PREFACE

Many countries in Sub-Sahara Africa, as in the rest of the world, face the challenge of transforming their economies to increase productivity and the earnings capacity of their workforce. This requires both interventions that promote the demand for productive labor, and those that ensure that a sufficiently equipped workforce is available to take on these jobs.

International experience shows that for a skills development system to generate the skills that are required on the labor market, it must be demand-responsive, implying that the number of graduates as well as the skills and competencies that they acquire through education and training must be aligned with quantitative and qualitative labor and skill demand. The establishment of an effective and efficient skills development system thus requires a sound information base, among others concerning the demand for labor and skills that can be expected to materialize in the short or longer term.

This report is developed taking into consideration that generating information on the expected labor and skill constraints for economic growth is essential for being able to ensure that investments in skill development are well-targeted and address skill bottlenecks as efficiently and effectively as possible.

The report aims to support governments, particularly ministries responsible for education and training, to decide on the most appropriate methodologies for forecasting labor and skill demand, as well as on the most appropriate institutional framework for carrying out forecasts and encouraging the use of their results, including what would be an appropriate role for the government in this framework.

By describing the main goals and approaches for labor and skill forecasting, illustrated through case studies from a variety of contextual settings, the report aims to provide guidance to governments on developing their own forecasting mechanisms as they continue their efforts to invest in training provision in the most effective and efficient manner. In alignment with the growth and skills development strategies of many governments in the region, the report places particular emphasis on approaches to forecast labor and skill demand for particular economic sectors and for particular occupations.

While demand projections are a prerequisite for developing appropriate skills interventions, these generally need to be accompanied by forecasts of labor and skills supply to obtain a good picture of where skills gaps and mismatches are most likely to occur. While this report does not explicitly focus on projecting supply, several of the case studies described in this report do include supply forecasts (i.e. projections on the availability of workers, disaggregated by sector, occupations, or qualifications), and interested readers are referred to the appropriate publications for further information on this topic.
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ABBREVIATIONS AND ACCRONYMS

APENZ: Association of Consulting Engineers New Zealand
ARR: Annual Recruitment Requirement
CBS: Centraal Bureau Statistiek (Netherlands Bureau of Statistics)
CCIC: Consultative Commission on Industrial Change (CCIC)
CCM: Consejo de Competencias Mineras (Chilean Mining Skills Council)
CEDEFOP: European Centre for the Development of Vocational Training
CEFIC: European Chemical Industry Council
CIC: Construction Industry Council (UK)
CITB: Construction Industry Training Board (UK)
CIHE: Council for Industries and Higher Education (UK)
CompTIA: Computing Technology Industry Association
CPB: Centraal Plan Bureau (Netherlands Bureau for Economic Policy Analysis)
DIUS: Department of Innovation, Universities and Skills (UK)
EC: European Commission
ETB: Engineering Technology Board (UK)
EU: European Union
GDP: Gross Domestic Product
ILO: International Labor Organization
IPENZ: Institution for Professional Engineers of New Zealand
IT: Information Technology
IT-ITeS: Information Technology and Information Technology-enabled Services
LFS: Labor Force Survey
NASSCOM: National Association of Software and Services Companies (India)
R&D: Research and Development
ROA: Researchcentrum voor Onderwijs en Arbeidsmarkt (Maastricht University Research Centre for Education and Labor Market)
SBB: Samenwerkingsorganisatie Beroepsonderwijs Bedrijfsleven (Cooperation Vocational Training and the Labor Market, Netherlands)
SET: Science, Engineering, and Technology
STEM: Science, Technology, Engineering and Mathematics
SWOT: Strengths, Weaknesses, Opportunities, and Threats
TVET: Technical and Vocational Education and Training
UK: United Kingdom
UKCES: United Kingdom Commission for Employment and Skills
UN: United Nations
USA: United States of America
UWV: Uitvoeringsorganisatie Werknemers Verzekeringen (Netherlands’ Employee Insurance Agency)
VCA: Value Chain Approach
SUMMARY AND RECOMMENDATIONS

a) Summary

Forecasts of labor and skill demand are an important tool to guide policy-decisions and efficient investments in education and training, and thus better align labor and skill supply with demand. Broad types of forecasting methodologies include quantitative models, stakeholder surveys, consultative methodologies, and a combined approach in which several of these methodologies are applied in a complementary manner.

