	Total factor productivity spillover effects
Investment allocation (domestic/foreign direct investment)		Labour and capital spillover effects
Wage rates adjustment mechanisms		Adjustment of labour structure by skill category

The CGE modelling system developed in this paper represents an economy with the following features:

- The production sphere of the economy is composed of 13 production activities/commodities (agriculture, extraction, petroleum products, manufacturing industries, electricity and water, building and construction, transport and trade, information and communication, finance and insurance, real estate and business services, R&D, education and health and public administration);
- The model includes five domestic institutions or economic agents (urban and rural households, private and public corporations, and general government) as well as the outside world. Domestic institutions have both current and capital accounts;
- Factors of production include labour and capital services. Labour factors (or compensation of employees) are broken down by production activity, economic sector (private, public and government labour) and skill category (high-, medium- and low-skilled labour). Capital services include public and private accounts for each production activity. The markets of goods and services in the model are composed of domestic, imported, exported and composite commodities (merging domestic with imported goods), with each divided into 13 commodity types;
- Gross capital formation is composed of private (households and private companies) and public (government and public enterprises) investments as well as FDI. The SAM and the model make the distinction between investments by sectors of origin and destination using a square matrix;
- Government account disaggregates net tax income into direct and indirect taxes and subsidies. Direct taxes include personal and corporate tax. Indirect taxes are broken down into import duties, the newly adopted value-added taxes and other commodity indirect taxes. Commodity subsidies are divided into food supplies, petroleum products, electricity and other subsidies;
- The rest of the world account includes net transfers from abroad in the form of worker remittances, investment income, foreign direct investments, current transfers to domestic institutions and imports and exports of goods and services.

In the within-period model, each producer (represented by an activity) is assumed to maximize profits, defined as the difference between revenue earned and the cost of factors and intermediate inputs, subject to a production technology constraint (the production function). The production function is explained as a multilevel nested function. At the top level, the technology is specified by a constant elasticity of substitution (CES) function of the quantities of value added and intermediate inputs. This choice is preferable if empirical evidence suggests that available techniques permit the aggregate mix between value added and intermediate inputs to vary; if not, a Leontief fixed quantity share production function is adopted.

Value added is itself a two-level CES function of primary factors, whereas the aggregate intermediate input is defined as a Leontief function of disaggregated intermediate inputs. The sector-specific value added uses a CES function to allocate income between compensation of employees (income of labour services) and gross operating surplus (return on capital services). Given the important role of human capital formation in the transformation process, a CES disaggregation function links skill categories of labourers involved in the production process.

The model assumes that there is considerable unemployment for a given labour category. Each activity is free to hire any desired quantity at its fixed, activity-specific wage (which, implicitly, is indexed to the model numéraire, a basic standard by which value is computed). This formulation also permits estimates for unemployment rates if the quantity of supplied labour is provided in the inter-period model.

On the supply side, aggregated domestic output is allocated between exports and domestic sales on the assumption that suppliers maximize sales revenue for any given aggregate output level, subject to imperfect transformability between exports and domestic sales, expressed by a constant elasticity of transformation (CET) function. In international markets, export demands are infinitely elastic at given world prices. The price

received by domestic suppliers for exports is expressed in domestic currency and adjusted for the transactions cost (to the border) and export taxes (if any). The supply price for domestic sales is equal to the price paid by domestic demanders, minus the transaction cost of domestic marketing (from the supplier to the demander) per unit of domestic sales. If the commodity is not exported, total output is passed to the domestic market.

Households (disaggregated into urban and rural areas) receive income from the factors of production (directly or indirectly, via the enterprises), and transfers from other institutions. Transfers from the rest of the world to households are fixed in foreign currency. In fact, all transfers between the rest of the world and domestic institutions and factors in the model are fixed in foreign currency. Households use their income to pay direct taxes, save, consume goods and services, and make transfers to other institutions.

Direct taxes, transfers to other domestic institutions and savings are defined as fixed shares of household income. Income that remains (after taxes, savings and transfers to other institutions) is spent on consumption. Household consumption covers marketed commodities, purchased at market prices. It is allocated across different commodities according to a linear expenditure system demand functions. Instead of being paid directly to households, factor incomes may be paid to one or more enterprises. Private and public enterprises may also receive transfers from other institutions. Enterprise revenues are allocated to direct taxes, savings and transfers to other institutions. Apart from this, payments to and from enterprises are modelled in the same way as the same payments to and from households.

The government collects taxes and receives transfers from other institutions. All taxes are at fixed ad valorem rates. The government uses this income to purchase commodities for its consumption and for transfers to other institutions. Government consumption is fixed in real terms whereas government transfers to domestic institutions (urban and rural households and public and private enterprises) are fixed in nominal terms. Government savings (the difference between government income and current spending) is computed as a residual. The rest of the world is the only remaining institution. As noted, transfer payments from the rest of the world to domestic institutions and factors are all fixed in foreign currency. Commodity trade with the rest of the world and foreign savings (or the current account deficit) will be discussed in the closure rules (annex).

B. DEFINING POLICY CHOICES

The issue-oriented economy-wide simulation model is designed to capture the medium- to long-term transformation process towards a knowledge economy based on appropriate policies for R&D, innovation, creativity and other productivity enhancement measures. This orientation has its start-up in the selection of the disaggregation levels of the SAM and the model, as well as their specific structure.

To generate alternative future development paths for Egypt, a comprehensive and consistent set of policy measures and development choices need to be defined. These measures can be grouped under six specific categories.

The **first category** includes policy variables and/or external conditions reflecting current transfers to the Egyptian economy in foreign currency, such as return on Egypt's investments abroad, worker remittances and other transfers to domestic institutions (government, households and corporation).

The **second category** determines current government spending and capital transfers, including government final consumption expenditure in real terms, broken down by public wage bill and purchases of goods and services, current government transfers to domestic and foreign institutions in nominal terms, and the allocation of government final consumption spending to different commodity groups. Tax and subsidy rates are also part of government strategy to reduce price distortions in the domestic markets and increase revenue through a new value-added tax system on the one hand, and improving the tax collection process on the other. These measures are fully defined in the fiscal reform agreement between the IMF and Egypt. To properly deal with this recent agreement, Egypt's tax system in the model is broken down into direct taxes on

households and corporations, value-added taxes, import taxes and other commodity indirect taxes. Subsidies differentiate between the rates applied to petroleum products, electricity, food supplies and other subsidies.

The **third category** is concerned with the pricing policy at large. The inputs here include fixed wage rates by skill category, exchange rate policy and expected movement in the world price of exports and imports. Since gross fixed capital formation is considered one of the tools that can be applied to achieve growth and productivity, the **fourth category** of policy measures relates to investment quantity and allocation patterns. Both the magnitude and distribution patterns of public and private investment are exogenously handled in the model. Further, gross fixed capital formation is composed of domestic investment and FDI.

The **fifth category** concerns parameters and variables ensuring the economy's dynamic path. It includes base year population and labour force, alongside parameters to project their future values, such as the natural population growth, the breakdown of population among urban and rural areas based on expected internal migration, the participation rate or the gross activity rate of the labour force. Base year capital stocks in the private and public sectors, the prevailing depreciation rates (or consumption of fixed capital) and the return on fixed capital are also needed to dynamically adjust physical capital stock over time.

On the knowledge and research, development and innovation (RDI) fronts, the ratio of return on knowledge stock to its base year value needs to be estimated, guesstimated or determined from similar studies. The analytical part is based on research by the European Commission and the Organisation for Economic Co-operation and Development (OECD). Depreciation of knowledge is another concept to be identified and measured. In previous studies, knowledge depreciation has been neglected or not considered as part of the knowledge capital stock updating mechanism. In the model, it is assumed that the creation of knowledge and its updating over time needs investment in RDI, in addition to a per cent of gross fixed capital formation in the education sector. Similar parameters and base year input indicators are needed for the adjustment of the software industry, information technology and other intangible assets, such as cultural and creative services, trademarks and industrial designs, printing and publishing, and online creative products. Determining the subsectors to be used in updating software and other intangible assets requires more disaggregation than the basic 13 sectors of the model. This is explained in the annex.

The **sixth category** of inputs needed to run the model are the behavioural parameters of the within-period model, such as the elasticity of substitution between domestic and imported goods and services, value added and intermediate inputs in the production function by economic activity, labour compensation and capital income, as well as the elasticity of substitution among labour income by skill category. The model also uses an elasticity of transformation to allocate gross output between domestic sales and exports, and estimates of trade elasticity by sector based on a mathematical relation that computes world demand for Egyptian goods as a function of the relative prices of domestic prices and average world prices.

Estimates for the elasticity of spillover effects of knowledge creation and RDI enhancement policies on total factor productivity, labour efficiency by skill category and the efficiency of using capital stock are required for the inter-period dynamic relations. Such estimates assess the impact of knowledge and RDI transformation policy measures on total factor productivity and factors efficiency in the sectoral production functions of the economy.

C. Formulation of the tested development scenarios

It must be flagged that the model applied is highly constrained in its assumptions. For example, an export-led growth where global demand induces a process of rapid structural transformation and technological transfer à la East Asia is ruled out from the start. It is important to stress the objective of this exercise is not to model the implications of implementing a vision of long-term structural transformation where there is drastic structural change, such as in the case of the Republic of Korea during the 1980s. Rather, the objective is to model the implications of enhancing the knowledge generation spillover effects within the existing macroeconomic framework agreed with the IMF.

To this end, two questions will be addressed:

(a) What are the long-term growth prospects for the Egyptian economy in the best-case scenario based on the IMF agreement (assuming there are no shocks from the balance of payments such as explained previously)?

(b) Taking the assumptions related to scenario one into account, what are the macroeconomic implications of implementing knowledge-based pro-innovation policies?

Based on the above rationale, two development scenarios are formulated. The first assumes the continuation of the current policy measures, including foreign exchange rate floating measures, encouraging exports and rationalizing imports. A continuation of public and private investment quantities and allocation patterns are also considered. Government revenue and spending policies follow the same pattern, with special references to the adopted fiscal reform programme concluded with the IMF. This scenario assumes that Egypt will pursue its policy of encouraging FDI as well as private initiative. In particular, the new value-added tax programme and fuel and electricity subsidy elimination measures are part of this scenario.

The second scenario assumes Egypt is applying advanced measures towards transforming to a knowledge economy. This would include the development of high value-added knowledge-intensive technology-based manufacturing and services activities based on increased current and capital spending on R&D, innovation, creative outputs and intangible assets.

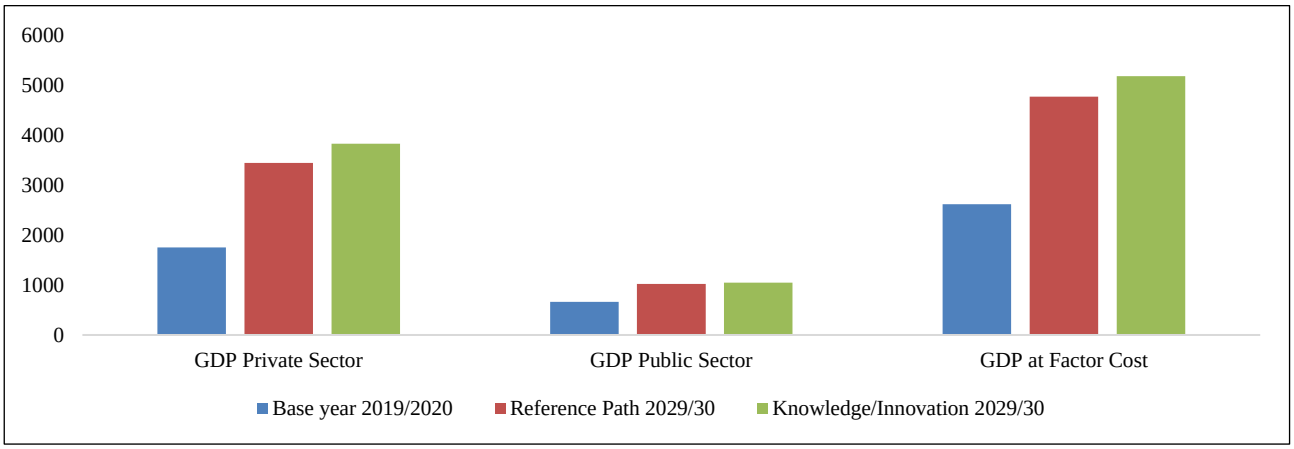
Given its long-term nature, the policy instruments for applying this knowledge-oriented scenario include public, private and FDI investment quantities and allocation patterns, plus public spending measures to encourage the transformation process. The adopted policies will concentrate on the reallocation process of public and private capital and current spending towards knowledge and innovation-related industries and sectors rather than increasing the aggregate quantity of gross fixed capital formation. RDI, information and communication and real estate and business, and financial and cultural services will all benefit from this reallocation process, while retaining reasonable investment growth rates for other economic sectors. However, higher expenditure on an enabling environment, such as education and health, is considered. This would reflect government and non-government spending on training human capital formation (the process of acquiring skills). To implement this second scenario, the mechanisms of updating knowledge and intangible assets are activated in order to compute the spillover effects on total factor productivity and efficiency of inputs in the sectoral production functions using sector-specific elasticity of spillover.

