# Forecasts of Future Labour Market Requirements for Oman: An Application of the OMAGE model

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**Abstract**

This paper describes the theory of OMAGE, a dynamic computable general equilibrium model of the Oman economy, and its application to forecast labour-market requirements to the year 2030. A distinctive feature of the model is the detailed modelling of labour demand and labour supply, by industry, occupation, qualification and nationality, and the possibility of running the model in two modes: integrated or independent determination of the two sides of the labour market. As Oman uses a large expatriate workforce, in this paper we adopt an intermediate position, with growth in employment demand for Omanis tied to growth in labour supply of Omanis, but the supply of Non-Omanis is generally determined by employment demand. Key inputs to this forecast include information from external forecasting agencies on population and labour-force participation, commodity-using technological and household-taste changes, multi-factor productivity, and current consensus view for the world price of crude oil and for Oman's production and reserves of oil. The results indicate that, despite the fall in oil production and price, the Omani economy is forecast to grow at an average annual rate of 3.3 per cent. Export-oriented and import-competing industries outside of the oil sector are expected to expand, assisted by real depreciation and growth in world demand. Service and manufacturing sectors that sell primarily to households and government are also expected to have relatively good growth prospects due to higher-than-real-GDP growth in private and public consumption. Consequently, demand for occupations and qualifications used intensively in those sectors will have better growth prospects that those used intensively in the oil sectors. Fastest growing occupations include sales, services and managers and investor occupations. Fastest growing study fields include personal services, management and commerce, and create arts.[1]

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## 1 Introduction

The Oman economy has been growing steadily at an average 4.8% since 2000, largely due to the expansion of the oil sectors. To meet the demand for economic expansion, the economy uses a large foreign workforce, which comprises about two third of the total workforce. However, conscious of the volatility in the oil market, the government has always been trying to diversify the economy. It has also been implementing policies to reduce the dependence on foreign labour by encouraging companies to employ locals and by developing a skilled national workforce via education and training. Forecasting labour requirements is an important element in the development of an effective education and training policy.

Policy interest in economy-wide labour market forecasting for education and planning purposes has been growing since the 20's due to the recognition of the role of human capital in economic development and the desire to minimize skill mismatches in the labour market. However, most of the labour force planning focused on "manpower requirements" by occupation and qualification, which were calculated so as to meet specific macro and/or sectoral targets. An important criticism of the approach was the use of fixed coefficients in moving from macro, to industrial, occupational and qualification-specific forecasts via input-output (IO) models and fixed Employment Requirement Matrices.

Disappointment with the manpower planning models led to the development of more advanced models. These included integrated macroeconomic models, and CGE models for economic projections, and stock-flow accounting frameworks for modeling qualifications. Many forecasting systems now model both the demand side and the supply sides of the labour market. Internationally, the most sophisticated and comprehensive large scale policy-oriented labour market forecasting systems are to be found in Australia (Meagher and Pang 2011), the UK (Wilson and Homenidou 2012), the EU (CEDEFOP 2012), Canada (Ignaczak 2012), the Netherlands (Dupuy 2009) and the USA (BLS 2013).

However, most of existing systems still model the demand-sides and supply-sides of labour markets independently (see a review by Boswell *et al.* , 2004:36). With independent demand-side and supply-side modelling of the labour market, the main way that existing labour market forecasting models have informed policy in the area of skill imbalances is via the analysis of mismatches between labour demand and labour supply. Broadly, this approach has four important methodological shortcomings: (i) it fails to account for endogenous demand-side adjustment to qualification- or occupation-specific labour imbalances; (ii) it fails to account for endogenous supply-side adjustment, via offers to work in occupations in short supply, adjustment to hours worked or participation rates, or offers to enrol in courses leading to qualifications in high demand; (iii) with its focus on skill shortages, it gives insufficient attention to the economic cost of excess supply; (iv) by focusing on quantities, rather than prices, mismatch analysis does not measure the economic damage, in terms of GDP foregone, of skill imbalances.

This paper develops a labour market modelling in which labour supply and labour demand are integrated within a dynamic general equilibrium model. The model is then used to forecast employment requirement for the Oman economy by 2030.

# 2 THE OMAGE MODEL

OMAGE has two distinct theoretical parts: (i) the modelling of the economy and its demand for labour by occupation, nationality and skill, hereafter called the core CGE model; and (ii) the modelling of supply of labour by skill, occupation and nationality, hereafter called the labour supply module. Our discussions below focus on these two parts.

## *2.1 The core CGE model*

The core CGE structure of OMAGE consists of equations describing: demands for produced inputs and primary factors for current production purposes; commodity supplies by individual industries; industry-specific demands for inputs to capital formation; household commodity demands; export demands distinguished by commodity; government demands distinguished by commodity; the relationship of basic values to production costs and to purchasers' prices; market-clearing conditions for commodities and primary factors; and numerous macroeconomic variables, such as balance of trade, government budget, foreign liabilities and assets.

In OMAGE each industry is assumed to minimise unit costs subject to given input prices and a nested constant returns to scale production function. Three primary factors are identified (labour, capital and land) with labour further distinguished by occupation, nationality and skill. Capital is assumed to be sector-specific, while occupation-specific labour is perfectly mobile across industries. Households are modelled as constrained maximisers of utility functions. Units of new industry-specific capital are cost-minimising combinations of local and foreign commodities. For all commodity users, imperfect substitutability between imported and local varieties of each commodity is assumed. The export demand for any given Omani commodity is inversely related to its foreign-currency price. The model recognises consumption of commodities by government and the details of taxation instruments. It is assumed that all sectors are competitive and all goods markets clear. Purchasers' prices differ from producer prices by the value of indirect taxes and trade and transport margins. All agents are assumed to be price-takers, with producers operating in competitive markets which prevent the earning of pure profits.

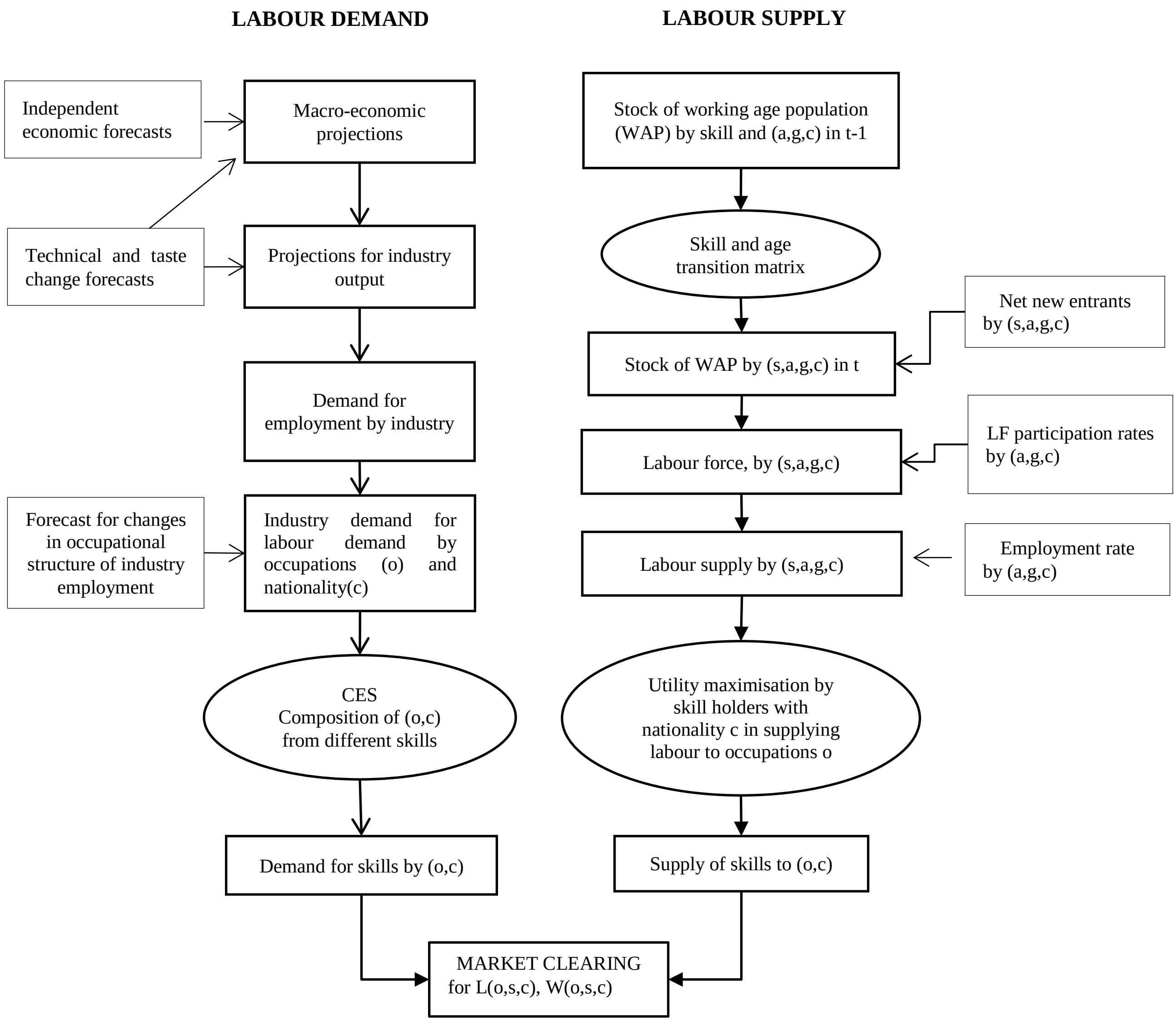
OMAGE is dynamic. The dynamic mechanisms in OMAGE's core CGE structure include: (a) stock/flow accounting for the accumulation of capital stocks via investment and depreciation; (b) accounting for changes in net foreign liabilities via changes in investment and saving; and(c) lagged adjustment mechanisms in the labour market. Capital accumulation is industry-specific, and linked to industry-specific net investment. Annual changes in the net liability position of the economy are related to the annual investment/savings imbalance. In policy simulations, the model provides the option of allowing the labour market to follow a lagged adjustment path. With this option activated, short-run real consumer wages are sticky. Hence short-run labour market pressures mostly manifest as changes in employment. In the long-run, employment returns to baseline, with labour market pressures reflected in changes in real wages.