There is no ‘one size fits all’ methodology for labor and skill demand forecasting. Regardless of whether forecasts are for an entire economy, for a particular economic sector, or for workers with particular skill sets, there is a range of methodologies available which all have their own merits and challenges. Yet, certain methodologies are more appropriate than others depending on the specific objectives of the forecast and the context within which they are applied.

The selection of a forecasting approach should be informed by the objectives of the forecasting exercise, as well as on the availability of data, financial resources and time. As each methodology can, to an extent, be adapted to suit particular objectives within an available resource envelope and time span, there is flexibility in determining the right approach in each setting. Nevertheless, the following broad rules of thumb can be applied in the selection of the methodology:

- **Objectives**: An important determining factor of the appropriate methodology is whether the desired results relate to quantitative (number of jobs) or qualitative (competencies) aspects of labor demand. **Quantitative models** tend to be appropriate to forecast quantitative aspects of labor and skill demand, especially when the market to which the projections apply is not prone to unpredictable, external shocks. **Stakeholder surveys** can project qualitative and quantitative aspects of demand, and generate relatively detailed projections when they focus on specific economic sectors, occupations, or worker qualifications. **Consultative methodologies**, such as expert consultations and literature review, can capture qualitative and quantitative aspects of demand and be easily geared toward particular segments of the labor market. By design, they produce subjective results, and they are particularly appropriate in volatile economies and contexts where quantitative models or stakeholder surveys are not likely to generate reliable projections. Finally, a **combined approach** is appropriate when a multifaceted and comprehensive analysis is required, as it allows exploiting the merits of all the different methodologies that are combined in this approach.

- **Data needs**: The various methodologies differ substantially in the amount and type of data that must be available to apply them. **Consultative approaches** can be applied in any context, since stakeholder and expert consultations require little more than the identification of appropriate experts and stakeholders. **Stakeholder surveys** can be applied in data-scarce environments as well, but they do require the identification of a representative stakeholder sample; in low and middle income economies this is likely to include informal sector firms or workers. **Quantitative models** are data-
intensive, and require the availability of sufficient and credible statistical data. While this limits the possibility to use models in data-scarce economies, it should be noted that in many contexts there is at least a basis of acceptable data which can serve as input for a rudimentary model. Such a model can be used to generate broad findings, and possibly complement forecasting results from other methodologies when it is included in a combined approach.

- **Financial resources and time:** To an extent, the scope and level of sophistication of forecasts can be adapted to suit available funding and time. Nevertheless, consultative approaches generally can be assumed to require relatively modest resources and time. The time and costs required to apply quantitative models depend largely on whether there exists a (third party) quantitative model that can be used as basis for the projections, and whether necessary statistical data are available in a user-friendly manner. If this is the case, then the costs and time required to apply a model may be limited. If a model or (more importantly) data do not exist, then the substantial costs and time needed to develop or collect these may prove prohibitive to applying a quantitative model. Stakeholder surveys are generally both cost- and time-intensive. However, resource requirements can be reduced if a representative sample is relatively small and can be easily identified, by limiting the size and complexity of survey questionnaires, and by conducting the survey online. Finally, the resources needed for a combined approach are relatively substantial and will be a function of the resources needed to generate results through each of the methodologies included in the approach.

There are some differences in executing forecasts that target particular economic sectors and those that focus on workers with particular qualifications or occupations. In principle, any of the identified methodologies can be applied for forecasts targeting specific segments of the labor market, such as economic sectors or worker qualifications. However, sector forecasts may generally be easier to develop, since sector-specific data are more likely to be readily available through for example national accounting systems, labor force surveys, and firm-registration systems. Data related to worker occupations or qualifications, on the other hand, may be more difficult to identify, particularly in countries with less-developed information systems. Another difference relates to the stakeholders who execute the forecasts: as is demonstrated through the case studies presented in this note, education and training providers appear more prone to play a key role in the development of forecasts related to occupations or qualifications, whereas private sector representatives such as industry associations more often take a leading role in the execution of sector-specific projections.