D. MAIN RESULTS

As per figure 8 on the GDP sources at factor cost, there is a net amelioration of the private GDP between the reference path and the knowledge innovation scenario, which will reach a growth of 7.1 per cent in scenario one and 9.6 per cent in scenario two in 2029-2030. There is no significant growth between the two scenarios for public and government GDP, but the GDP at factor cost will experience a high growth of 8.4 per cent in the knowledge innovation scenario. Thus, the transformation process is majorly felt in the medium- to long-term path.

Based on the specific structure of the Egyptian economy, the set of sectors contributing to the long-term transformation to the knowledge innovation economy pertains mainly to the private sector. Based on this rationale, the terminal year growth rate of the private GDP in real term has reached 9.6 per cent, whereas the public enterprises GDP growth rate is only approximately 5.4 per cent.

Figure 8. GDP sources at factor cost of alternative scenarios
(*Real terms, billions of Egyptian pounds*)



As per figure 9, the adopted knowledge innovation policy measures contributed to increasing the annual growth rate of per capita real GDP. Under the reference path and the knowledge innovation scenarios, this was LE 38,565 and 44,738 respectively, which suggests applying the knowledge innovation scenario would help improve the quality of life and welfare of Egyptian citizens. The difference in performance between the two scenarios becomes significant from 2024-2025, as noted in figure 10, more than five years after knowledge innovation policy measures are applied.

Figure 9. Per capita real GDP
(*Real terms, Egyptian pounds*)

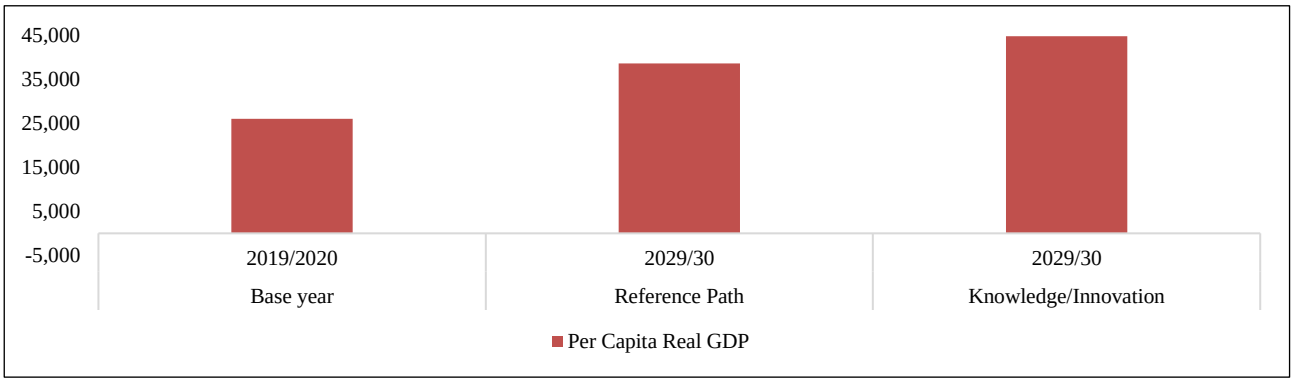
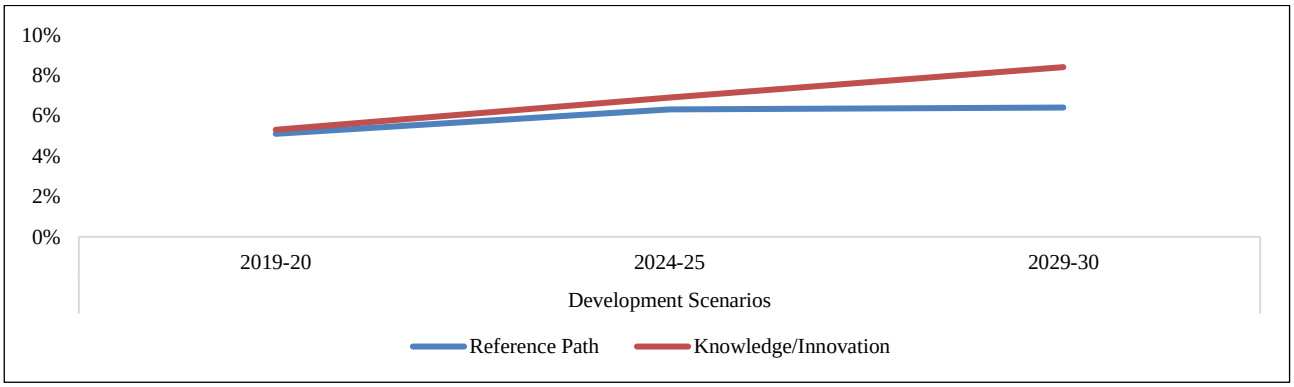
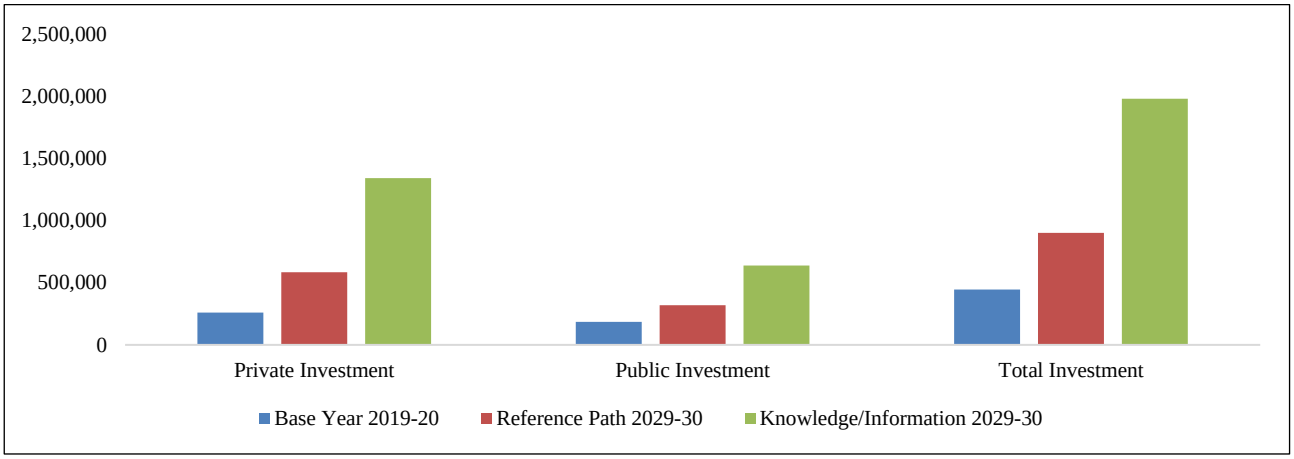


Figure 10. GDP growth in the development scenarios
(*Percentage*)



As per figure 11, given the limited change in the quantity of total investment between the scenarios, gains in the growth rates of most GDP components associated with the knowledge-innovation scenario results primarily from the reallocation of private and public gross fixed capital formation, government policies and incentives to promote this transformation, and total factor productivity and efficiency of inputs improvements. It is noted that according to the model's specification, the efficiency gain is the outcome of the spillover effect of changes in knowledge stock over time, software development and other intangible assets. The magnitude is sector specific, based on an elasticity of spillover reflecting the response of the sector to the increased assets and stocks.

Figure 11. Investment in alternative scenarios
(*Real terms, millions of Egyptian pounds*)



According to figure 12, the annual growth rate of real exports 2029-2030 is expected to increase from 5 per cent in the reference path scenario to approximately 8.7 per cent when various knowledge innovation measures are adopted. The productivity growth and factors efficiency gain in the knowledge-based scenario would result in higher production, with optimum use of inputs and then a larger portion of production directed to sales in outside world markets (exports). With fewer imports compared with the reference path, the knowledge innovation scenario would result in improvements in Egypt's external balance. The increase of GDP per capita is linked to the economy's focus on research and innovation, which also leads to an increase in product competitiveness and exports.

Figure 12. Exports, imports and trade balance
(*Real terms, billions of Egyptian pounds*)

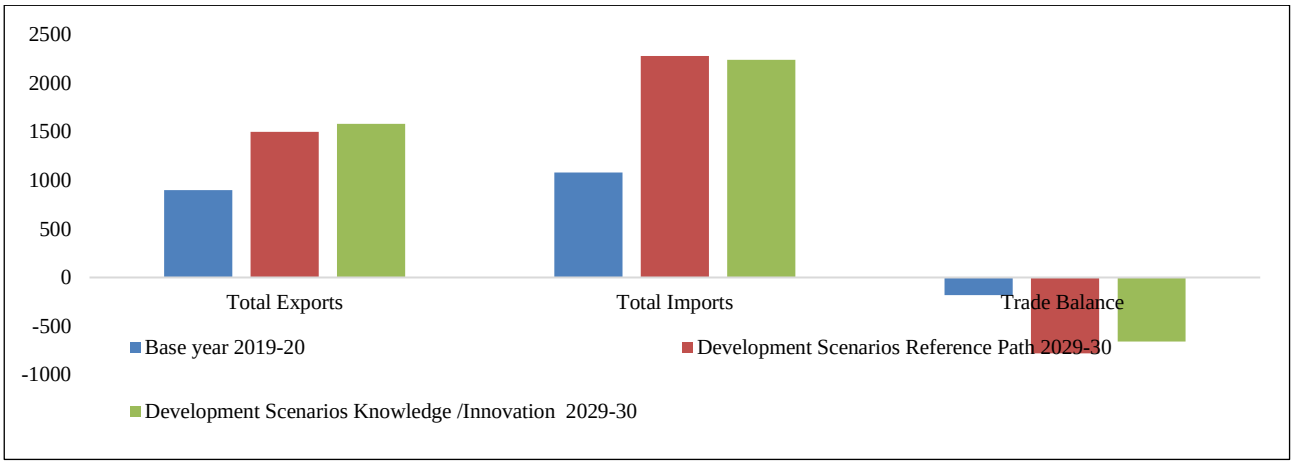
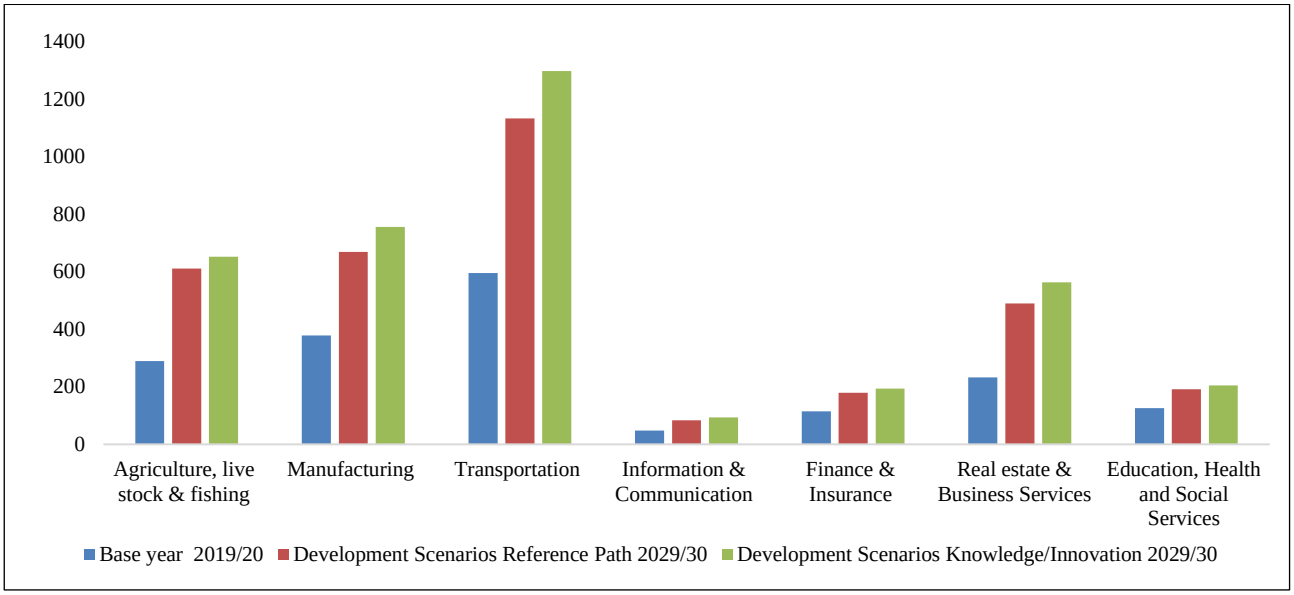


Figure 13, figure 14, figure 15 summarize the performance of the GDP in selected economic sectors. The sectors expected to contribute to Egypt's transformation to a knowledge intensive innovation-led economy, and gain from the impact on efficiency of inputs and total factor productivity, include a subset of the manufacturing industry, plus specific service activities such as information and communication, finance and insurance, real estate and business and R&D.