## *2.2 Labour market modelling*

### *2.2.1 Labour demand*

Figure 1 illustrates the labour market forecasting framework in OMAGE. On the demand side, the starting point is the projections for macroeconomic variables and industry outputs generated from the core CGE component of the model. These are based on available independent information on predicted or planned changes in key macro variables and changes in technology and preferences. Projections for industry outputs are then used as input to compute projections for industry demand for labour by occupation and nationality. For occupations, it is assumed that relative market wage rates are given, and that producers' minimize the overall cost of purchasing occupations to achieve the overall required level of employment. Occupations by nationality are then a cost-minimising combination of different skills. The results are the demand for skills by occupation and nationality.

**Figure 1: Labour Market Forecasting Framework in OMAGE**




Notes: o(occupations) ∈{98 3-digit occupations}; a(age) ∈{5-year age groups for the population aged 15+}; g (gender) ∈{male, female}; c (nationality) ∈{Omani, NonOmani}; s (skills)∈{7 qualification levels x 13 broad study fields}; and there are 51 industries in the model

### *2.2.2 Labour supply module*

On the supply side, the starting point is the stock of working age population (WAP) by qualification (q), age (a), gender (g) and nationality (c) in the base year. In a year-to-year simulation, this stock evolves based on the changes in skill acquisition patterns and in age of the existing stock, plus new entrants into the labour market. The labour force is calculated by multiplying WAP with labour force participation rates, by age, gender and nationality. Labour supply by hours is then the product of labour force, employment rate, and hours worked per worker.

Workers with a given nationality and skill then supply their labour to occupations to maximise utility, which has occupational hourly wage rates as an argument. In *integrated mode,* Labour supply by occupation, skill and nationality (o,s,c) is reconciled with labour demand by occupation, skill and nationality (o,s,c) to determine the employment level and wage rates for (o,s,c).

More formally, the labour supply module contains the mechanism for stock/flow accounting for skill accumulation in the working age population. It starts with the stock of the working age population (WAP) in year 2011 (year *t-1* in OMAGE), distinguished by skill, age, gender and citizenship. The WAP in year *t* is defined as:

$$WAP_{a,g}^{s,c} = WAP_{aa,g}^{(t-1)ss,c} \times T_{(aa,a),g}^{(ss,s),c} + NEW_{a,g}^{s,c} \qquad (1)$$

where:

- $WAP_{a,g}^{s,c}$ is working age population by age (a), gender (g), citizenship (c), holding skill (s) in year *t*;
- $WAP_{aa,g}^{(t-1)ss,c}$ is working age population of (g,c), having age (aa) and skill (ss) in year *t-1*;
- $NEW_{a,g}^{s,c}$ is the net number of persons by (a,g,c and s) entering the labour market at the beginning of year *t*. They consist of people already in Oman turning 15 year of age in *t*, and new foreign workers; and
- $T_{(aa,a),g}^{(ss,s),c}$ is the transition matrix showing the probability that a person aged (aa) in year *t-1* will become a person aged (a) in year *t*, and the probability that a person with skill ss in year *t-1* will acquire skill *s* in year *t*.

The age transition probabilities can be calculated based on the number of years in each age group, and the death rate by age groups. The initial qualification transition can be estimated using educational data on the probability of group of people by age, gender and citizenship staying with the same qualification or acquiring a different qualification from *t-1* to *t*. We expect that this skill matrix is mainly diagonal, especially for older age groups.

The qualification transition matrix is not static, but has the potential to change from year to year based on changes in relative wage rates between qualifications according to the following equation:

$$T_{(aa,a),g}^{(ss,s),c} = AT_{(aa,a),g}^{(ss,s),c} \times \left( \frac{W_c^s}{W_c^{ss}} \right)^{\alpha_{a,g,c}} \qquad (2)$$

where:

- $AT_{(aa,a),g}^{(ss,s),c}$ are the autonomous shifts in transition rates for age and qualification, which shows the probability of people changing their skill types (qualification fields and/or qualification levels) due to reasons other than changes in the relative wage rates between skills;
- $W_c^{ss}$ is the wage rate for skill (ss) for people with (a,g,c) characteristics;
- $W_c^{ss}$ is the wage rate for qualification q for people with (a,g,c) characteristics; and
- $\alpha_{a,g,c}$ is the elasticity of qualification acquisition to relative skill wage rates by people with (a,g,c) characteristics.

Equation (2) says that if there is no change in the relative wage rates between the people's existing skill (ss) and skill (s), people will tend to stay in their skill category, except for the autonomous transitions. But if the wage rate of skill s is higher than that for skill ss, then more people in skill (ss) would acquire the skill s. The strength of this response to relative wage rates is governed by the parameter, which may differ between age groups, gender and nationality.

Once the stock of working age population by skill is determined, labour force by skill ( $LF_{a,g}^{s,c}$ ) in year t is determined as:

$$LF_{a,g}^{s,c} = WAP_{a,g}^{s,c} \times PR_{a,g}^{s,c} \qquad (3),$$

and labour supply by skill ( $LS_{a,g}^{s,c}$ )in year *t* is determined as:

$$LS_{a,g}^{s,c} = LF_{a,g}^{s,c} \times ER_{a,g}^{s,c} \qquad (4)$$

where

- $PR_{a,g}^{s,c}$ is the labour force participation rate by people of (a,g,c) holding skill *s* in year *t*; and
- $ER_{a,g}^{s,c}$ is the employment rate for (s,a,g,c) in year *t*. These the employment rates could be determined endogenously from labour market clearing equations at given wage rates, or set exogenously.

### *2.2.3 Linking the core CGE model and the labour supply module*

OMAGE allows the user to link the core CGE model and the labour supply module via the markets for skill and occupation, by nationality. On the demand side, industries first chose labour inputs by occupation and nationality based on their demand for primary factors, which, in turn, are based on their level of activity. They then chose a combination of skills to minimise the cost of compiling a unit of labour by occupation and nationality. On the supply side, workers with a given qualification and nationality supply their labour to occupations to maximise a utility function which has hourly wage rates as an argument. Together, labour demand and labour supply in occupation-, qualification- and citizenship-specific labour markets are then reconciled via endogenous movements in wage rates.

Integration of labour demand and labour supply allows endogenous adjustment in the labour market. For example, if a policy change or an economic shock causes a shortage of a particular occupation, the wage of the occupation will rise relative to that of other occupations. This will cause, on the demand side, a relative decline in demand for that occupation from industries compared to other occupations. On the supply side, the rise in the occupation wage rates causes more people to offer to work in the occupation. This, in turn, encourages more people to enroll in qualifications used intensively in that occupation. These adjustments occur until a new equilibrium is established.

For skill gap analysis, the two sides of the labour market can also be run independently, with labour demand describing future workforce needs.

Regardless of which labour-market mode is in operation, the OMAGE labour market forecasting framework has many advantages over other forecasting methods, such as the use of expert opinions or time series forecasting. This is due to the richness of the demand side modelling, particularly:

- It's coherence - whatever their level of detail, all forecasts are consistent with each other, and with an articulated, defensible view about the future of the economy;
- it's embodiment of very large amounts of relevant economic data and expert opinion - as a formal modelling system, the CGE model provides a framework for incorporating data from a wide variety of sources in a consistent manner;
- it's flexibility - the model and the forecast methodology are flexible enough to enable improvements over time in line with new information; and
- it's timeliness - the forecasts can be updated regularly and can be subject to good quality control, if the model and the forecasts are made transparent to the public, and so are subject to public scrutiny and feedback.

### *2.3 Database*

OMAGE's database comprises two parts: (i) economic data for the core CGE model; and (ii) data for the labour supply module.