The credibility and effective use of forecasting results are dependent on the institutional setting within which they are developed. An appropriate institutional setting ensures that (i) projections are relevant for key stakeholders; (ii) applied methodologies are of good quality and produce credible results; (iii) forecasting results are effectively disseminated; and (iv) forecasting exercises are conducted regularly. A setting which achieves these objectives generally includes a (semi) formal and permanent forum with representation of all key public and private stakeholders, which is responsible for guiding the scope and focus of forecasting exercises, ensuring transparency and consistency on applied methodologies, disseminating and archiving relevant information, and ensuring that the predictive value of forecasts is regularly reviewed and improved.
b) Recommendations

The following key recommendations can be distilled from the remainder of this report:

1. **Combine the development of labor and skill demand forecasts with building sound institutional settings for future forecasting exercises.** As described above, sound institutional settings are essential for promoting the development of labor and skill demand forecasts in the systematic manner that is essential to ensure their credibility and use. While the establishment of such institutional settings should therefore be facilitated, their establishment is a gradual process that will likely span several years, and there is no need to postpone carrying out forecasting exercises until these structures are firmly in place. Rather, any group of stakeholders which is part of an emerging institutional framework for forecasting exercises is likely to benefit greatly from ‘learning-by-doing’. In other words, the execution of forecasting exercises can go hand-in-hand with the development of appropriate institutional settings, and the quality of both the forecasts and the institutional framework is expected to improve gradually and simultaneously.

2. **The government can play a leading role in initiating forecasting exercises and establishing sound institutional settings.** Even in countries where strong forecasting mechanisms exist and are largely managed by non-public stakeholders, the government generally initially played a major role in the establishment of the system. Departments of labor or employment are likely candidates to take on this role, but the responsibility can also be assigned to departments with responsibility for economic development and planning, education and training, or industries. As the system develops and capacity is built, stakeholders such as industry associations and representatives of educational institutions may take on larger responsibilities and the government can gradually take on a less active role.

3. **Select the appropriate forecasting methodology based on objectives and resources.** Table 1 below provides guidance for selecting the appropriate forecasting methodology. It summarizes, for each methodology, the type of findings that can be generated, input requirements (data, time and costs), and its distinguishing features compared to the other methodologies. Whereas the input requirements will be partly determined by the intended scope and level of detail of each forecasting exercise, they can be used as rule of thumb and to compare requirements across various methodologies. Finally, the last column of the table indicates the case studies in this report that apply these methodologies, and the sections of the report where they are described in more detail.
### Table 1  Forecasting methodologies: summary of applications and requirements

<table>
<thead>
<tr>
<th>Methodology</th>
<th>Aspects of demand</th>
<th>Data requirements</th>
<th>Time and cost requirements</th>
<th>Distinguishing features</th>
<th>Case study examples*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Quantitative model</strong></td>
<td>Quantitative</td>
<td>High(^1)</td>
<td>Moderate(^5)</td>
<td>Robust approach for quantitative forecasts, if there are sufficient data and model design is of sufficient quality.</td>
<td>Tanzania (II.b) Netherlands macro-model (II.b) and technical sector (III.b1) UK STEM workers (IV.b1) UK SET workers (IV.b2)</td>
</tr>
<tr>
<td><strong>2. Stakeholder Survey</strong></td>
<td>Quantitative and/or qualitative</td>
<td>Moderate(^2)</td>
<td>High(^6)</td>
<td>Well-tested approach, with particular relevance for shorter term forecasts.</td>
<td>Chile mining sector (III.b2) USA manufacturing (III.b3) USA IT workers (IV.b3)</td>
</tr>
<tr>
<td><strong>3. Consultations</strong></td>
<td>Quantitative and/or qualitative</td>
<td>Low - Moderate(^3)</td>
<td>Low - Moderate(^7)</td>
<td>Especially appropriate for strategic, medium/long term forecasts; often used in combined approach.</td>
<td>Swaziland agribusiness (III.b4) EU pharmaceuticals (III.b5)</td>
</tr>
<tr>
<td><strong>4. Combined approach</strong></td>
<td>Quantitative and/or qualitative</td>
<td>Moderate - High(^4)</td>
<td>Moderate - High(^8)</td>
<td>Can generate multi-faceted and comprehensive forecasts.</td>
<td>UK construction (III.b6) Netherlands technicians (IV.b4) India IT workers (IV.b5) New Zealand engineers (IV.b6)</td>
</tr>
</tbody>
</table>