Figure 13. Impact of development scenarios on sectoral GDP
(*Real terms, billions of Egyptian pounds*)



The relative changes in fixed price sector specific GDP in 2029-2030 resulting from the adopted knowledge innovation policies ranged from 14-15 per cent in real estate and business services, and manufacturing and transportation, to 7-8 per cent in agriculture, finance and insurance, education and cultural services.

Figure 14. Impact of development scenarios on the shares of subsectors in GDP
(*Percentage*)

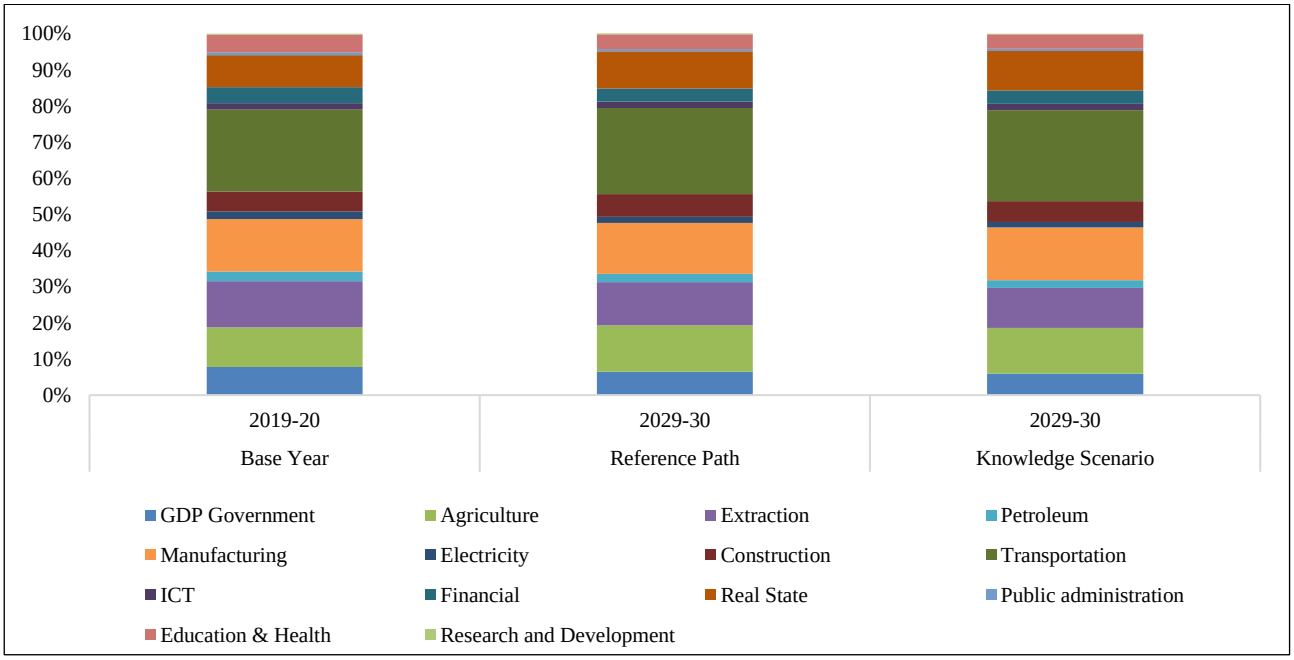
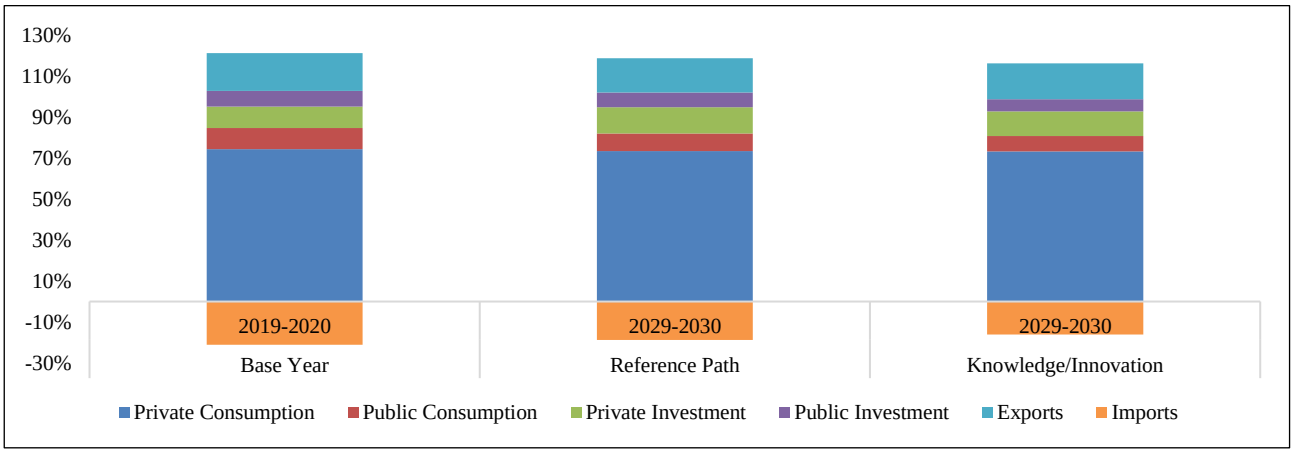
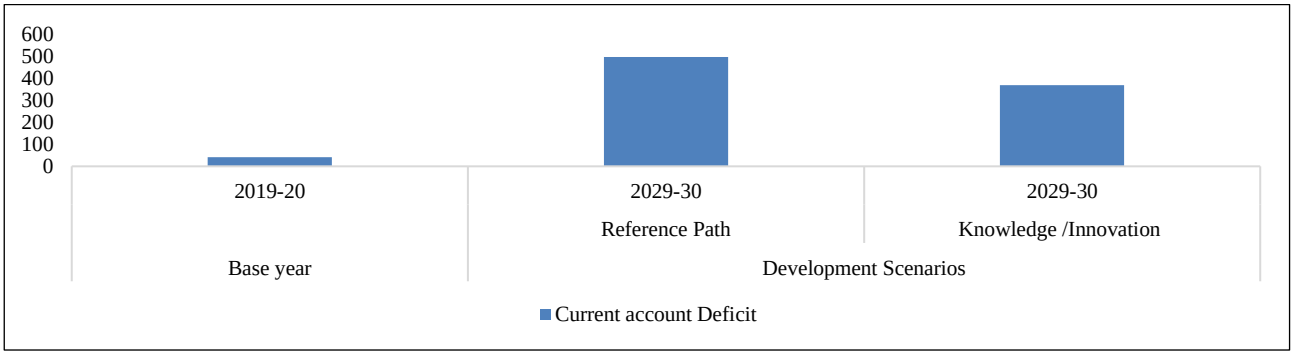


Figure 15. Composition of GDP expenditures in the development scenarios
(*Per cent of GDP*)



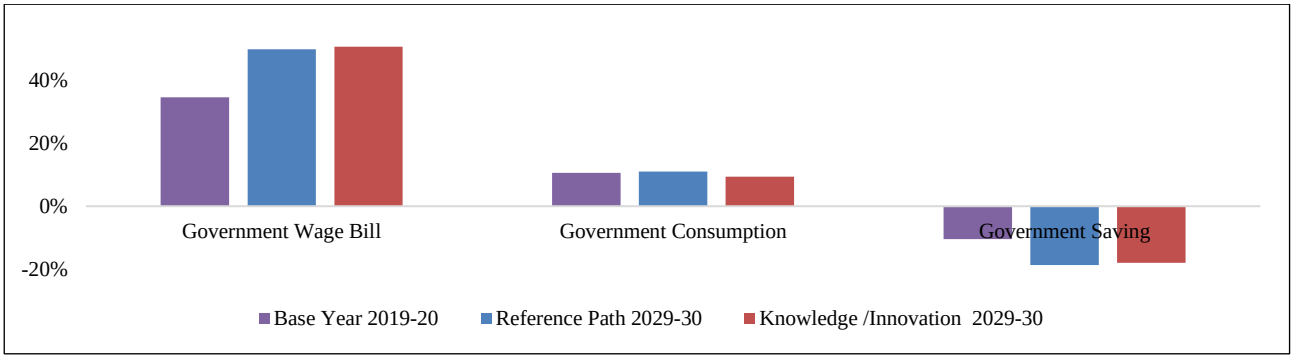
The numbers of the current account of the balance of payments during the projection period show a better export performance and a rationalization of imports. The outcome is a decline in the trade deficit for goods and services trade as well as in the current account deficit (figure 16).

Figure 16. Current account deficit
(*Billions of Egyptian pounds*)



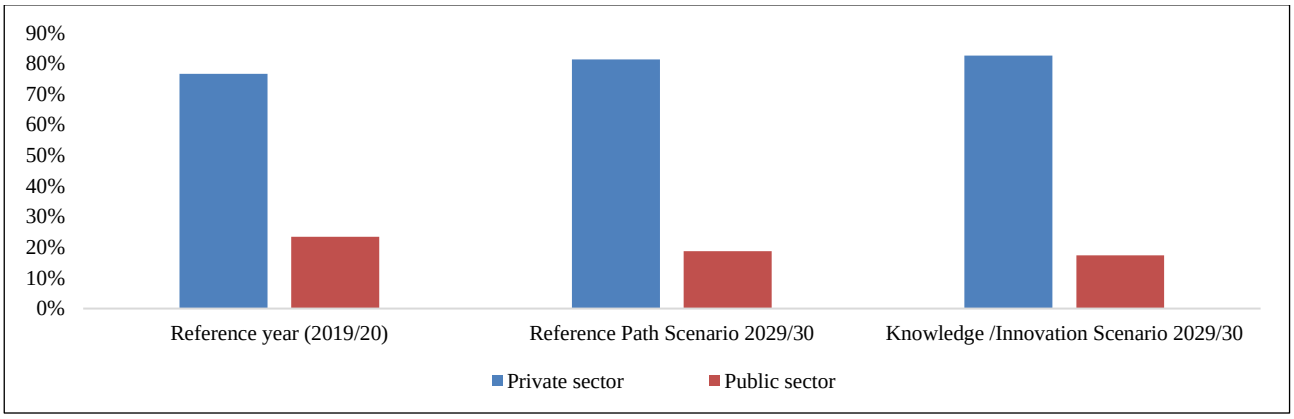
Government expenditures (figure 17), specifically the wage bill and total expenditures, have increased in both scenarios, and government negative savings have decreased. Although government saving is slightly better under the knowledge innovation scenario, this improvement cannot be explained by investment in developing the scenario, as these are mostly done at the private level.

Figure 17. Government expenditures
(*In terms of GDP*)



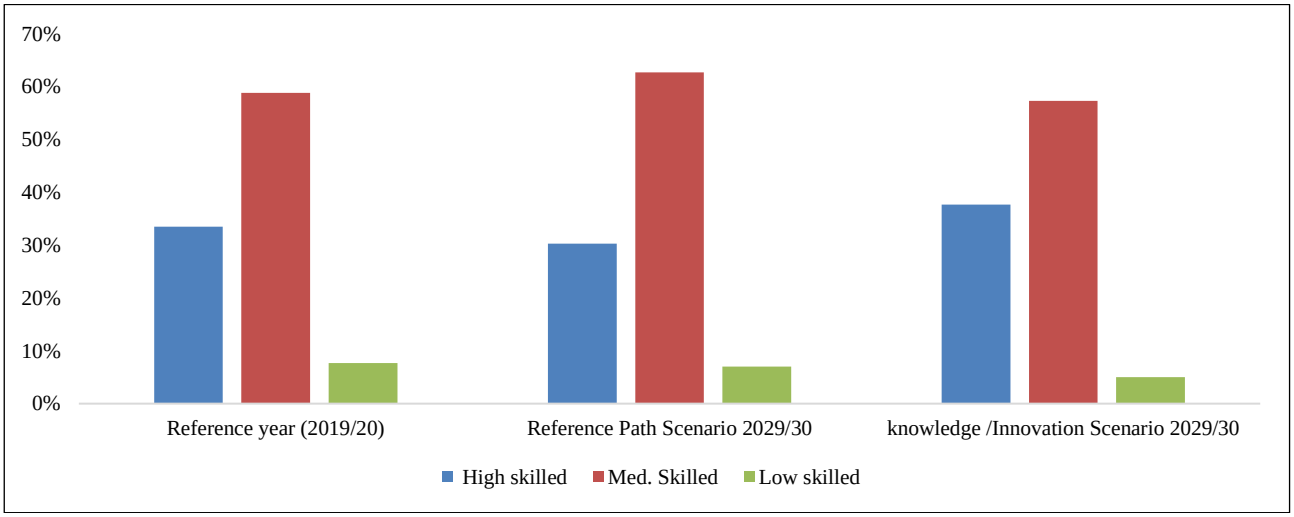
Government labour, public labour and private labour in real terms have all increased indifferently between both development scenarios. To reflect the duality among private and public enterprises, along with their role in the reform programme and the transformation process, activities are divided into private and public enterprises, with each having its own value added. As shown in figure 18, demand for private labour increased in both scenarios, with higher demand in the knowledge innovation scenario due to the considerable increase in the growth prospects of the economy. It is noted that an increase in the efficiency of inputs might lead to a decline in the quantity of labour services required.