At the heart of the data file for the core model is an input-output table. This shows the flows of goods and services between industries, and between industries and final demanders, such as households, government, investment and exports. OMAGE's core data are calibrated to the 2007 Oman input-output database in the GTAP 8.0 database (Narayanan et al. 2012), complemented by data published by Oman National Centre for Statistics and Information (NCSI) for the year 2007. It is then updated to 2012, the latest year for which published data are available at the time of this project, using data from NCSI for the period 2008-2012. Overall, the model recognizes 51 industries, 98 occupations, 55 skill types, 11 age groups, gender, and nationality. Generally, the higher the level of detail, the more useful are the labour market projections for policy making in general, and for the alignment of the education and training system with the needs of the labour market in particular. The level of detail in OMAGE currently corresponds to the level of detail in the available data, but can be expanded if more detailed data become available.

Data for the labour supply module are compiled from statistics taken from the 2010 Census and the 2008 Labour Force Survey. These data are then updated using data for population, persons employed, and education attainment published in statistical yearbooks between 2008 and 2012.

## 3 FORECAST DESIGN AND KEY INPUTS

### *3.1 Simulation design*

The following general assumptions are made for the operation of labour markets, key aspects of the macro economy and for large projects in the forecasting simulation.

In this forecast we assume that growth in employment demand for Omanis is tied to growth in labour supply of Omanis as predicted by the labour supply module. For Non-Omanis we assume perfectly elastic supply at a real wage rate which moves in line with the real wage rate received by Omanis. This means that labour-supply and employment for non-Omanis is generally determined by employment demand so as to keep the relative wage rates between Omanis and Non-Omanis unchanged. This is to avoid short-run and medium-run supply-side exerting an undue influence on long-term labour needs forecast.

We assume that aggregate nominal consumption (private and public) is a fixed proportion of nominal Gross National Disposable Income (GNDI). That is, we assume a constant average national propensity to consume out of GNDI throughout the simulation. This determines aggregate consumption as a function of GNDI. But the division of that consumption into private and public is governed by our assumption of a constant ratio of real public to real private consumption.

Within any given year, capital available for production in each industry is given at the start of the year. Within each year, industry-specific investment responds to deviations in expected rate of return away from normal rate of return to generate changes in capital formation that gradually return rates of return to normal level over time.

As the Omani economy grows, so does the rest of the world. In OMAGE, changes in world trading conditions occur via changes in the position of downward sloping export demand schedules and changes in foreign currency prices of imports. For these forecasts it is assumed that demand from the rest of the world for non-oil Omani products expands through the projection period at a rate which keeps the average foreign-currency price of exports (other than oil) unchanged. The position of the foreign demand schedule for oil exports is endogenous, and moves to achieve the exogenously imposed changes in price shown in Table 1. No change is assumed for foreign-currency import prices. This, combined with the assumption for non-oil export prices, means that the economy's non-oil terms of trade is fixed. The overall terms of trade, however, falls as a result of the reductions in oil's export price (Table 1).

In the forecasts from OMAGE reported in this paper, we impose on the model some information from specialist external forecasting agencies. OMAGE is then used to trace out the implications of these external forecasts at the level of detail required for the labour market projections.

### *3.2 Inputs into the forecasts*

For the years 2013 to 2018, for crude oil we use as input IMF (2011) projections for Omani production and export price through to 2018. For gas, we allow the model to determine exports and prices. After 2018, for oil production and price, we use extrapolations of medium-term trends. Inputs relating to oil are given in Table 1.

**Table 1. Projections for changes in crude oil resource, output and export price (percentage annual growth rates)**

| Year | Crude oil resource | Crude oil production | Crude oil export price |
|---|---|---|---|
| 2013 | -2.0 | 2.30 | -3.70 |
| 2014 | -2.0 | -1.05 | -3.35 |
| 2015 | -2.0 | -1.06 | -4.38 |
| 2016 | -2.0 | -1.08 | -3.12 |
| 2017 | -2.0 | -1.08 | -1.93 |
| 2018 | -2.0 | -1.09 | -1.31 |
| 2019 | -2.0 | -1.20 | -0.89 |
| 2020 | -2.0 | -1.32 | -0.61 |
| 2021 | -2.0 | -1.45 | -0.41 |
| 2022 | -2.0 | -1.60 | -0.28 |
| 2023 | -2.0 | -1.76 | -0.19 |
| 2024 | -2.0 | -1.93 | -0.13 |
| 2025 | -2.0 | -2.12 | -0.09 |
| 2026 | -2.0 | -2.34 | -0.06 |
| 2027 | -2.0 | -2.57 | -0.04 |
| 2028 | -2.0 | -2.83 | -0.03 |
| 2029 | -2.0 | -3.11 | -0.02 |
| 2030 | -2.0 | -3.42 | -0.01 |

Source: NCSI for 2013; IMF (2013) for 2014-2018; our assumption of the continuation of the trend for 2019-2030.

Table 2 reports for Omanis projections for growth in working-age population, changes in participation rates, and growth in the labour force used as input in our forecasts. The number for working age population growth was calculated using the OMAGE labour supply model and World Bank projections for new entrants into the labour force (World Bank, 2011). For participation rates we use data from ILO (2011). ILO provides projections for participation rates, by age and gender, for the period 2012-2018, which we extend via simple extrapolation to 2020. Thereafter, participation rates are assumed to remain unchanged from their level in 2020. The ILO has assumed that participation rates increase in 2013 for both male and female. For males, the rates are assumed to decline between 2014 and 2018. For females, the rates are assumed to increase to 2017, but to decline in 2018.

**Table 2. Projections for labour market indicators (percentage annual growth rates)**

| Year | Working age population growth rate (Omanis)[(a)] | Labour force participation rates Level[(b)] | | Growth rate[(c)] | | Labour force (Omanis) [(d)] |
|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | |
| 2012 | | 82.60 | 28.70 | | | |
| 2013 | 2.30 | 82.90 | 29.00 | 0.37 | 1.04 | 4.04 |
| 2014 | 2.28 | 82.60 | 29.20 | -0.45 | 0.81 | 3.67 |
| 2015 | 2.27 | 81.60 | 29.30 | -1.20 | 0.52 | 3.36 |
| 2016 | 2.29 | 80.40 | 29.40 | -1.48 | 0.29 | 3.09 |
| 2017 | 2.31 | 79.20 | 29.40 | -1.51 | 0.06 | 2.86 |
| 2018 | 2.32 | 78.00 | 29.40 | -1.52 | -0.14 | 2.67 |
| 2019 | 2.34 | 76.80 | 29.30 | -1.52 | -0.26 | 2.50 |
| 2020 | 2.36 | 75.60 | 29.20 | -1.51 | -0.33 | 2.36 |
| 2021 | 2.22 | 75.60 | 29.20 | 0.00 | 0.00 | 2.03 |
| 2022 | 2.10 | 75.60 | 29.20 | 0.00 | 0.00 | 1.91 |
| 2023 | 1.98 | 75.60 | 29.20 | 0.00 | 0.00 | 1.79 |
| 2024 | 1.86 | 75.60 | 29.20 | 0.00 | 0.00 | 1.67 |
| 2025 | 1.76 | 75.60 | 29.20 | 0.00 | 0.00 | 1.55 |
| 2026 | 1.69 | 75.60 | 29.20 | 0.00 | 0.00 | 1.43 |
| 2027 | 1.62 | 75.60 | 29.20 | 0.00 | 0.00 | 1.31 |
| 2028 | 1.56 | 75.60 | 29.20 | 0.00 | 0.00 | 1.20 |
| 2029 | 1.50 | 75.60 | 29.20 | 0.00 | 0.00 | 1.10 |
| 2030 | 1.44 | 75.60 | 29.20 | 0.00 | 0.00 | 1.00 |

Source: (a) Calculated using the labour supply model described in Section 2.2 and World Bank projection for the new entrants into the labour force by 2030 (WB 2011); (b) ILO (2011) for the period 2012-2018. We assume that the labour force participation rates stay unchanged after 2020; (c) calculated from (b); (d) Calculated from (a) and (c).

Other exogenous inputs include the following. Multi-factor productivity grows in non-oil industries at the rate of 1.0 per cent per annum. In line with declining production, the natural resource in crude oil production declines at an average annual rate of 2.0 per cent. There is no change in the availability of natural resources in other industries such as agriculture. We assume that there will be changes in household preferences away from fossil fuel products (such as natural gas, petroleum, electricity), and products associated with unhealthy lifestyles such as tobacco products. It is also assumed that, due to growing affluence of Omani households, there will be changes in household preferences toward meat, dairy, motor vehicle, electronic equipment, and services (such as hotels and restaurants, air transport, communication, financial services, insurance, real estate service, other business services, education, health, and recreation, community and personal services).

## 4 FORECAST RESULTS FOR 2013-2030

### *4.1 Macro results*

Table 3 shows projections for key macroeconomic variables. The first four columns of Table 3 show annual average growth rates over four periods spanning 2012 to 2030. The last column reports annual average growth rates over the whole forecast period. To aid our understanding of macroeconomic outcomes, we also report in Table 4 results for crude oil - the most important sector, which at the start of the forecast contributes around 45 per cent of total value added.