Figure 18. Impact of demand for labour by sector
(*Percentage*)



Since knowledge-intensive and RDI activities require highly skilled labour services, the labour compensation account is broken down into the three skill categories of low, medium and high. As can be seen in figure 19, all were positively impacted in the development scenarios, with a large increase in demand for high- and medium-skilled labour in a knowledge and innovation-oriented economy.

Figure 19. Demand for labour by skill category
(*Percentage*)



In principle, the impact of the knowledge innovation scenario on the demand for labour is generally explained by three different effects:

(a) The spillover effect of the knowledge innovation scenario on total factor productivity (TFP) produces an increase in the demand for labour as a result of the increase in gross output;

(b) The spillover effect of the knowledge innovation scenario on labour efficiency by production sector is inducing a reduction in the demand for labour services given the increase in efficiency (output per unit labour);

(c) The impact of the knowledge innovation scenario on the mobility of labour across skills is reflected in the upward movement of labour, from low to medium skilled, and part of the medium-skill to high-skill category. Mobility between categories is a function of the magnitude of increased labour efficiency resulting from the transformation to a high value-added knowledge-intensive economy;

(d) These different effects on labour demand show a net increase in total or aggregate demand for labour services between the two development scenarios, from 35,071 workers in the reference path scenario to 37,852 workers in the knowledge innovation scenario in 2029-2030;

(e) Given that the base scenario of labour supply (as a function of expected population growth rates and crude participation rates of labour force in the economic activity), which accounts for 38,500 workers, benefits from a reduction in the aggregate unemployment of about 1.7 per cent in 2029-2030;

(f) With the structure of labour demand by sector, both scenarios contribute to increasing the private sector's share from 76 per cent in 2019-2020 to approximately 81 per cent in 2029-2030. This mirrors in principle official policy trends adopted by the Egyptian government and IMF programme. Additionally, the results show a slight drop in the relative share of high-skilled labour from 33.5 per cent in 2019-2020 to 30.3 in 2029-2030 when the reference path scenario is adopted, but an increase to 37.7 per cent in the knowledge innovation scenario. This positive effect is the combined outcome of increased labour efficiency and the mobility of labour across skill categories (figure 19).

IV. POLICY CONSIDERATIONS

Over the past decade, macroeconomic policies in Egypt have produced growth but not inclusive growth that reduces poverty or creates decent work for the vast majority of workers. As a result, since 2000, the share of workers has declined, as has the income of poor households. The trend suggests that unless Egypt's growth is rapid, its development strategy and macroeconomic policies will tend to reproduce informality and poverty rather than reduce it. The character of its growth, in other words, is likely to be 'anti-poor' rather than 'pro-poor'. Thus, the foremost challenge is to shift to a more inclusive growth trajectory.

How can this be done? The key is a massive increase in decent employment. This will not be easy. The Egyptian economy needs to create 7 million more jobs by 2030 just to absorb new entrants into the labour force, and this without factoring in the targets of reducing unemployment and raising women's participation to the average for developing countries. Moreover, the public sector, which has in the past accounted for much of the formal sector employment, can no longer provide sufficient decent-paying jobs to a rapidly growing labour force. Substantially more employment needs to be provided by the private sector.

The long-term objective of all development, however, is to move the workforce, and poor workers in particular, out of low-productivity sectors, poorly resourced regions and low-skilled employment with high value added. This implies moving poor workers out of agriculture and into industry and a more modern service sector. But it also suggests a leading role for the knowledge-intensive subsectors where the productivity growth potential is highest. If knowledge-intensive sectors are able to grow rapidly, and generate skilled employment broadly, poverty will be reduced as poor workers move into more highly productive, higher-paid jobs.

For countries like Egypt, this transformation to a knowledge economy is not a matter of choice. The fast-moving pace of change is constantly pushing the technological frontier, demanding significant efforts to catch the technological leaders and achieve levels of productivity and competitiveness that will allow effective participation in the global economy. Import-substitution strategies achieved this during the 1960s. This paper questions whether it can be achieved within the framework and constraints of the current growth strategy based on the IMF agreement.

The answer, again, is a conditional yes. The high road to development will not be feasible unless Egypt adopts policies that put expanding indigenous technological capacity at the core of structural adjustment and enhances competitive advantages in higher value-added goods and services. This calls for an expansion of knowledge-based assets that will lead to increased investment and productivity growth.[15] The formulation and assessment of knowledge-inducing policies cannot be done in the abstract. It has to be context-specific, conceptualized within the realm of possibilities of an 'industrial policy space' constrained by enforceable international commitments as well as the effects of globalization, or increasing economic interdependence, in undermining national sovereignty and consequently limiting policy options. Support is needed to allow firms time to transition to higher levels of competitiveness.[16] This is not generally disputed. What has been queried is the set of instruments chosen to allow firms to become competitive, such as subsidies, financial instruments, government procurement practices and technological support.

Despite the difficulties and the creative efforts required in implementing a knowledge-based, research-intensive and innovation-led development scenario, the message for Egypt's policymakers is that it is a necessary condition to achieve the objectives of the sustainable development strategy. These include accelerating economic growth, enhancing production efficiency, improving the external balance, increasing citizens' welfare, restoring tangible and intangible economic assets and reforming the labour markets with more skilled labour and less unemployment. Traditional development strategies will likely fail to achieve these socioeconomic objectives within the limited time frame up to 2030. Results from the tested alternative development scenarios have shown that a future reference path based on the current socioeconomic policy trends, fiscal reform programme and exchange rate reform would probably achieve an annual economic growth ranging from 6 to 7 per cent at most. The knowledge-based scenario is expected to increase GDP growth to approximately 8 to 9 per cent per year by 2029-2030. Further, the per capita real GDP will increase significantly, from LE 38,565 under the reference path to approximately LE 44,738 when a knowledge innovation scenario is adopted. Similar improvements are observed on the external balance front, labour market skill structure and overall productivity of the economy at large, and the efficiency of factors in general. The Government of Egypt has made a tough choice and applied price reform, fiscal adjustment and exchange rate policies. It remains for the government to adopt the more difficult option of enhancing the productivity of Egyptian society through building an economy based on R&D, innovation and high value-added knowledge-intensive industries and services.

To transform to a knowledge economy requires a realistic long-term macroeconomic policy framework that considers the following:

- First, appropriate government interventions with clear rule-based policy discipline can improve the innovation process.[17] Historical evidence shows that industrialized countries, including those in East Asia, have successfully transformed from agrarian to advanced economies mainly with the help of pro-active governments.[18] Investing in R&D and modern infrastructure, incentivizing private businesses and academic institutions, and encouraging patent systems and large public procurements are support measures that industrialized countries maintain to advance upgrading and diversification;

[15] According to Amsden (2001), knowledge-based assets comprise managerial and technological skills allowing a firm to produce a product at above prevailing market prices or below market costs and determining a country's long-term growth.

[16] There are qualifications to the infant industry argument: first, reduction in costs over time should compensate for higher costs during assistance period; second, assistance should be linked to performance by recipient; and third, appropriate support should be granted for factors creating knowledge or learning by firms.

[17] According to Hausmann and Rodrik (2003), interventions tend to create market distortions. By imposing policy disciplines, such as encouraging investment in the modern sector beforehand, and by rationalizing production afterwards, governments can counteract possible distortions.

[18] Lin and Monga, 2010.

- Second, economic policymakers need to do more to encourage private investment and FDI in high value-added sectors, especially manufacturing and service sectors with high export growth potential. This can be done through partnership agreements with other countries (China in particular), preferential credit schemes, tax exemptions and/or concessional long-term land lease agreements, though a coordinated trade and industrial policy strategy is needed to ensure such measures are within the policy space permitted by Egypt's trade agreements, including with the World Trade Organization. Encouragingly, non-traditional commodity exports are rising. Their contribution to overall exports and growth is currently too low but there is a trend to exploit further;
- Third, public investment can be used more effectively. Egypt should invest in building capacity in new technologically advanced sectors and in renewable energy and water security, with a focus on upper Egypt, which can lead Africa on green economy initiatives. Coupled with smartly designed, export-oriented small and medium-sized enterprise developments, such initiatives can more effectively reduce poverty, and bring a faster return on public investment, at the same time helping to relax the two most binding resource constraints. Conducted simultaneously, alongside other economic governance reforms and with an equitable taxation policy (such as that proposed by the IMF), these measures can have a positive quantitative and qualitative impact on the long-term performance of the economy, inducing higher crowding-in and productivity of public and private investments;
- Fourth, and as recommended by the IMF, Egypt should work on increasing the employment of women and youth, two groups with high unemployment rates. This will require more than supply side interventions. Unemployment is due mainly to a lack in demand for high-skilled work, not so much because of a mismatch between demand and the offer of skills in the labour market. Inadequate working arrangements in the private sector and other supply side factors are problematic. Increasing the safety of public transport and ameliorating working conditions with the provision of childcare and maternity leave are essential to draw in the skilled female labour force. But unless there is a demand for such services with decent wages, the root cause of the problem will remain. While not disregarding the importance of enhancing skills and removing supply side bottlenecks, government interventions should focus on generating such demand.

To summarize, shifts in the orientation of current economic policy are needed to make Egypt's growth more inclusive and pro-middle class by being more pro-skilled labour. This will ensure demand for decent jobs is generated at a fast pace with decent real wages to support the regrowth of the middle class. At the same time, more effort is needed to support the extremely poor and other vulnerable groups. This will require a shift in both social and economic policies from a focus on social protection to both social and economic empowerment. In both cases, we assume that such a transition will rely on endogenous growth dynamics where knowledge sectors and technological change play a lead role in shifting the productivity of the economy.

Annex I

STRUCTURE AND ECONOMIC RATIONALE OF THE COMPUTABLE GENERAL EQUILIBRIUM MODEL

This issue-oriented, knowledge innovation, multisectoral, medium- to long-term computable general equilibrium simulation model is developed under the auspices of the ESCWA. The model is based on the social accounting matrix (SAM) principles of the United Nations System of National Accounts (SNA) as its accounting framework, and the computable general equilibrium tradition. The model is particularly formulated to analyse the transformation process of Egypt's economy and society towards the so-called knowledge era via enhanced R&D policies, an effective national innovation system (NIS) and supported high value-added knowledge-intensive industries and services. To meet this long-term objective, the SAM and model structures, and the level of disaggregation reflect the following features:

1. The disaggregation level is designed to capture the new features necessary to analyse the structural transformation to a high value-added knowledge-intensive scenario, while keeping other characteristics reflecting the current status and the context of the Egyptian economy.

2. The activity-commodity breakdown in the SAM and the model includes most of the activities representing the knowledge economy, highly generated value added, and efficient research and innovation performance based on national accounting data.

3. Since knowledge-intensive and RDI activities require skilled labour services, the labour compensation account is broken down into three skill categories: low, medium and high.

4. To follow the increase in the stock of knowledge produced by R&D activities, a separate activity/commodity is allocated to R&D, both in the SAM and the model.

5. To consider activities that are candidates for being knowledge-intensive, the services sector is disaggregated to include information and communication, finance and insurance, as well as real estate and business services.

6. The model divides investment goods by sectors of origin and destination. This investment matrix permits testing of alternative investment allocation policies targeting the knowledge era. Further, total investment spending is broken down into gross fixed capital formation in the private and public sectors, and the breakdown of its sources into domestic investments and FDI.

7. Detailed tax and subsidy accounts are included in the SAM and in the model to reflect Egypt's recently approved fiscal reform programme and permit analysis of any repercussions on the future performance of the economy.

8. To indicate the duality between private and public enterprises, and their role in the reform programme and transformation process, activities are divided into private and public enterprises, each having its own value added and labour and capital services. As with most economy-wide models, the SAM has a separate account for general government services.