We begin by examining column 5 of Table 3, before examining the results for earlier periods in the preceding columns. Average annual growth in Omani employment (persons) is 2.1 per cent (row 17). As discussed earlier, Non-Omani labour is assumed to be available in perfectly elastic supply at a given real wage. Over the whole forecast period, this has the effect of expanding employment of Non-Omanis at about the same rate as Omani employment (row 18).

Multi-factor productivity (MFP) growth (row 6, Table 3) is projected to contribute approximately 1 percentage point to annual GDP growth. Natural resource supply (row 5) is forecast to decline at an annual average rate of approximately 1.4 per cent. With natural resources representing approximately 25 per cent of GDP at the start of the period (see Table 1), this damps annual average GDP growth by approximately (1.4 × 0.25 =) 0.35 percentage points. However, with wage-bill weighted employment growth of 2.5 per cent and multi-factor productivity growth of around 1 per cent, capital growth is projected to be strong (row 2, column 5). Together, the growth rates in employment, capital, natural resources and MFP generate average annual growth in real GDP of 3.3 per cent.

Forecast growth in real GDP is not constant through the forecast period. In the first two periods, 2012-2015 and 2016-2020, the growth rate of real GDP is relatively steady at about 3.9 per cent. However, the growth rate declines progressively from 2020 onwards. The same declining trend can be found for growth in aggregate capital stock, employment, and the expenditure-side components of GDP.

There are two important supply side factors driving the results of declining GDP growth. First, growth of labour supply of Omanis (row 17, Table 3) is forecast to fall from 3.1 per cent in the first period to 1.2 per cent by the last period. Second, reductions in oil output progressively increase over the period (Tables 1 and 4). The forecast reduction in output is accommodated by endogenous primary-factor productivity change in the presence of a fixed rate of decline in resource (i.e., sub-soil asset) supply. With the rate of growth in oil output steadily declining over the period, the model projects a steadily falling rate of oil productivity growth (row 5 Table 4). Given constant MFP growth in non-oil sectors of 1 per cent, this implies a declining trend in the economy-wide rate of MFP growth (row 6, Table 3). As growth in employment and MFP decline over the forecast, so too does growth in the national capital stock (row 2).

We now turn to expenditure side of GDP. Looking at rows 8 and 9 of Table 3, the composite of private and public consumption grows faster than real GDP. This occurs despite declines in the terms of trade (row 14). The explanation lies in the country's high rate of savings. This leads to growing net foreign assets over the period, which buoys real GNDI relative to real GDP. We note also that in row 10, on average, the rate of real investment growth also exceeds the real GDP growth rate. To sustain the growth rate of capital stock at 3.7 per cent, given the initial economy-wide investment to capital ratio, investment must grow at an average of 4.5 per cent per annum.

With all the components of GNE growing more strongly than real GDP, the export growth rate must be less than the import growth rate (compare row 11 with row 12, Table 3). Ceteris paribus, this requires real appreciation of the Oman currency. However, the decline in oil production and exports causes a reverse Dutch Disease effect, generating real depreciation in order to secure expansion in non-oil export for any given level of imports. This results in net real depreciation (row 13).

**Table 3. Macroeconomic variables (average annual growth rates, %)**

| | (1) 2012-2015 | (2) 2016-2020 | (3) 2021-2025 | (4) 2026-2030 | (5) 2012-2030 |
|---|---|---|---|---|---|
| *A. Income components of GDP* | | | | | |
| 1.Real GDP | 3.8 | 3.9 | 3.2 | 2.5 | 3.3 |
| 2.Capital stock | 3.1 | 4.8 | 3.8 | 3.0 | 3.7 |
| 3.Employment, persons | 5.3 | 2.2 | 1.4 | 0.9 | 2.1 |
| 4.Employment, wage-bill weighted | 5.6 | 2.8 | 1.8 | 1.2 | 2.5 |
| 5.Natural resource | -1.2 | -1.6 | -1.4 | -1.3 | -1.4 |
| 6.Multi-factor productivity | 1.3 | 1.2 | 0.9 | 0.7 | 1.0 |
| 7.Real wage (CPI deflated) | 3.6 | 4.7 | 1.1 | 0.5 | 2.3 |
| *B. Expenditure components of GDP* | | | | | |
| 8.Real private consumption | 5.5 | 4.0 | 3.0 | 2.3 | 3.5 |
| 9.Real public consumption | 5.5 | 4.0 | 3.0 | 2.3 | 3.5 |
| 10.Real investment | 9.6 | 4.9 | 3.2 | 2.5 | 4.5 |
| 11.Export volumes | 6.1 | 4.4 | 2.6 | 1.4 | 3.3 |
| 12.Import volumes | 11.8 | 5.9 | 2.2 | 1.0 | 4.4 |
| *C. Other macro indicators* | | | | | 0.0 |
| 13.Real exchange rate | 4.8 | 0.3 | -2.3 | -2.4 | -0.4 |
| 14.Terms of trade | 2.9 | -0.6 | -2.2 | -2.2 | -0.9 |
| 15. Real GNP | 5.9 | 4.3 | 3.0 | 2.2 | 3.6 |
| 16. GDP price deflator | 1.0 | 0.1 | -1.1 | -1.2 | -0.4 |
| 17. Employment for Omanis (persons) | 3.1 | 2.7 | 1.8 | 1.2 | 2.1 |
| 18. Employment for Non-Omanis (persons) | 5.9 | 2.1 | 1.3 | 0.8 | 2.1 |

**Table 4. Projections for Crude oil**

| | (1) 2012-2015 | (2) 2016-2020 | (3) 2021-2025 | (4) 2026-2030 | (5) 2012-2030 |
|---|---|---|---|---|---|
| A. *Average annual growth rate, %* | | | | | |
| 1. Output[(a)] | 0.05 | -1.15 | -1.77 | -2.85 | -1.60 |
| 2. Employment[(b)] | -2.27 | -3.34 | -2.28 | -2.35 | -2.60 |
| 3. Capital stock[(b)] | -0.55 | -2.58 | -2.12 | -2.17 | -2.00 |
| 4. Natural resource[(a)] | -2.00 | -2.00 | -2.00 | -2.00 | -2.00 |
| 5. Multi-factor productivity[(b)] | 1.05 | 1.20 | 0.31 | -0.77 | 0.38 |
| 6. Export volume[(b)] | -0.07 | -6.06 | -6.94 | -12.53 | -7.19 |
| B. *Average share in the economy (%)* | | | | | |
| 7.Share in aggregate value added[(b)] | 40.4 | 27.3 | 21.4 | 17.8 | 25.3 |
| 8.Share in aggregate export value[(b)] | 62.3 | 36.8 | 23.0 | 14.3 | 31.5 |

Source: (a) exogenous input (see Section 4.2.1); (b) simulation result.

## *4.2 Industry production*

Table 5 reports average annual growth rates for industries over each five-year period, and their rankings over the full forecast period.[2]

[2] The model contains 51 industries, 98 occupations and 55 skill levels. For brevity, in this paper we aggregate them to 26 industries, 10 broad occupational groups, and 13 broad study fields.

**Table 5. Industry production**
**(average annual growth rates, %) and industry ranking over the full period**

| Sector | Average annual growth rate, % | | | | | Ranking, 2012-2030 |
|---|---|---|---|---|---|---|
| | 2012-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2012-2030 | |
| 1. Agriculture | 5.5 | 4.7 | 2.2 | 1.4 | 3.2 | 21 |
| 2. Fishing | 3.7 | 2.5 | 1.5 | 1.1 | 2.0 | 22 |
| 3. Crude oil | 0.0 | -1.2 | -1.8 | -2.9 | -1.6 | 26 |
| 4. Natural gas | 2.7 | 2.0 | 1.3 | 1.2 | 1.7 | 23 |
| 5. Other mining industries | 2.7 | 1.4 | 1.2 | 1.0 | 1.5 | 24 |
| 6. Food, beverage and tobacco | 12.6 | 15.4 | 4.3 | 0.5 | 7.5 | 5 |
| 7. Textile, clothing and footwear | 4.8 | 6.9 | 7.2 | 5.7 | 6.3 | 8 |
| 8. Non-metal products | 6.3 | 6.7 | 4.3 | 2.9 | 4.9 | 12 |
| 9. Petroleum refining and coke | 11.0 | 11.7 | 4.7 | 3.3 | 7.2 | 6 |
| 10. Chemicals, rubber and plastic products | 5.6 | 11.1 | 10.6 | 8.4 | 9.3 | 3 |
| 11. Metal products | 7.0 | 11.2 | 9.3 | 6.5 | 8.6 | 4 |
| 12. Transport equipment | 9.9 | 13.4 | 4.9 | 1.6 | 7.1 | 7 |
| 13. Other machinery and equipment | 8.7 | 15.9 | 9.9 | 3.5 | 9.5 | 2 |
| 14. Other manufacturing | 14.0 | 20.5 | 10.3 | 3.5 | 11.7 | 1 |
| 15. Electricity, gas and water | 6.2 | 4.9 | 3.8 | 3.1 | 4.3 | 17 |
| 16. Construction | 4.2 | 1.0 | 0.3 | 0.1 | 1.1 | 25 |
| 17. Wholesale and retail trade | 8.6 | 6.7 | 4.1 | 3.0 | 5.2 | 9 |
| 18. Accommodation and food drink services | 8.8 | 7.6 | 3.5 | 2.3 | 5.2 | 10 |
| 19. Transport and communication | 9.2 | 7.4 | 3.4 | 2.2 | 5.1 | 11 |
| 20. Finance and insurance | 8.4 | 6.1 | 3.3 | 2.4 | 4.6 | 14 |
| 21. Other business services | 9.7 | 5.4 | 3.5 | 3.1 | 4.9 | 13 |
| 22. Public administration | 5.6 | 3.9 | 2.9 | 2.2 | 3.4 | 20 |
| 23. Education | 7.3 | 4.1 | 2.9 | 2.3 | 3.8 | 18 |
| 24. Health care | 5.8 | 4.0 | 3.2 | 2.6 | 3.7 | 19 |
| 25. Recreation and other services | 8.4 | 5.4 | 3.3 | 2.5 | 4.5 | 16 |
| 26. Dwelling services | 6.7 | 5.0 | 4.0 | 3.3 | 4.5 | 15 |

On the basis of our discussion of macroeconomic results, we should expect (a) with aggregate capital rising relative to aggregate employment, capital intensive sectors will have relatively good growth prospects; (b) export and import-competing industries outside of the oil sector will be assisted by real depreciation and growth in world demand necessary to keep the average non-oil export price unchanged; and (c) with growth in private and public consumption higher than growth in real GDP, relatively good growth prospects for service and manufacturing sectors that sell primarily to households and government.

Indeed, we see industries with the highest growth prospect include Other manufacturing, Other machinery and equipment, Chemical, rubber and plastic product. These industries are relatively capital intensive, and/or have a high initial export propensity and import penetration. The Other manufacturing industry, for example, exports just under half of its output; and imports comprise half of the local market for these products. Capital comprises over two third of value added in this industry.

The industry with the worst growth prospects is crude oil, by assumption (Table 4). Another industry with poor prospects is Construction services. This is an important industry in our forecasts, because it contributes around one third to total employment in Oman. The construction services sector sells almost 90 per cent of its output to investment in general. However, output growth of construction is lower than we might have expected from an understanding alone that real investment grows strongly over the period (see Table 3). The explanation lays in the sale patterns of construction services. While the sector sells almost all of its output to investment generally, nearly half of these sales are to crude oil, which, as discussed above, is a slow growing sector. This damps output growth for construction services relative to growth in investment in general.

The results for other industries can be explained largely by changes in the macro economy, their cost and sale structures, and input-output linkages in the model.

### *4.3 Employment by industry*

In explaining results for employment, it is helpful to begin with a simple representation of the OMAGE equation governing industry employment. In words, growth in employment in industry *i* equals growth in production of industry *i* less labour-saving technological progress that reduces the use of employment per unit of output, with an allowance for a change in the price of labour relative to the price of primary factors generally. The last-mentioned effect is a substitution effect. If the price of labour rises relative to the price of factors generally, then all else unchanged industry *i* will reduce its usage of labour in favour of other primary factors (capital and natural resource).

Equation (5) expresses the same idea in mathematical form:

$$l_i = z_i + a_i - \sigma_i (w_i - p_i) \qquad (5)$$

where

- $l_i$ is percentage growth in employment in industry i;
- $z_i$ is percentage growth in industry output;
- $a_i$ is the percentage change in labour-saving technological progress (include MFP);
- $\sigma_i$ is the substitution elasticity applying to primary factors;
- $w_i$ is the annual percentage change in the average wage rate faced by industry i; and
- $p_i$ is the annual percentage change in the average cost of primary factor inputs..

The dominant influence on the distribution of industry employment outcomes is the term $z_i + a_i$. This is clear from Figure 2, which reports industry output and employment outcomes. The correlation coefficient between industry output and industry employment is 98%. This indicates that, relative to the contribution of industry outputs, the second term in Equation (5) ($-\sigma_i(w_i - p_i)$) is exerting a trivial influence on the industry employment ranking. This is to be expected for two reasons. First, on average, for sectors outside of oil and gas, almost 50% of movements in $p_i$ are explained by movements in $w_i$.[3] Hence, there is a strong propensity for w to approximately equal $p_i$. Second, a typical value for $\sigma_i$ is 0.5, damping the influence of relative wage movements on the distribution of sectoral employment outcomes.

[3] Outside of the oil and gas sectors, on average, 46% of returns to primary factors are explained by payment to labour.

The final point to note in regard to Figure 2 is the systematic positive gaps between industry output and employment outcomes. In terms of equation (5), this is explained by changes in the technology variable, $a_i$. As discussed in the macro section, our simulation carries an assumption of an annual 1% improvement in primary factor technical efficiency. In terms of equation (5), this opens a 1% gap between average output and employment outcomes by industry.

**Figure 2: Industry employment and industry output, average annual growth rates, 2012 to 2030, %**

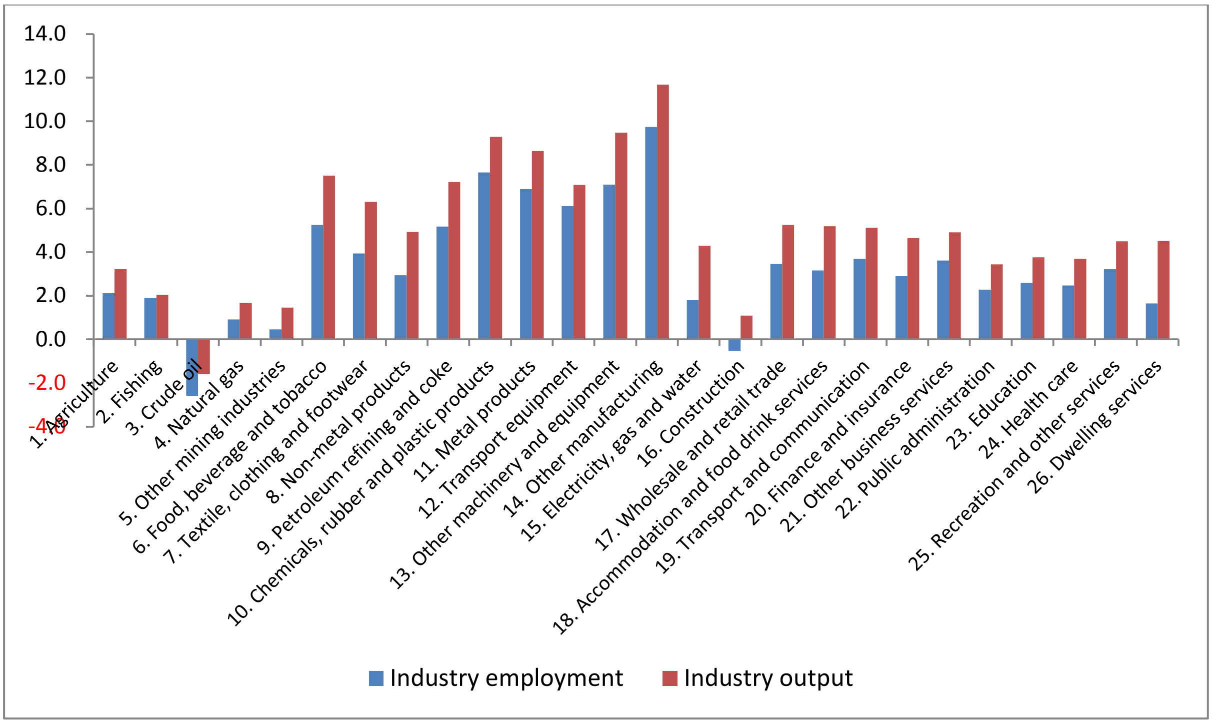



Table 6 reports the projected average annual growth rates of industry employment and their ranking over the full forecast period. This has the same format as Table 5.