9. The urban-rural dimensions and dualities are captured in the household income and expenditure accounts.

Breakdown of the SAM and model accounts

The table below summarizes the disaggregation levels of the SAM, which delineate the following analytical points:

1. Primary activities include two sectors, agriculture and fishing, and mining and querying, which is mainly composed of oil extraction.

2. Manufacturing industries are broken down into petroleum products and other manufacturing. While the petroleum product sector is capital intensive and not necessarily part of knowledge economy or innovation efforts, some manufacturing sectors will be part of the knowledge economy transformation process.

3. To adjust knowledge stock over years, a separate sector for R&D and experimental development is included in the SAM and the model.

4. Since innovation is felt much more in the services sectors, the breakdown includes the financial and insurance sector, the real estate and business sector, and information and communication.

5. To best capture the impact of education and health, they are included in one sector, along with creative and intellectual services.

6. Other model classification is done to include the IMF's fiscal reform package. Disaggregated tax and subsidy accounts are considered to explicitly implement the new tax policy and the subsidy elimination process.

7. Some accounts are disaggregated to reflect the particular features and duality prevailing in the Egyptian economy, such as private versus public activities, and among urban and rural households.

8. Gross fixed capital formation, as an important policy-oriented tool, is divided by sectors of origin and destination, by private and public enterprises, and by sources of finance (FDI and gross fixed capital of domestic origin). An explicit matrix by sectors of origin and destination is developed for investment allocation policies.

Disaggregation levels of Egypt's SAM and model				
	Levels of the model disaggregation			
Account type	Level 1	Level 2	Level 3	Level 4
Production activities	Private activities	1. Agriculture and fishing		
		2. Oil extraction and other mining		
		3. Petroleum products		
		4. Manufacturing		
		5. Electricity, gas and water		
		6. Building and construction		
		7. Transport and internal trade		
		8. Finance and insurance services		
		9. Real estate and business services		
		10. Information and communication		
		11. Research, development and innovation		

Disaggregation levels of Egypt's SAM and model				
	Levels of the model disaggregation			
Account type	Level 1	Level 2	Level 3	Level 4
		12. Public admin and social insurance		
		13. Health, education and other social services		
	Public activities	13 sectors		
Commodities	Composite	13 sectors		
	Domestic	13 sectors		
	Imported	13 sectors		
	Exported	13 sectors		
Factors of production	Labour compensation	Private sector	High-skilled labour	
			Medium-skilled labour	
			Low-skilled labour	
		Public sector	3 skill levels	
		Government sector	3 skill levels	
Capital services	Private	13 sectors		
	Public	13 sectors		
Institutions (current accounts)	Households	Urban area		
		Rural area		
	Companies	Private		
		Public		
	General government			
	Rest of world			
Institutions (capital accounts)	Saving/investment	12 sectors of origin		
	Investment by destination	12 sectors of destination		
Taxes and subsidies accounts	Taxes accounts	Direct and personal taxes		
		Tax on production		
		Value-added tax		
		Indirect commodity tax		
		Import taxes		
	Subsidies accounts	Food supply		
		Petroleum products		
		Electricity		
		Other subsidies		

Model closure rules

The model's set of closure rules or market-clearing mechanisms cover domestic, imported and exported commodity markets, factor markets, government and other institutions' saving closure, foreign exchange balance and investment saving macroeconomic closure. These rules are as follows:

1. Input and output of the 13 activities are modelled using multilevel production function. The first level divides output into gross value added and intermediate inputs. The second decomposes gross output into private and public value added. The third breaks down both private and public values added into labour compensation and capital services. The final level divides labour income according to skill level (low, medium and high). Commodity markets produced by the 13 activities apply a flexible price clearing mechanism. All production functions are equipped with total factor productivity parameters and labour and capital efficiency parameters.

2. Government income is composed of profits transferred from public enterprises, which is treated as a fixed value share of their income, transfers from domestic and foreign institutions based on income distribution shares, and direct taxes (personal and company taxes) and indirect tax revenues (value-added tax, other indirect commodity taxes and import taxes) that use a fixed tax rate. This tax rate is fixed in the within-period submodel but can be changed in the inter-period dynamic adjustment submodel. On the expenditure side, government final consumption spending (including the government wage bill and purchases of goods and services) is fixed in real terms (or in constant prices). Government current transfers to domestic and foreign institutions are fixed in nominal terms (or in current prices), and spending on subsidies is done using a fixed subsidy rate. Given government income and current spending, general government savings clears government account (they are computed as a residual).

3. The investment-saving macroeconomic closure rule differs between private and public institutions. Savings of public sector capital accounts, including general government and public enterprises, are computed using a fixed saving rate of disposable income for public companies, and as residual for general government. After excluding public-private capital transfers and public investment spending (which is exogenous in the within-period model), public borrowing from the outside world (or public current account deficit) clears public sector capital account. Private sector savings, composed of households and private corporations, are computed as a fixed value share of their disposable income, private-public capital transfers are treated as exogenous variables, private sector borrowing from (or lending to) the outside world is exogenous in the within-period submodel, and private investment spending (gross fixed capital formation plus change in stock) clears the private sector capital market (it is an endogenous variable determined by the equilibrium solution of the within-period model). An alternative formulation of the private saving investment balance is handled in a similar manner to the public investment saving balance. The choice between the two will be determined during the validation exercise and based on the reliability of the obtained economy-wide projections.

4. Labour compensations are broken down by skill level (low, medium and high). Demand for labour by skill level is determined from a multilevel nested production function, with the rule of profit subjected to technology constraint (the production function). Given the exogenous average wage rate per skill category, the quantity of labour by production activity and skill category is computed as a demand-driven quantity. Further, given the fixed supply of labour, computed from population growth rate and labour force activity or participation rate in the inter-period part of the model, the unemployment rate is determined. Note that the production functions in the model are equipped with an efficiency of labour factor by skill category. This labour efficiency factor can be simulated as an exogenous variable or embodied in an inter-period dynamic relation that can be affected by knowledge, R&D, innovation and other intangible assets, which is the case in our model. Government labour by skill category is determined within its final consumption spending as a fixed quantity share.

5. The foreign exchange market is treated as follows. Supply of exports as the outcome of profit maximization rule subject to a CET. The outcome of the profit maximization problem determines also domestic sales. On the other hand, outside world demand for Egyptian exports is determined as a function of base year exports, the ratio of world prices in domestic currency to the producer's supply price of exports, as well as the sector-specific trade elasticity. The interaction between forces of supply and demand for exports determines their equilibrium quantities. Imports of goods and services are computed using the composite commodity approach (or Armington elasticity). According to this approach, demand for composite commodity (composed of both domestic and imported goods and services) is estimated from intermediate demand (as a fixed quantity share of gross output based on the Leontief production function), government final consumption demand (fixed in quantity term), urban and rural household final consumption using a linear expenditure system, and public and private investment spending (derived from the saving-investment balance explained in point 2). The demand for composite commodity is then broken down into domestic sales and imports based on a cost minimization rule subject to a constant elasticity of substitution or a CES function. Note that the equilibrium domestic sales are determined jointly by the confrontation of the CET function transforming output to exports and domestic sales, and Armington CES function distributing composite demand between domestic sales and imports.

The inter-period dynamic relations

The inter-period model is composed of the relations needed to ensure the dynamic path of the economy under alternative development policies. The first set of equations adjusts the physical capital stock as a function of previous year capital stock, investment spending and the consumption of fixed capital. Similar equations are developed to update knowledge stock, software and information technology, and other intangible assets. These updating relations are explained in a later section. A second set of relations covers those estimating the spillover effects of changes in knowledge, software and other intangible assets on total factor productivity and the efficiency of labour and capital inputs based on the sector-specific elasticity of spillover effect. A further set addresses labour mobility between different labour skill categories (low, medium and high). The inter-period relations also include the population and labour force projections, the breakdown of investment into gross capital formation of domestic origin and FDI flows, and a wage rate adjustment mechanism.

Knowledge stock and intangible assets updating mechanisms

With regards to sectors contributing to the creation and dissemination of knowledge, development of technological and non-technological innovation as well as creative output and intangible assets are generally specific or part of the 13 sectors of the model, or a combination of both. Knowledge stock, for example, is dynamically adjusted by investment in R&D, a major contributor to its increase, in addition to being part of the outcome of the education process (which contributes to creating knowledgeable human capital). Intangible assets producing creative output appear in specific portions of sectors such as business services, programming and broadcasting, publishing activities and the software industry.

Based on this rationale, knowledge stock and R&D, and other knowledge economy-related activities, can be partially captured from more detailed activity breakdown from a dipping or mining process into the ISIC to estimate its percentage share in the sector GDP. It should be noted, however, that this process is based on the logic and understanding of what we mean by industries satisfying the knowledge economy, along with high value added, knowledge workers and knowledge-intensive activities with considerable spending on R&D and innovation.

A detailed investigation of each activity in the model has been made to identify these knowledge, R&D and innovation-related activities based on the said rationale. The main outcome is represented by the sub activities of ISIC related to computer programming and consultation, information services, programming and broadcasting, motion pictures and TV, broadcasting, publishing activities, advertising and market research, creative services, and parts of the financial, real estate business, transport, and other creative and intangible

services. Based on the conceptual design discussed, the sectors of the model are disaggregated to estimate the relative weight of these knowledge-innovative activities in GDP as a proxy to update the software and other intangible capital stocks, as shown below.

Information and communication	Per cent of GDP
Software and IT creative activities: • Computer programming and consultation • Information service activities	8.2 (6.8) (1.4)
Creative outputs and intangible assets: • Motion picture, video and TV • Programming and broadcasting • Publishing activities	7.7 (1.0) (4.0) (2.7)
Real estate and business services: • Advertising and market research • Business services	 3.58 24.12
Education, health and cultural services: • Education • Creative arts and entertainment • Libraries, archives, museums and other cultural activities • Health	 36.74 0.160 0.003786 63.096
Financial sector: • Financial services • Insurance and ancillary activities	 90.65 9.35
Transport, trade and storage: • Wholesale and retail trade • Others	 59.1 40.9

The obtained relative weights are used to estimate the percentage share of knowledge innovation-related activities in the composition of each sector GDP, and their per cent in the investment spending allocated to each economic sector defined in the model. R&D activity is taken as a whole in updating the knowledge stock. The estimation of the spillover effects on sector-specific total factor productivity and factors efficiency parameters is based on the changes in knowledge stock, software and other IT assets and other intangible assets coupled with the elasticity of each sector to these changes (spillover parameters by activity or sector). The mathematical implementation of this process is explained in the following sections. It constitutes an integral part of the inter-period dynamically adjusted submodel.

Updating of knowledge stock

RRKW(t+1) = RRKW(t)*(1-DELK) + [INV(RDI, t) + 0.4*(INVP(ED,t)

+ INVR(ED,t)] * RKW …….(1)

Where:

RRKW (t) = Rate of return on knowledge stock in period t

DELK = Consumption of fixed capital (depreciation) of knowledge stock

Inv(RDI,t) = Gross fixed capital formation in real terms allocated to RDI at period t

Inv(ED,t) = Gross fixed capital formation in real terms allocated to the education sector at period t

RKW = Base year ratio of return on knowledge assets to knowledge stock

Software creative output

RRIT(t+1) = RRIT(t) (1- DELS) + 0.082 *[INVP(ICT,t) + INVR(ICT,t)]

*RIT ……..(2)

Where:

RRIT(t) = Return on software and IT assets at period t

INVP(ICT, t) = Public sector gross fixed capital formation in real terms allocated to information and communication sector at period t

INVR(ICT, t) = Private sector gross fixed capital formation in real terms allocated to information and communication sector at period t

RIT = Base year ratio of return on software development assets on software and other IT stock

DELS = Consumption of fixed software and IT capital stock

Intangible assets

RROI(t+1) = RROI(t) * (1 – DELOI) +

[0.077 * [INVP(ICT,t) + INVR(ICT,t)]

+ 0.277 * [INVP(REL,t) + INVR(REL,t)]

+ 1.000 * [INVP(FIN,t) + INVR(FIN,t)]

+ 0.400 * [INVP(TRN,t) + INVR(TRN,t)]

+ 0.00164 * [INVP(EDH,t) + INVR(EDH,t)]

+ 0.044 * INVP(PAD,t)]* ROI ……(3)

Where:

RROI(t) = Return on intangible assets at period t

INVP(REL, t) = Public sector gross fixed capital formation in real terms allocated to real estate and business sector at period t

INVR(REL, t) = Private sector gross fixed capital formation in real terms allocated to real estate and business sector at period t

INVP(FIN, t) = Public sector gross fixed capital formation in real terms allocated to financial sector at period t

INVR(FIN, t) = Private sector gross fixed capital formation in real terms allocated to financial sector at period t

INVP(TRN, t) = Public sector gross fixed capital formation in real terms allocated to transport and trade sector at period t