**Table 6. Industry employment**
(average annual growth rates, %) and industry ranking over the full period

| | Average annual growth rate, % | | | | | Ranking, 2012-2030 |
|---|---|---|---|---|---|---|
| | 2012-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2012-2030 | |
| 1. Agriculture | 4.7 | 3.3 | 1.2 | 0.3 | 2.1 | 19 |
| 2. Fishing | 4.5 | 2.7 | 1.2 | 0.3 | 1.9 | 20 |
| 3. Crude oil | -2.3 | -3.3 | -2.3 | -2.4 | -2.6 | 26 |
| 4. Natural gas | 2.6 | 0.9 | 0.4 | 0.4 | 0.9 | 23 |
| 5. Other mining industries | 1.9 | 0.3 | 0.2 | -0.0 | 0.5 | 24 |
| 6. Food, beverage and tobacco | 17.4 | 10.0 | 0.7 | -1.4 | 5.2 | 6 |
| 7. Textile, clothing and footwear | 2.4 | 3.7 | 4.9 | 4.1 | 3.9 | 8 |
| 8. Non-metal products | 5.7 | 3.5 | 2.3 | 1.4 | 2.9 | 14 |
| 9. Petroleum refining and coke | 16.6 | 4.7 | 2.5 | 1.8 | 5.2 | 7 |
| 10. Chemicals, rubber and plastic products | 9.2 | 8.7 | 7.6 | 5.8 | 7.6 | 2 |
| 11. Metal products | 8.1 | 8.8 | 6.7 | 4.4 | 6.9 | 4 |
| 12. Transport equipment | 11.7 | 10.9 | 3.9 | 0.5 | 6.1 | 5 |

| | Average annual growth rate, % | | | | | Ranking, 2012-2030 |
|---|---|---|---|---|---|---|
| | 2012-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2012-2030 | |
| 13. Other machinery and equipment | 10.0 | 12.1 | 6.3 | 1.4 | 7.1 | 3 |
| 14. Other manufacturing | 18.4 | 16.4 | 6.8 | 1.6 | 9.7 | 1 |
| 15. Electricity, gas and water | 4.1 | 0.5 | 1.8 | 1.7 | 1.8 | 21 |
| 16. Construction | 2.0 | -1.1 | -1.0 | -1.0 | -0.5 | 25 |
| 17. Wholesale and retail trade | 8.2 | 3.5 | 2.4 | 1.7 | 3.5 | 11 |
| 18. Accommodation and food drink services | 9.2 | 3.8 | 1.3 | 0.9 | 3.2 | 13 |
| 19. Transport and communication | 11.3 | 4.8 | 1.4 | 0.6 | 3.7 | 9 |
| 20. Finance and insurance | 7.6 | 2.9 | 1.8 | 1.3 | 2.9 | 15 |
| 21. Other business services | 9.7 | 3.1 | 2.2 | 2.0 | 3.6 | 10 |
| 22. Public administration | 4.4 | 2.6 | 1.8 | 1.1 | 2.3 | 18 |
| 23. Education | 6.1 | 2.7 | 1.7 | 1.3 | 2.6 | 16 |
| 24. Health care | 4.6 | 2.6 | 2.0 | 1.5 | 2.5 | 17 |
| 25. Recreation and other services | 7.5 | 3.8 | 2.0 | 1.4 | 3.2 | 12 |
| 26. Dwelling services | 2.6 | 1.0 | 1.9 | 1.6 | 1.6 | 22 |

### 4.4 *Employment by occupation*

OMAGE forecasts growth prospects for 98 occupations. For reporting purposes, we aggregate them to 10 major occupational groups, as reported in Table 7.

**Table 7. Employment for major occupational groups**
**(average annual growth rates, %) and skill ranking over the full period**

| Occupation | Average annual growth rate, % | | | | | Ranking, 2012-2030 |
|---|---|---|---|---|---|---|
| | 2012-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2012-2030 | |
| 1. Managers and investors | 6.39 | 2.94 | 1.90 | 1.22 | 2.73 | 3 |
| 2. Professionals | 5.48 | 2.40 | 1.59 | 1.08 | 2.31 | 6 |
| 3. Technicians | 4.92 | 2.07 | 1.46 | 0.95 | 2.05 | 9 |
| 4. Clerical Occupations | 5.81 | 2.74 | 1.74 | 1.17 | 2.53 | 5 |
| 5. Sales Occupations | 8.00 | 3.67 | 2.37 | 1.55 | 3.42 | 1 |
| 6. Service Occupations | 7.84 | 3.51 | 1.79 | 1.22 | 3.09 | 2 |
| 7. Agricultural Occupations | 5.18 | 3.31 | 1.33 | 0.45 | 2.26 | 7 |
| 8. Industrial, chemical and food occupations | 4.56 | 2.67 | 2.38 | 1.92 | 2.69 | 4 |
| 9. Engineering occupations | 3.67 | 0.89 | 0.67 | 0.27 | 1.11 | 10 |
| 10. Armed forces | 4.36 | 2.65 | 1.76 | 1.14 | 2.26 | 8 |

The table shows that fastest growing occupations are projected to be sales occupations, service occupations, and managers and investors. Slowest growing occupations are projected to be engineering occupations, technicians, and armed forces.

The explanations for these results come from the results for industry employment. OMAGE's theory of industry employment by occupation is essentially top-down with allowance for relative changes in occupation-specific wage rates. In words, for industry *i* if there were no changes in wage rates, then an *x* per cent growth in employment by the industry would lead to an *x* per cent growth in employment of all occupations in the industry. All else unchanged, if the wage rate of occupation *o* rises relative to the average labour cost in the industry, then the industry would employ less of occupation *o* and more of other occupations.

Mathematically, a simple representation of industry specific demand for labour distinguished by occupation, ignoring the nationality dimension, is of the form:

$$l_{o,i} = l_i - \sigma_i (w_{o,i} - w_i) \qquad (6)$$

where:

$l_{o,i}$ is percentage growth in employment, by occupation and industry;

$l_i$ is percentage growth in employment, by industry;

$\sigma_i$ is the elasticity of substitution between occupations within each industry;

$w_{o,i}$ is the percentage change in the nominal wage, by occupation and industry; and

$w_i$ is the average percentage change in the nominal wage in industry *i*.

Our macroeconomic closure for the labour market is configured to allow the model to express future workforce needs, while simultaneously constraining aggregate employment growth in a way consistent with demographically-based projections for labour supply by Omanis. This has the effect of allowing little change in inter-occupational wage relativities. Hence, in terms of equation (6), we have $w_{o,i} \approx w_i$, allowing (6) to be simplified to $l_{o,i} \approx l_i$.

In this section our aim is to explain economy-wide employment by occupation. In terms of levels, this is given by:

$$L_o = \sum_{i \in IND} L_{o,i} \qquad (7)$$

where

$L_o$ is the number of employed persons, by occupation

$L_{o,i}$ is the number of employed persons, by occupation and industry

Converting (7) into percentage growth form, we have:

$$L_o \times l_o = \sum_{i \in IND} L_{o,i} \times l_{o,i} \qquad (8)$$

where

$l_o$ and $l_{o,i}$ I are percentage changes in $L_o$ and $L_{o,i}$.

Noting that $w_{o,i} \approx w_i$, we can use the above equation to substitute $l_i$ for $l_{o,i}$, leading to the following back-of-the-envelope (BOTE) equation for predicted employment by occupation.

$$l_o^{(Predicted)} = \sum_{i \in IND} \frac{L_{o,i}}{L_o} \times l_i^{(Actual)} \qquad (9)$$

Equation (9) says that changes to employment by each occupation ($l_o$) can be largely explained in terms of contributions from employment by industries, which are products of industry shares in total employment by the occupation (the $L_{o,i}/L_o$ term) and changes in industry employment (the $l_i^{(Actual)}$ term). To assist us in this regard, in Table 8 we report the occupation growth rates, ranked in the declining order, and the shares of the five largest employing industries within each occupation.

**Table 8. Occupation average annual growth rates (2013-2030), ranked down, and their five largest employing industries, (%)**

| | | Share of five largest employing industries in the occupation employment | | | | | |
|---|---|---|---|---|---|---|---|
| Occupations | Growth rate | Industry 1 | Industry 2 | Industry 3 | Industry 4 | Industry 5 | Total of the top 5 |
| 5. Sales Occupations | 3.42 | Trade: 77.6 | TransComm: 3.8 | Construction: 2.5 | OthManuf: 2.3 | OthBusServ: 2.3 | 88.4 |
| 6. Service Occupations | 3.09 | RecrOthServ: 44.3 | HotelRest: 16.4 | OthBusServ: 9.8 | PublicAdmin: 7.8 | Trade: 6 | 84.4 |
| 1. Managers and investors | 2.73 | Trade: 26.8 | PublicAdmin: 20.4 | Construction: 9.7 | TransComm: 8.2 | FinanceIns: 5.8 | 70.9 |
| 8. Industrial, chemical and food occupations | 2.69 | TCF: 33.3 | Trade: 14.1 | Construction: 9.4 | NMetalProd: 8.3 | FoodBevTob: 8 | 73.0 |
| 4. Clerical Occupations | 2.53 | PublicAdmin: 42.9 | Trade: 12.5 | TransComm: 8.9 | FinanceIns: 7.2 | Construction: 6.6 | 78.1 |
| 2. Professionals | 2.31 | PublicAdmin: 33.5 | Education: 17.9 | Construction: 9.7 | Trade: 9.1 | TransComm: 5.4 | 75.5 |
| 7. Agricultural Occupations | 2.26 | Agriculture: 83.2 | RecrOthServ: 5.9 | Fishing: 4.4 | PublicAdmin: 4 | Trade: 1.1 | 98.6 |
| 10. Armed forces | 2.26 | PublicAdmin: 99.7 | OthBusServ: 0.1 | RecrOthServ: 0.1 | Health: 0 | TransComm: 0 | 99.9 |
| 3. Technicians | 2.05 | PublicAdmin: 32 | Construction: 16.7 | Education: 13 | Trade: 9.9 | Health: 8.2 | 79.7 |
| 9. Engineering occupations | 1.11 | Construction: 57.6 | Trade: 14.5 | MetalProds: 5.7 | TransComm: 5.3 | NMetalProd: 3.9 | 87.0 |

The ranking of occupational employment outcomes can be largely explained by the application of equation 9 to industry shares in Table 8 and industry employment outcomes in Table 6. This is the case even though Table 8 only reports industry employment shares for occupations for the top five employing industries for each occupation. As is clear from the final column, for every occupation, there is a strong tendency toward concentration of employment in a handful of industries.

We see in Table 8 that, by a narrow margin, the Sales occupations and the Services occupations are the highest ranked occupations. This does not reflect strong growth prospect in any particular industries in which these occupations are strongly employed, but rather, that employment in the occupations is spread across industries which are enjoying strong growth prospects. In contrast, the Engineering occupations and Technicians are the lowest ranked. This is because they are mainly working in industries with low employment growth prospects, such as Construction and public administration.

### *4.5 Employment by skill*

Demand for labour by skill is a derived demand from labour by occupation. As such, we can begin our explanation for employment outcomes by skill on the basis of employment outcomes by occupation. We begin by deriving from the OMAGE skill demand equation a simple BOTE equation that explains growth rates in employment by skill in terms of (i) growth rates in employment by occupation; and (ii) the skill composition of occupation-specific employment.

The OMAGE equation defining cost-minimising demands for skills by occupations can be represented in a stylised way by:

$$l_{s,o} = l_o - \sigma_o (w_{s,o} - w_o) \qquad (10)$$

where:

| | |
|---|---|
| $l_{s,o}$ | is the percentage growth in employment, by skill and occupation |
| $l_o$ | is the percentage growth in employment, by occupation |
| $\sigma_o$ | is the occupation-specific elasticity of substitution across skills |
| $w_{s,o}$ | is the percentage change in wage, by skill and occupation |
| $w_o$ | is the average percentage change in the wage of occupation *o* |

Equation (10) says that, for each occupation *o*, if there are no relative changes to $w_{s,o}$ and $w_o$, a 10% increase in employment by the occupation will lead to a 10% increase in employment of all skills within the occupation. However, if the wage rate of skill *s* rises relative to the average cost of occupation *o* ($w_o$), the occupation would use less skill *s* and more of other skills.

As already discussed, by design, our macro closure minimises movements in occupational and skill-specific wage rates. Hence, in terms of equation (10), we have $w_{s,o} \approx w_o$.[4]
Our aim is to explain economy-wide employment by skill. In the levels, this is given by:

$$L_s = \sum_{o \in OCC} L_{s,o} \qquad (11)$$

[4] Note that from the discussion in the previous section, these wage rates also equal industry wage rates.

where

$L_s$ is the number of employed persons, by skill type

$L_{s,o}$ is the number of employed persons, by skill and occupation

Converting (11) to percentage growth form yields:

$$L_s \times l_s = \sum_{o \in OCC} L_{s,o} \times l_{s,o} \tag{12}$$

where $l_s$ and $l_{s,o}$ I are percentage growth rates in $L_s$ and $L_{s,o}$.
Noting that $w_{s,o} \approx w_o$, we can use equation (12) to substitute $l_o$ for $l_{s,o}$, leading to the following back-of-the-envelope (BOTE) equation for predicted employment by skill:

$$l_s^{(predicted)} = \sum_{o \in OCC} \frac{L_{s,o}}{L_s} \times l_o^{(Actual)} \tag{13}$$

According to (13), growth in employment by each skill type ( $l_s$ ) can be largely predicted in terms of contributions from growth in employment by occupations, which are products of occupational shares in total employment by the skill (the $L_{s,o}/L_s$ term) and changes in occupational employment (the $l_o^{(Actual)}$ term).

**Table 9. Employment for 13 broad fields of study (average annual growth rates, %) and skill ranking over the full period**

| Study fields | Average annual growth rate | | | | | Ranking for 2013-2030 |
|---|---|---|---|---|---|---|
| | 2013-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2013-2030 | |
| Natural and Physical Sciences | 6.26 | 2.76 | 1.80 | 1.20 | 2.63 | 4 |
| Information technology | 5.91 | 2.59 | 1.70 | 1.14 | 2.48 | 9 |
| Engineering and related technologies | 4.98 | 1.71 | 1.21 | 0.73 | 1.84 | 11 |
| Architecture and building | 4.16 | 1.02 | 0.81 | 0.47 | 1.32 | 13 |
| Agricuture, environment studies | 5.64 | 2.93 | 1.74 | 1.06 | 2.52 | 8 |
| Health | 5.39 | 2.67 | 1.94 | 1.36 | 2.55 | 5 |
| Education | 5.09 | 2.62 | 1.68 | 1.10 | 2.34 | 10 |
| Management and Commerce | 7.72 | 3.25 | 2.07 | 1.35 | 3.12 | 2 |
| Society and Culture | 5.70 | 2.76 | 1.79 | 1.25 | 2.55 | 6 |
| Religion and Philosophy | 5.05 | 2.93 | 1.86 | 1.32 | 2.53 | 7 |
| Creative Arts | 7.34 | 2.87 | 1.86 | 1.26 | 2.87 | 3 |
| Personal Services | 9.51 | 4.01 | 1.87 | 1.18 | 3.51 | 1 |
| Combined Broad Fields | 4.93 | 1.79 | 1.06 | 0.59 | 1.77 | 12 |

Similar to the results for detailed skill categories, results for the broad study fields can be explained by the contributions of the occupations which utilise these skills according to equation (13). As discussed earlier, the contributions are calculated as the product of (i) the shares of occupations in the skills, and (ii) the growth rates of the occupations. Table 10 reports these required ingredients, with both occupations and study fields ranked by their average annual growth rates over the forecast period. Table 11 reports the calculated contributions of each occupation to each of the fields. The rankings of both occupations and study field are useful in the identification of the patterns of impacts of employment growth outcomes for occupations on the outcomes for the study fields.