INVR(TRN, t) = Private sector gross fixed capital formation in real terms allocated to transport and trade sector at period t

INVP(EDH, t) = Public sector gross fixed capital formation in real terms allocated to education and health sector at period t

INVR(EDH, t) = Private sector Gross fixed capital formation in real terms allocated to education and health sector at period t

INVP(PAD, t) = Public sector Gross fixed capital formation in real terms allocated to Public administration sector at period t

ROI = Base year ratio of return on intangible assets to intangible stock

DELOI = Consumption of fixed capital of other intangible assets

Impact on total factor productivity (TFP) by sector

$$TFP(i,t+1) = TFP(i,t) * [RRKW(t+1)/RRKW(t)]^{**}SKW(i) * [RRIT(t+1)/RRIT(t)]^{**}SIT(i) * [RROI(t+1)/RROI(t)]^{**}SOI(i) \quad \ldots\ldots\ldots(4)$$

i. € { agr, ext, pet, man, elc, con, turn, ict, fin, rel, rdi, edu, pad}

Where:

TFP(i, t) = total factor productivity of sector i at period t

SKW(i) = elasticity of TFP of sector i to change in knowledge assets

SIT(i) = elasticity of TFP of sector i to change in software assets

SOI(i) = elasticity of TFP of sector i to change in intangible assets

Annex II

MATHEMATICAL SPECIFICATIONS OF THE COMPUTABLE GENERAL EQUILIBRIUM MODEL

Block one: Notation principles

Item	Notation
Endogenous variables	Upper-case Latin letters without a bar
Exogenous variables	Upper-case Latin letters with a bar
Parameters	Lower-case Latin letters (with or without a bar) or lower-case Greek letters (with or without subscripts)
Set indices	Lower-case Latin letters as subscripts to variables and parameters

Block two: List of variables and notations

I. Sets and institutions

A. Activities/commodities

i,j□ I = { agr agriculture and fishing
ext oil extraction and other mining
pet petroleum products
man other manufacturing
elc electricity, gas and water
con building and construction
trn transport, communication and internal trade
fin finance and insurance services
rbs real estate and business sector
hes health, education and other social and community services
pdi research, developmental innovation
adm public administration and social insurance }

TICI = tradable goods and services
NTICI = non-tradable goods and services

B. Economic sectors

s□ S = economic sectors
{ prv private sector
pub public sector }

C. Commodity subsidies

sb □ SB = { sub supply commodity subsidies
pet petroleum subsidies
elc electricity subsidies
oth other commodity subsidies }

D. Labour breakdown by skill category

ls □ LS = { low low-skill category
med medium-skill category
hig high-skill category }

E. Investment spending by sector of destination

k □ K ={ agr,ext,pet,man,elc,con,trn,fin,rbs,hes,pdi,adm }

F. Institutions

h □ H = { urb urban households
rur rural households
prv private companies
pub public companies
gov general government
row rest of the world }
h □ HD ⊂ H = { urb,rur,prv,pub,gov }
h □ HH ⊂ H = households institutions { urb,rur }
h □ HNG ⊂ H = non-government institutions { urb,rur,prv,pub }
h □ HC ⊂ H = corporate institutions { prv,pub }

II. Endogenous variables

A. Price relations

PM_i	Import price index of commodity i (domestic currency), i □ I
PE_i	Export price index of commodity i (domestic currency), i □ I
PDD_i	Demand price for commodity i produced and sold in domestic markets, i □ I
PDS_i	Supply price for commodity i produced and sold in domestically
PQ_i	Price of composite commodity i, i □ I
PX_i	Price of activity (price of gross output) i □ I
$PINTA_i$	Aggregate intermediate input price of activity i, i □ I
PVA_i	Price of unit value added in sector i (factor income per unit of activity)
PVA_{is}	Price of unit value added in activity i and sector s, s □ S and i □ I
WL_{is}	Wage rate in activity i and sector s, s □ S and i □ I
PK_{is}	Rate of return on physical capital stock in activity i and sector s, s □ S and i □ I
$WL_{is,ls}$	Wage rate in activity i, sector s and skill category ls; i □ I, s □ S and ls □ LS
CPI	Consumer price index

B. Price relations

QX_i	Quantity produced by activity i, i □ I
QVA_i	Quantity of value added generated in sector i, i □ I
$QINTA_i$	Quantity of aggregate input of commodity i as intermediate input to activity j, i,j □ I
QVA_{is}	Quantity of value added generated in activity i and sector s, s □ S and i □ I
QL_{is}	Quantity of labour demand in activity i and sector s, s □ S and i □ I
$QL_{is,ls}$	Quantity of labour demand of skill category ls in activity i and sector s, s □ S, i □ I and ls □ LS
QE_i	Quantity of exported commodity supplied by activity i, i □ I
QE_i^d	Rest of the world demand for exports of commodity i, i □ I
$QINT_{ij}$	Quantity of commodity i used as intermediate input to activity j; i,j □ I
QD_i	Quantity sold in the domestic markets of domestic output, i □ I
QQ_i	Quantity of commodity i supplied to domestic market from both domestic and imported sources (composite supply), i □ I
QM_i	Quantity of imported commodity i □ I
$QINV_{is}$	Quantity of investment demand for commodity i and sector s, i □ I and s □ S
QG_i	Government consumption demand for commodity i, i □ I
$QINVO_i$	Investment spending by origin of commodity i, i □ I

C. Institutional income and spending

YLS_{ls}	Compensation of employees of factors skill category ls □ LS
YLG	Compensation of employees in government sector (government nominal wage bill)
YLNG	Compensation of employees in non-government sector
YLA_s	Compensation of employees in sector s, s □ S
YLT	Total wage bill or compensation of employees
RL_{sh}	Distribution of compensation of employees (labour income) to institution h in sector s, s □ S and h □ HH
RK_{sh}	Distribution of operating surplus (capital income) to institution h in sector s; s □ S and h □ HD
YI_h	Income of domestic non-government institution h, h □ HNG

$TRII_{h,h'}$ Transfers from institution h' to h_i; h and h' □ HNG (intra institutional transfers)

EH_h Consumption spending for household h, h □ HH

QH_{ih} Quantity consumed of commodity i by household h, i □ I and h □ HH

QC_h Current spending of companies h, h □ HC

YG General government revenue

EG Government expenditures

SAVP Saving of private sector (including urban and rural households and private companies)

SAVB Saving of public sector (including general government and public enterprises)

D. System constraints

GSAV Government savings

UNEMPT Aggregate unemployment rate

$UNEMPT_{ls}$ Unemployment rate of labour skill category ls; ls □ LS

$FSAV_s$ Foreign savings (in foreign currency) of sector s, s □ S

III. Exogenous variables

$\overline{IADJ}$ Investment adjustment factor

$\overline{GADJ_s}$ Government consumption adjustment factor

$\overline{QL_{ls}}$ Quantity demanded of labour skill category ls in general government sector; ls □ LS

$\overline{WL_{ls}}$ Nominal wage rate of labour skill category ls; ls □ LS

$\overline{EXR}$ Exchange rate (local currency unit (LCU) per unit of foreign currency unit (FCU))

$\overline{QLS}$ Quantity supplied of labour factor

$\overline{QK_{i,s}}$ Real return on capital physical assets in activity i and sector s; s □ S and i □ I

$\overline{TR_{h,gov}}$ Government current transfers to non-government institution h, h □ HNG

IV. Parameters

A. Price relations

pwm_i	Import price of commodity i in foreign currency (cif), i □ I
pwe_i	Export price of commodity i in foreign currency (fob), i □ I
tm_i	Import tariff rate levied on commodity i, i □ I
te_i	Export tax rate levied on commodity i, i □ I
tq_i	Rate of indirect tax on domestic commodity
ica_{ij}	Per unit of activity j quantity of commodity (I,j □ I)
$cwts_i$	Weight of commodity i in the CPI, i □ I

B. Real flow equations

α_i^a	Efficiency parameter in the CES production function i □ I
δ_i^a	CES activity function share parameter of activity i, i □ I
$\mathbf{l}_i^a$	CES production function exponent of activity i, i □ I
iva_i	Quantity of value added per activity unit i, i □ I
$inta_i$	Quantity of aggregate intermediate input per activity unit
α_i^v	Efficiency parameter in the CES value added aggregation function of activity i, i □ I
δ_{is}^v	CES value added aggregation function share parameter, in activity i and sector s and i, i □ I and s □ S
$\mathbf{l}_i^v$	CES value added aggregation function exponent in activity i, i □ I
α_{is}^{vs}	Efficiency parameter in the CES value added function by activity i and sector s, i □ I and s □ S
θ_i^s	Elasticity of substitution between private and public value added in activity i, i □ I
α_{is}^l	Labour efficiency parameter of the CES value added function by activity i and sector s, s □ S and i □ I
θ_i^l	Elasticity of substitution between labour and capital services in the labour capital aggregation function of activity i, i □ I
α_{is}^k	Capital efficiency parameter of the CES labour capital aggregation function of activity i and sector s; i □ I and s □ S

α_{is}^{m} Efficiency parameter in the CES aggregation function and in activity i skill category s i □ I and s □ S

$\delta_{i,s,ls}^{m}$ CES labour skill aggregation function share parameter in activity i, sector s and labour skill category ls, ls □ LS, i □ I and s □ S

l_{is} CES labour skill aggregation function exponent in activity i and sector s; s □ S and i □ I

$\alpha_{i,s,ls}^{m}$ Efficiency parameter in the CES function of demand for labour by skill ls, activity i and sector i; i □ I and s □ S and ls □ LS

$\theta_{i,s}^{ls}$ Elasticity of substitution between labour skill category by activity i and sector s; i □ I and s □ S

α_{i}^{t} CET function shift parameter of activity i, i □ I

δ_{i}^{t} CET function share parameter in activity i, i □ I

l_{i}^{t} CET function exponent in sector i, i □ I

η_{i} Trade elasticity of export demand for commodity i, i □ I

α_{i}^{q} Armington function shift parameter for commodity i, i □ I

l_{i}^{q} Armington function exponent for commodity i, i □ I

δ_{i}^{q} Armington function share parameter of commodity i, i □ I

$\overline{qinv_{is}}$ Base year quantity of investment demand of commodity i in sector s; s □ S and i □ I

$\overline{qg_{i}}$ Base year quantity of government investment demand of commodity i, i □ I

α_{ik}^{i} Share of investment by origin sector i in total investment in sector of destination k, k□ K and i □ I

q_{ik} Quantity of investment in sector of origin i and sector of destination k, i □ I and k □ K

C. Institutional income and spending

Δ_{sh}^{l} Share of gross labour income (compensation of employees) of sector s accruing to institution h; s □ S and h □ HH

Δ_{sh}^{k} Share of operating surplus generated in sector s, accruing to institution h, s □ S and h □ HD

$Transfr_{h,row}$ Current transfers of the outside world to institution h,h □ HD

$Invf_{h,row}$ Investment income from abroad accruing to institution h,h □ HD

$Wrf_{h,row}$	Worker's remittances transferred from abroad to domestic institution h,h □ HH
$del_{hh'}$	Share of total income of institution h' transferred to institution h, h,h' □ HNG
mps_h	Base year savings rate for domestic institution h, h □ HNG
td_h	Direct tax rate for institution h, h □ HNG
γ_{ih}^{c}	Subsistence consumption of marketed commodity i for household h; i □ I and h □ HH
β_{ih}^{c}	Marginal share of consumption spending on marketed commodity i for household h; i □ I and h □ HH
$Transfr_{gov,h}$	Current transfers from institution h to general government, h □ HDNG
$Transfr_{gov,row}$	Current transfers from the outside world to general government sector (in foreign currency)
$Tsub_{i,sb}$	Subsidy rate in sector i and commodity subsidy category sb; i □ I and sb □ SB

V. Inter-period dynamics

A. Physical capital stock/supply of capital services

$k_{i,t}^{r}$	Capital stock of activity (i) in private sector (r) at period (t), i □ I
$k_{i,t}^{p}$	Capital stock of activity (i) in public sector (p) at period (t); i □ I
δ_i^r	Annual depreciation rate (consumption of fixed capital in private sector (i)), i □ I
δ_i^p	Annual depreciation rate (consumption of fixed capital of public sector (i)), i □ I
$I_{i,t}^{r}$	Gross fixed capital formation allocation to private sector (i) at period (t), i □ I
$I_{i,t}^{p}$	Gross fixed capital formation allocation to public sector (i) at period (t), i □ I
k_i^{r0}	Base year private sector capital stock of activity (i), i □ I
k_i^{p0}	Base year public sector capital stock of activity (i), i □ I
RRK_i^{r0}	Base year rate of return on capital stock in private activity (i), i □ I
RRK_i^{p0}	Base year rate of return on capital stock in public activity (i), i □ I
RK_i^r	Ratio of return to base year capital stock in private activity (i)