**Table 10. Growth rates of study field and their occupational profile**

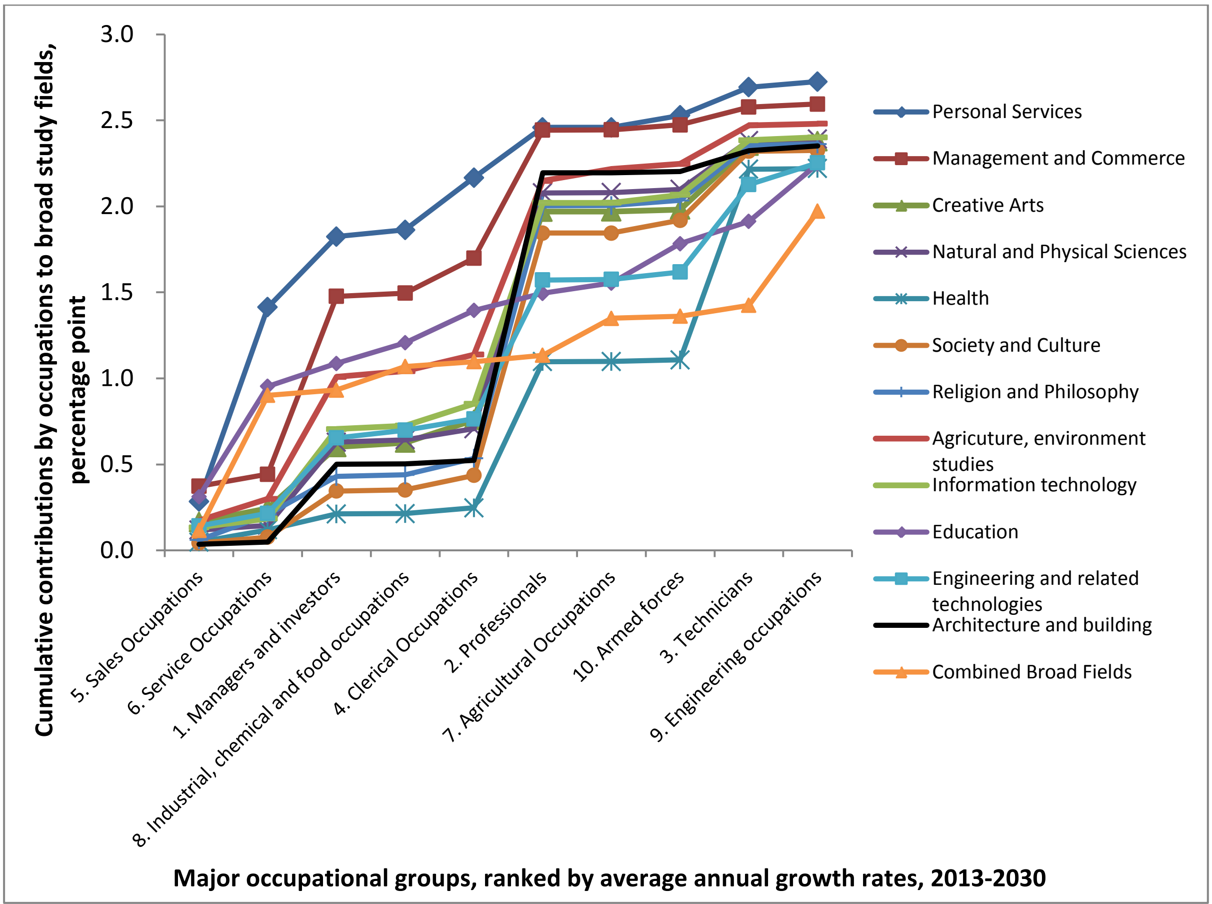
| Major occupational groups, ranked by their average annual growth rate over 2013-2030 in declining order | | 1. Sales Occupations | 2. Service Occupations | 3. Managers and investors | 4. Industrial, chemical and food occupations | 5. Clerical Occupations | 6. Professionals | 7. Agricultural Occupations | 8. Armed forces | 9. Technicians | 10. Engineering occupations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Occupational growth rate ($l_o$) | | 3.42 | 3.09 | 2.73 | 2.69 | 2.53 | 2.31 | 2.26 | 2.26 | 2.05 | 1.11 |
| Study field | Study field growth rate | Shares of occupations in employment number by each study field ($L_{s,o}/L_s$) | | | | | | | | | |
| 1.Personal Services | 3.5 | 0.083 | 0.365 | 0.150 | 0.014 | 0.120 | 0.127 | 0.000 | 0.031 | 0.080 | 0.030 |
| 2.Management and Commerce | 3.1 | 0.109 | 0.023 | 0.378 | 0.007 | 0.081 | 0.322 | 0.001 | 0.013 | 0.050 | 0.016 |
| 3.Creative Arts | 2.9 | 0.048 | 0.025 | 0.131 | 0.009 | 0.052 | 0.524 | 0.000 | 0.005 | 0.180 | 0.024 |
| 4.Natural and Physical Sciences | 2.6 | 0.035 | 0.009 | 0.177 | 0.005 | 0.026 | 0.594 | 0.001 | 0.008 | 0.138 | 0.008 |
| 5.Health | 2.6 | 0.014 | 0.023 | 0.034 | 0.001 | 0.013 | 0.368 | 0.000 | 0.004 | 0.540 | 0.003 |
| 6.Society and Culture | 2.5 | 0.013 | 0.011 | 0.098 | 0.003 | 0.034 | 0.609 | 0.000 | 0.033 | 0.196 | 0.004 |
| 7.Religion and Philosophy | 2.5 | 0.018 | 0.048 | 0.081 | 0.004 | 0.038 | 0.636 | 0.001 | 0.013 | 0.155 | 0.007 |
| 8.Agricuture, environment studies | 2.5 | 0.051 | 0.040 | 0.260 | 0.012 | 0.038 | 0.437 | 0.030 | 0.013 | 0.109 | 0.009 |
| 9.Information technology | 2.5 | 0.039 | 0.016 | 0.191 | 0.007 | 0.051 | 0.506 | 0.000 | 0.020 | 0.154 | 0.015 |
| 10.Education | 2.3 | 0.091 | 0.207 | 0.049 | 0.044 | 0.075 | 0.043 | 0.026 | 0.101 | 0.063 | 0.299 |
| 11.Engineering and related technologies | 1.8 | 0.042 | 0.024 | 0.161 | 0.017 | 0.026 | 0.350 | 0.002 | 0.019 | 0.247 | 0.114 |
| 12.Combined Broad Fields | 1.8 | 0.034 | 0.254 | 0.011 | 0.051 | 0.011 | 0.016 | 0.095 | 0.005 | 0.031 | 0.491 |
| 13.Architecture and building | 1.3 | 0.010 | 0.005 | 0.165 | 0.001 | 0.008 | 0.724 | 0.000 | 0.003 | 0.058 | 0.025 |

**Table 11. Contribution of employment by occupation to employment by skill** $=\left(L_{s,o}/L_s\right)\times l_o$), (**percentage point)**

| Major occupational groups | 1. Sales Occupations | 2. Service Occupations | 3. Managers and investors | 4. Industrial, chemical and food occupations | 5. Clerical Occupations | 6. Professionals | 7. Agricultural Occupations | 8. Armed forces | 9. Technicians | 10. Engineering occupations | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Study field** | | | | | | | | | | | |
| 1.Personal Services | 0.284 | 1.130 | 0.411 | 0.039 | 0.304 | 0.292 | 0.000 | 0.069 | 0.164 | 0.033 | 2.7 |
| 2.Management and Commerce | 0.374 | 0.070 | 1.034 | 0.018 | 0.203 | 0.744 | 0.002 | 0.029 | 0.103 | 0.018 | 2.6 |
| 3.Creative Arts | 0.166 | 0.078 | 0.358 | 0.025 | 0.132 | 1.211 | 0.001 | 0.011 | 0.370 | 0.026 | 2.4 |
| 4.Natural and Physical Sciences | 0.118 | 0.028 | 0.484 | 0.013 | 0.065 | 1.371 | 0.002 | 0.019 | 0.284 | 0.009 | 2.4 |
| 5.Health | 0.048 | 0.072 | 0.093 | 0.002 | 0.033 | 0.850 | 0.001 | 0.010 | 1.108 | 0.003 | 2.2 |
| 6.Society and Culture | 0.044 | 0.034 | 0.267 | 0.007 | 0.085 | 1.407 | 0.000 | 0.074 | 0.402 | 0.005 | 2.3 |
| 7.Religion and Philosophy | 0.061 | 0.148 | 0.220 | 0.010 | 0.095 | 1.468 | 0.002 | 0.030 | 0.319 | 0.008 | 2.4 |
| 8.Agricuture, environment studies | 0.174 | 0.125 | 0.710 | 0.033 | 0.096 | 1.009 | 0.069 | 0.030 | 0.224 | 0.010 | 2.5 |
| 9.Information technology | 0.135 | 0.050 | 0.521 | 0.019 | 0.128 | 1.168 | 0.001 | 0.046 | 0.317 | 0.017 | 2.4 |
| 10.Education | 0.313 | 0.641 | 0.133 | 0.120 | 0.188 | 0.099 | 0.060 | 0.229 | 0.130 | 0.333 | 2.2 |
| 11.Engineering & related technologies | 0.142 | 0.073 | 0.439 | 0.044 | 0.066 | 0.807 | 0.004 | 0.042 | 0.508 | 0.127 | 2.3 |
| 12.Combined Broad Fields | 0.117 | 0.785 | 0.031 | 0.137 | 0.029 | 0.037 | 0.215 | 0.012 | 0.064 | 0.547 | 2.0 |
| 13.Architecture and building | 0.035 | 0.014 | 0.452 | 0.003 | 0.019 | 1.673 | 0.000 | 0.008 | 0.119 | 0.028 | 2.4 |

To assist us further in our understanding of employment outcomes by skill, Figure 3 reports the cumulative contributions to employment outcomes by broad field of study of the employment outcomes of the major occupational groups, where on the x-axis, the major occupational groups are ranked in declining order of their average annual growth rates over the 2013-2030 period.

**Figure 3: Cumulative contribution of occupations to aggregate skill outcomes**




The last column of Table 11 reports the sums of the contributions for each of the study fields. Broadly, it corresponds reasonably well with the actual model projections reported in the first columns, Table 10. The correlation coefficient between these two series is 72%. This is lower than the 93% correlation between the predicted and actual projections for the detailed skill types reported earlier. The reason is that the aggregation of both occupations and skills makes it more difficult to account for the fine differences between the detailed occupations and skills. Nevertheless, Table 11 and Figure 3 are useful in assisting us to understand the results for the aggregate skills.

It is clear from Table 11 and Figure 3 that the relatively fast growing fields (such as Personal services, Management and Commerce, and Creative arts) receive relatively larger contributions from fast-growing occupations (such as Sales occupations, Services occupations and Managers and investors) than contributions from the lower-growing occupations (such as Engineering, Armed forces, and Agriculture). The relatively slower growing fields (such as Architecture and buildings, Combined broad fields, and Engineering and related technologies), on the other hand, receive more contributions from the slower-growing occupations than the fast-growing occupations.

## 5 Conclusions

This report describes a method for producing detailed forecasts of the industrial and employment structure of the Omani economy. The vehicle for the forecasting is OMAGE, a detailed dynamic CGE model.

The forecasts presented in this report include input from specialist forecasters of demographic trends and from experts in commodity markets. They also include in a limited way scenarios on changes in technology and household tastes which are important for structural forecasting. The role of OMAGE is to translate these inputs into forecasts for variables that are relevant to organisations with responsibilities that require them to take views about the future structure of the economy and its employment needs.

One context in which detailed structural forecasts might of additional interest to decision makers in Oman is in making investment decisions of various types. The forecasts presented in this report are relevant obviously to authorities responsible for resource allocation in the vocational education and training system. But they are also relevant to policy decisions with structural implications – microeconomic reform, for example. Detailed structural forecast are required if the adjustment costs associated with such reforms are to be assessed. In work in Australia, we have also found that the long-run effects of reforms on economic activity and economic welfare cannot be assessed without realistic forecasts as a base case for the analysis.

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