RK_i^p Ratio of return to base year capital stock in public activity (i)

B. Demand for capital services

$RRK_{i,t}^{dr}$ Demand for rate of return on physical assets in private sector i, at period

$RRK_{i,t}^{dp}$ Demand for rate of return on physical assets in public sector i, at period t

$p_{i,t}^{nr}$ Net price of private value added in sector i, at period t

$p_{i,t}^{np}$ Net price of public value added in sector i, at period t

$\varnothing_i^r$ Elasticity of substitution between labour and capital services in private sector i, at period t

$\varnothing_i^p$ Elasticity of substitution between labour and capital services in public sector i, at period t

δ_i^r, δ_i^p Scaling parameters in the function estimating the demand for capital services

$r_{i,t}^r$ Price of private capital in activity i at period t

$r_{i,t}^p$ Price of public capital in activity I at period t

$V_{i,t}^r$ Value added of private sector i at period t, evaluated at factor cost

$V_{i,t}^p$ Value added of public sector i at period t, evaluated at factor cost

C. Updating of knowledge stock

WK_t National stock of knowledge at period (t)

δ_t^w Depreciation rate of knowledge stock at period (t)

IRD_t Gross capital spending on R&D and innovation at period t

RRW_t Rate of return on knowledge stock at period t

RW Ratio of return on knowledge stock to knowledge stock in the base year

D. Updating of IT/software assets

ITK_t National intangible stock of information technology and software development at period t

IIT_t National investment spending on information technology and software development at period t

δ_t^{it} Depreciation rate of information technology and software development stock at period t

$RRIT_t$ Rate of return on information technology and software development at period t

RIT Ratio of return on information technology and software development stock to total assets

$RROI^0$ Base year return on information technology and software development assets

ITK^0 Base year capital stock of information technology and software development asset

E. Updating of the intangible assets

(*Creative human capital, organizational model, trademarks, industrial designs, cultural and creative goods, entertainment, media, printing and publishing*)

OIK_t National stock of intangible assets at period t

δ_t^{0i} Depreciation rate of other intangible assets at period t

OII_t National investment spending on intangible assets at period t

$RROI_t$ Rate of return on other intangible assets at period t

$RROI^0$ Base year rate of return on other intangible assets.

OIK^0 Base year stock of other intangible assets

ROI Ratio of rate return to stock of intangible assets in base year

F. Impact on total factor productivity

$TFP_{i,t}^r$ Total factor productivity of private activity i at period t, i □ I

$TFP_{i,t}^p$ Total factor productivity of public activity i at period t, i □ I

$\psi_i^{wr}, \psi^{sr}, \psi^{0r}$ Spillover effects of investments in R&D, software industry and other intangible assets in private activity

$\psi_i^{wp}, \psi^{sp}, \psi^{0p}$ Spillover effects of investments in R&D, software industry and other intangible assets in public activity

G. Population dynamics and labour force (*in thousands*)

POP_t Population size at period t (in thousands)

$\bar{g}_t^p$ Annual growth rate of population at size period t

POP_t^u Urban area population size at period t

POP_t^r Rural area population size at period t

$L_{u,t}^s$ Labour supply at period t (in thousands)

$L_{r,t}^s$ Labour supply in rural area at period t (in thousands)

$\bar{M}_t^g$ Rural – urban migration at period t (in thousands)

H. Private and public average wage rates

W_{t+1}^n Average wage rate in non-government sectors at period t

W_t^g Average wage rate in government sector at period t

P_t^c Consumer price index at period t

P_t^g Government consumption price index at period t

g_n^w Fixed annual growth rate of average non-government wage rate

g_g^w Fixed annual growth rate of average government wage rate

ω^n, ω^g Scaling parameters of price indices in computing average wage rates

I. Breakdown of total investment spending

$I_{i,t}^{rd}$ Private investment spending of domestic origin allocated to sector i in period t, i □ I

$I_{i,t}^{pd}$ Public investment spending of domestic origin allocated to sector i at period t, i □ I

$\bar{I}_{i,t}^{rf}$ Private foreign direct investment flows to sector i at period t, i □ I

$\bar{I}_{i,t}^{pf}$ Public foreign direct investment flows to sector i at period t, i □ I

J. Investment allocation pattern

$\delta_{i,t}^{r}$ Percentage share of total investment allocation to private sector i at period t

$\delta_{i,t}^{p}$ Percentage share of total investment allocation to public sector i at period t

$\bar{g}_{i,t}^{p}$ Growth rate of the percentage share of total investment allocated to public sector i from period t to t+1, i □ I

$\bar{g}_{i,t}^{r}$ Growth rate of the percentage share of total investment allocated to private sector i from period t to t+1, i □ I

K. Impact on labour efficiency by skill category

$LEF_{ls,t}^{r}$ Labour efficiency of skill category ls in the private sector at period t, $ls \in LS$

$LEF_{ls,t}^{P}$ Labour efficiency of skill category ls in the public sector at period t, $ls \in LS$

$\Psi_{ls}^{wr}, \Psi_{ls}^{sr} and \Psi_{ls}^{or}$ Spillover effect of investment in RDI, software industry and other intangible assets on labour efficiency by skill category in private sector; $ls \in S$

$\Psi_{ls}^{wp}, \Psi_{ls}^{sp} and \Psi_{ls}^{op}$ Spillover effect of investment in RDI, software industry and other intangible assets on labour efficiency by skill category in public sector $ls \in LS$

$M_{ls,ls',t}$ Quantity of labour lower level skill ls' to higher level skill ls at period t, $ls \& ls' \hat{I} S'$

α_{ls}^{m} Quantity of low skill category ls moving to higher skill as a per cent of labour efficiency at period t, $ls \in LS$

Block three: Price relations and indices

I. Prices of imports and exports

(1) $PM_i = pwm_i (1+tm_i).\ \overline{EXR}$; i□I

(2) $PE_i = pwe_i (1+te_i).\ \overline{EXR}$; i□I

II. Domestic commodity prices

A. Absorption

(3) Absorption $PDD_i = PDs_i (1+tq_i)$

(4) $PQ_i . QQ_i = PDD_i .QD_i + PM_i .QM_i$; i□I

B. Price of gross output

(5) $PX_i \cdot QX_i = PDS_i \cdot QD_i + PE_i \cdot QE_i$
; i□I

C. Aggregate price of intermediate inputs

(6) $\mathbf{PINTA}_j = \sum_{i \in I} PQ_i . icq_{ij}$
;i,j□ I; i≡Commodity, j≡activity

D. Activity revenue and cost

(7) $PX_i(1-ta_i).QX_i = PVA_i \cdot QVA_i + PINTA_i . QINTA_i$
;i□I

E. Price of value added

(8) $PVA_i . QVA_i = \sum_{s \in S} PVA_{i,s} . QVA_{i,s}$
$; i \in I \ \& \ s \in S$

F. Factor prices (*private and public value added*)

(9) $PVA_{is} . QVA_{is} = WL_{is} . QL_{is} + PK_{is} . QK_{is}$
$; i \in I \ \& \ s \in S$

G. Labour wage rate by skill category

(10) $WL_{is} = \sum_{ls \in LS} \overline{WL}_{is,ls} . QL_{is,ls}$
$; i \in I \ \& \ s \in S$

H. Consumer price index

(11) $CPI = \sum_{i \in I} PQ_i . cwts_i$
$; i \in I$

Block four: Real flow equations

I. Production functions (*Fig(1)*)

A. Activities with CES formulation

(12) $QX_i = \alpha_i^a (\delta_i^a . QVA_i^{-e_i^a} + (1-\delta_i^a) . QINTA_i^{-e_i^a})^{\frac{1}{e_i^a}}$
$; i \in I$

(13) $$\frac{QVA_i}{QINTA_i} = \left(\frac{PINTA_i}{PVA_i} . \frac{\delta_i^a}{1-\delta_i^a} \right)^{\frac{1}{1+1_i^a}}$$
$$; i \in I$$

B. Activities with Leontief technology

(14) $$QVA_i = iva_i . QX_i$$
$$; i \in I$$

(15) $$QINTA_i = \text{int}\, a_i . QA_i$$
$$; i \in I$$

C. Private and public value-added generation

(16) $$QVA_i = \alpha_i^{\upsilon} \left[\sum_{s \in S} \delta_{i,s}^{\upsilon} . QVA_{i,s}^{-e_i^{\upsilon}} \right]^{\frac{1}{e_i^{\upsilon}}}$$
$$; i \in I$$

D. Generation of public and private value added

(17) $$QVA_{i,s} = \alpha_{i,s}^{\upsilon s} \left[\frac{PVA_i}{PVA_{i,s(1-tva_{i,s})}} \right]^{\theta_i^s} . QVA_i$$
$$; i \in I \,\&\, s \in S$$

E. Factor demand

(18) $$QL_{i,s} = \alpha_{i,s}^{e} \left[\frac{PVA_{i,s}}{WL_{i,s}} \right]^{\theta_i^e} . QVA_{i,s}$$
$$; i \in I \,\&\, s \in S$$

(19) $$\overline{QK}_{i,s} = \alpha_{i,s}^{k} \left[\frac{PVA_{i,s}}{PK_{i,s}} \right]^{\theta_i^e} . QVA_{i,s}$$
$$; i \in I \,\&\, s \in S$$

F. Labour by skill category

(20) $$QL_{i,s} = \alpha_{i,s}^{m} \left[\sum_{ls \in LS} \delta_{i,s,ls}^{m} . QL_{i,s,sl}^{-e_{i,s}} \right]^{\frac{1}{e_{i,s}}}$$
$$; i \in I, s \in S$$

(21) $$QL_{i,s,sl} = \alpha^{m}_{i,s,sl}\left[\frac{WL_{i,s}}{WL_{i,s,sl}}\right]^{\theta^{ls}_{i,s}}.QL_{i,s}$$
$$; i \in I, s \in S \;\&\; sl \in SL$$

(22) $$WL_{sl} = \overline{WL}_{sl}$$
$$; sl \in SL$$

G. Disaggregation of intermediate inputs

(23) $$QINT_{ij} = icq_{ij}.QINTA_{j}$$
$$; i, j \in I$$

II. Output transformation

A. Output transformation (*CES function*)

(24) $$QX_{i} = \alpha^{t}_{i}(\delta^{t}_{i}.QE^{e^{t}_{i}}_{i} + (1-\delta^{t}_{i})QD^{e^{t}_{i}}_{i})^{\frac{1}{e^{t}_{i}}}$$
$$; i \in I$$

B. Export-domestic supply ratio

(25) $$\frac{QE_{i}}{QD_{i}} = \left[\frac{PE_{i}}{PDS_{i}}.\frac{1-\delta^{t}_{i}}{\delta^{t}_{i}}\right]^{\frac{1}{e^{t}_{i}-1}}$$
$$; i \in I$$

C. Output transformation (*IO formulation*)

(26) $$QX_{i} = QD_{i} + QE_{i}; i \in I$$

D. World demand for exports

(27) $$QE^{d}_{i} = \overline{E}^{o}_{i}\left(\frac{pwe_{i}.\overline{EXR}}{PE_{i}}\right)^{\eta_{i}}$$

(28) $$QE^{d}_{i} - QE_{i} = o$$

III. Composite supply (*arming ton function*)

A. Aggregation of domestic and imported commodities

(29) $$QQ_{i} = \alpha^{q}_{i}\left(\delta^{q}_{i}.QM_{i}^{-e^{q}_{i}} + (1-\delta^{q}_{i}).QD_{i}^{-e^{q}_{i}}\right)^{\frac{1}{e^{q}_{i}}}$$
$$; i \in I$$

B. Import – domestic demand ratio

$$\frac{QM_i}{QD_i} = \left[\frac{PDD_i}{PM_i}.\frac{\delta_i^q}{1-\delta_i^q}\right]^{\frac{1}{1+1_i^q}} \quad ;i \in I \tag{30}$$

C. Composite supply of commodities

$$QQ_i = QD_i + QM_i \quad ;i \in I \tag{31}$$

IV. Investment demand

A. Investment by sector of destination

$$QINV_{is} = I\overline{ADJ}_s.\overline{qinv}_{is} \quad ;i \in I \,\&\, s \in S \tag{32}$$

B. Investment matrix by origin and destination

$$QINVO_i = \sum_{s \in S} QINV_{is} \quad ;i \in I \tag{33}$$

$$q_{ik} = \alpha_{ik}^i.QINVO_i \quad ;i \in I; k \in K \tag{34}$$

V. Government consumption demand

$$QG_i = \overline{GADJ}.\overline{qg}_i \tag{35}$$

Block five: Institutional income and spending

I. Factor income

A. Labour wage income by skill category

$$YLS_{ls} = \sum_{i \in I}\sum_{s \in S} WL_{i,s,ls}.QL_{i,s,ls} + \overline{QL}_{ls}^{g}.\overline{WL}_{ls} \quad ;ls \in LS \tag{36}$$

$$YLG = \sum_{sl \in SL} \overline{QL}_{ls}^{g}.\overline{WL}_{ls} \tag{37}$$

$$YLNG = \sum_{i \in I}\sum_{s \in S}\sum_{ls \in LS} WL_{i,s,ls}.QL_{i,s,ls} \tag{38}$$

$$YLA_s = \sum_{i \in I} \sum_{ls \in LS} W_{i,s,ls}.QL_{i,s,ls} \quad (39)$$
$$; i \in I, ls \in LS \ \& \ s \in S$$

$$YLT = YLNG + YLG \quad (40)$$

$$RL_{sh} = \Delta^{l}_{sh}.\sum_{i \in I} \sum_{ls \in LS} WL_{i,s,ls}.QL_{i,s,ls} \quad (41)$$
$$; s \in S, h \in HH$$

B. Capital income

$$RK_{sh} = \Delta^{k}_{sh}.\sum_{i \in I} PK_{i,s}.QK_{i,s} \quad (42)$$
$$; s \in S, h \in HD$$

II. Income of non-government domestic institutions

A. Income of institutions

$$YI_h = \sum_{s \in S} (RL_{sh} + RK_{sh}) + \sum_{h' \in HNG} TRII_{h,h'} + \overline{TR}_{h,gov} + (trnsfr_{h,row} + invf_{h,row} + wrf_{h,row}).\overline{EXR} \quad (43)$$
$$; h \in HNG$$

B. Intra-institutional display

$$TRII_{hh'} = del_{hh'}.(1 - mps_{h'}).\left[1 - td_{h'}\right].YI_{h'} \quad (44)$$
$$; h, h' \in HNG$$

III. Expenditure of non-government domestic institution

A. Household spending net of transfers, saving and taxes

$$EH_h = \left[1 - \sum_{h' \in HNG} del_{hh'}\right].(1 - mps_h).(1 - td_h).YI_h \quad (45)$$
$$; h \in HH$$

B. Household final consumption

$$QH_{ih} = \gamma^{c}_{ih} + \frac{\beta^{c}_{ih}}{PQ_i}\left[EH_h - \sum_{j \in I} \gamma^{c}_{jh}.PQ_j\right] \quad (46)$$
$$; h \in HH \ \& \ i \in I$$

C. Companies spending

$$QC_h = \left(del_{hh'} + mps_h + \left[\frac{td_h}{1+td_h} \right] \right).YI_h \quad (47)$$

$$; h \in HC$$

IV. Government sector income and spending

$$\begin{aligned} YG = & \sum_{h \in HNG} td_h.YI_h + \sum_{i \in I} \sum_{s \in S} tva_{is}.PVA_{is}.QVA_{is} \\ & + \sum_{i \in I} ta_i.PX_i.QX_i + \sum_{i \in I} tm_i.pwm_i.QM_i.\overline{EXR} \\ & + \sum_{i \in I} te_i.pwe_i.QE_i.\overline{EXR} \\ & + \sum_{i \in I} tq_i.PQ_i.QQ_i + \sum_{h \in HNG} trnsfr_{gov,h} \\ & + trnsfr_{gov,row}.\overline{EXR} - \sum_{i \in I} \sum_{sb \in SB} tsub_{i,s,b}.PDD_i.QD_i \end{aligned} \quad (48)$$

$$EG = \sum_{i \in I} PQ_i.QG_i + \sum_{i \in HNG} \overline{TR}_{h,gov} \quad (49)$$

V. National savings

$$SAVP = \sum_{h \in HNG} mps_h.(1-td_h).YI_h \quad (50)$$

$$; h \notin \{Pub\}$$

$$SAVB = GSAV + mps_{pub}.(1-td_h).YI_{pub} \quad (51)$$

Block six: System constraints

I. Factor markets

$$UNEMPT = 1.0 - \left(\frac{\sum_{i \in I} \sum_{s \in S} QL_{is}}{\overline{QLS}} \right) \quad (52)$$

$$UNEMP_{ls} = 1.0 - \left(\frac{\sum_{i \in I} \sum_{s \in S} QL_{isls}}{\overline{QLS}_{ls}} \right) \quad (53)$$

$$; ls \in LS$$

II. Composite commodity markets

$$QQ_i = \sum_{j \in I} QINT_{ij} + \sum_{h \in HH} QH_{ih} + QG_i + QINVO_i \quad (54)$$

$$; i \in I$$

III. Current account balance of the rest of the world (in foreign currency)

$$(55)\quad \begin{aligned} &\sum_{i\in I} pwm_i.QM_i + \sum_{h\in HD} trnsfr_{row,h} = \\ &\sum_{i\in I} pwe_i.QE_i + \sum_{h\in HD} (trnsfr_{h,row} + invf_{h,row} + wrf_{h,row}) \\ &+\sum_{s\in S} FSAV_s \end{aligned}$$

IV. Government balance

$$(56)\quad GSAV = YG - EG$$

V. Saving – investment balance

A. Basic formulation

$$(57)\quad \begin{aligned} &\sum_{h\in HNG} mps_h(1-td_h).YI_h + GSAV + \sum_{s\in S} \overline{EXR}.FSAV_s \\ &= \sum_{s\in S}\sum_{i\in I} PQ_i.QINV_{si} \end{aligned}$$

B. Alternative formulation

$$(58)\quad \begin{aligned} &\sum_{h\in HNG} mps_h(1-td_h).YI_h + GSAV \\ &+\overline{EXR}.\overline{FSAV}_{Prv} + \overline{EXR}.FSAV_{Pub} \\ &= \sum_{i\in I} PQ_i.\overline{IADJ}_{Pub}.qinv_{i,Pub} \\ &+\sum_{i\in I} PQ_i.IADJ_{Prv}.\overline{qinv}_{i,\mathrm{Prv}} \end{aligned}$$

Block seven: Inter-period dynamics

A. Updating of physical capital stock

$$K^r_{i,t+1} = K^r_{i,t}\left(1-\delta^r_i\right) + I^r_{i,t} \text{.....(59)}$$

$$K^p_{i,t+1} = K^p_{i,t}\left(1-\delta^p_i\right) + I^p_{i,t} \text{.....(60)}$$

$$RK^r_i = \frac{RRK^{r0}_i}{K^{r0}_i} \text{.....(61)}$$

$$RK^p_i = \frac{RRK^{p0}_i}{K^{p0}_i} \text{.....(62)}$$

B. Supply of return on physical capital

$$RRK^r_{i,t+1} = RRK^r_t(1-\delta^r_i) + RK^r_i \times I^r_{i,t} \text{.....(63)}$$

$$RRK^p_{i,t+1} = RRK^p_t(1-\delta^p_i) + RK^p_i \times I^p_{i,t} \text{.....(64)}$$

C. Change in knowledge stock

$$WK_{t+1} = WK_t(1-\delta_t^w) + IRD_t \text{.....(65)}$$

IRD_t= *Gross spending on R&D at the national level*

$$RW = \frac{RRW^0}{WK^0} \text{.....(66)}$$

$$RRW_{t+1} = RRW_t(1-\delta_t^w) + IRD_t \times RW \text{.....(67)}$$

(*Latest revision of SNA assumes that expenditure or R&D is considered as investment spending*)

D. Change in IT/software assets

$$ITK_{t+1} = ITK_t(1-\delta_t^{it}) + IIT_t \text{.....(68)}$$

$$RIT = \frac{RRIT^0}{ITK^0} \text{.....(69)}$$

$$RRIT_{t+1} = RRIT_t(1-\delta_t^{it}) + IIT_t \times RIT \text{.....(70)}$$

E. Updating of other intangible assets

(*Creative human capital, organization model, trademarks, industrial designs, cultural and creative goods, entertainment, media, printing and publishing*)

$$OIK_{t+1} = OIK_t(1-\delta_t^{0i}) + OII_t \text{.....(71)}$$

$$ROI = \frac{RROI^0}{OIK^0} \text{.....(72)}$$

$$RROI_{t+1} = RROI_t(1-\delta_t^{0i}) + OII_t \times ROI \text{.....(73)}$$

F. Impact on total factors productivity

$$TFP_{i,t+1}^r = TFP_{i,t}^r . \left(\frac{RRW_{t+1}}{RRW_t}\right)^{\psi_i^{wr}} . \left(\frac{RRIT_{t+1}}{RRIT_t}\right)^{\psi_i^{sr}} . \left(\frac{RROI_{t+1}}{RROI_t}\right)^{\psi_i^{0r}} \text{.....(74)}$$

$$TFP_{i,t+1}^p = TFP_{i,t}^p . \left(\frac{RRW_{t+1}}{RRW_t}\right)^{\psi_i^{wp}} . \left(\frac{RRIT_{t+1}}{RRIT_t}\right)^{\psi_i^{sp}} . \left(\frac{RROI_{t+1}}{RROI_t}\right)^{\psi_i^{0p}} \text{.....(75)}$$

G. Population dynamics and labour force in thousands

$$POP_{t+1} = POP_t(1+\bar{g}_t^p) \text{.....(76)}$$

$$POP_{t+1}^u = S_t^u . \overline{POP}_{t+1} \text{.....(77)}$$

$$POP_{t+1}^r = POP_{t+1} - POP_{t+1}^u \text{.....(78)}$$

$$L_{u,t+1}^s = POP_{t+1}^u . P_{u,t+1}^r + \bar{M}_t^g \text{.....(79)}$$

$$L_{r,t+1}^s = POP_{t+1}^r . P_{r,t+1}^r - \bar{M}_t^g \text{.....(80)}$$

H. Government and non-government average wage rates

$$W_{t+1}^{n} = W_{t}^{n}(1+g_{n}^{w}) + \omega^{n}\left[\frac{P_{t}^{c} - P_{t-1}^{c}}{P_{t-1}^{c}}\right] \text{.....(81)}$$

$$W_{t+1}^{g} = W_{t}^{g}(1+g_{g}^{w}) + \omega^{g}\left[\frac{P_{t}^{g} - P_{t-1}^{g}}{P_{t-1}^{g}}\right] \text{.....(82)}$$

I. Breakdown of total investment spending

$$I_{i,t}^{r} = I_{i,t}^{rd} + \bar{I}_{i,t}^{rf} \text{.....(83)}$$

$$I_{i,t}^{p} = I_{i,t}^{pd} + \bar{I}_{i,t}^{pf} \text{.....(84)}$$

J. Investment allocation patterns

$$\delta_{i,t+1}^{p} = \delta_{i,t+1}^{p}(1+\bar{g}_{i,t}^{p}) \text{.....(85)}$$

$$;\sum_{i} \bar{g}_{i,t}^{p} = 1$$

$$\delta_{i,t+1}^{r} = \delta_{i,t}^{r}(1+\bar{g}_{i,t}^{r}) \text{.....(86)}$$

$$;\sum_{i} \bar{g}_{i,t}^{r} = 1$$

K. Impact on labour efficiency by skill category

$$LEF_{ls,t+1}^{r} = LEF_{ls,t}^{r}.\left(\frac{RRW_{t+1}}{RRW_{t}}\right)^{\psi_{ls}^{wr}}.\left(\frac{PPIT_{t+1}}{RRIT_{t}}\right)^{\psi_{ls}^{sr}}.\left(\frac{RROI_{t+1}}{RROI_{t}}\right)^{\psi or} \text{.....(87)}$$

$$;ls \in LS$$

$$LEF_{ls,t+1}^{p} = LEF_{ls,t}^{p}.\left(\frac{RRW_{t+1}}{RRW_{t}}\right)^{\psi_{ls}^{wp}}.\left(\frac{PPIT_{t+1}}{RRIT_{t}}\right)^{\psi_{ls}^{sp}}.\left(\frac{RROI_{t+1}}{RROI_{t}}\right)^{\psi_{ls}^{op}} \text{.....(88)}$$

$$;ls \in LS$$

$$LEF_{ls,t+1} = LEF_{ls,t+1}^{p} + LEF_{ls,t+1}^{r} \text{.....(89)}$$

$$;ls \in LS$$

L. Impact on labour movement across skill categories

$$QL_{hig,t+1} = QL_{hig,t+1} + M_{hig,med,L+1} \text{.....(90)}$$

$$M_{hig,med,t+1} = \alpha_{med}^{m}.LEF_{med,t+1} \text{.....(91)}$$

$$QL_{med,t+1} = QL_{med,t+1} + M_{med,low,t+1} - M_{hig,med,t+1} \text{.....(92)}$$

$$M_{med,low,t+1} = \alpha_{low}^{m}.LEF_{low,t+1} \text{.....(93)}$$

$$QL_{low,t+1} = QL_{low,t+1} - M_{med,low,t+1} \text{.....(94)}$$

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