* References in this column are to the chapters and sections in the report where these case studies are described.

**Notes:**

1. Requires substantial, credible, and sufficiently detailed statistical data;
2. Need to be able to identify appropriate survey sample;
3. Data requirements for expert and stakeholder consultations are low; for literature review, at least some relevant documentation needs to be available;
4. Depending on the mix of methodologies applied;
5. If pre-existing data and, potentially, a pre-existing model can be used; otherwise, time and cost requirements are very high;
6. Requires sample selection; survey design, testing, execution; data processing. Resource requirements can be reduced if the sample is small, the questionnaire is simple, and/or the survey is carried out online.
7. Requirements for expert and stakeholder consultations will be more limited when they are well-prepared and well-structured; the time and cost requirements for literature review depend on the scope of documents available;
8. Depending on the mix of methodologies applied.
I. INTRODUCTION

a) Objective and outline of the report

This report aims to assist Ministries who wish to produce labor and skill demand forecasts, in particular those responsible for education and training provision, in determining the most appropriate approach to carry out the forecasts. With a focus on sectoral and occupational forecasts, the report provides examples of methodologies that are applied in a variety of contexts, by different stakeholders, and with varying objectives and institutional arrangements. The report will be complemented with practical templates to guide the preparation and execution of forecasts.¹

The report is structured as follows: The remainder of this Chapter describes the various objectives that labor and skill demand forecasts can serve, and how different objectives can require different methodologies and scope of the forecasting exercise. It also describes the importance of an appropriate institutional framework for carrying out and effectively disseminating forecasting results, including the possible role of the government within such a framework. Chapter II provides an overview of forecasting methodologies, describing their key features including their data needs and the type of results that they generate, as well as advantages and disadvantages. Chapter III describes and assesses various examples of methodologies that are applied to forecast the demand for labor and skills in specific economic sectors. Chapter IV describes and reviews methodologies to forecast the demand for workers with particular qualifications or occupations. Since in many economies particularly shortages of skills in science, technology, engineering and mathematics (STEM) are expected to pose serious constraints to technology and innovation-based economic growth, this last chapter focuses on forecasting the demand for this type of skills.

b) Labor and skill demand forecasts: objectives determine the approach

Forecasting labor and skill demand refers to the development of informed projections of the future demand for labor and skills. The objective of forecasts is to allow stakeholders with an interest in labor and skills to make informed decisions about their future actions. These stakeholders include governments, employers, (prospective) labor force participants, and education and training institutions. Forecasts can have various specific objectives, which often vary between stakeholders as they tend to have different stakes and roles related to the provision of and demand for labor and skills. For example:

- Government Ministries, including those responsible for Education, Finance, Industry, Private Sector Development, and Labor may use forecasts to guide policy reforms and investments in areas such as economic policy, education and training, social protection, and migration.

¹ These templates are currently under development.
• **Employers** may use forecasts to guide decisions on recruitment, salary levels, training activities, as well as on changes in business processes and firm locations.

• **Employees and students** may use forecasts on job availability and earnings to determine the education and training they select to obtain, and the location where they will look for jobs.

• **Education and training institutions** may use forecasts to adjust their course offer and course content to improve the employment and earnings capacity of their graduates.

**Depending on the objectives of the forecasting exercises, they will vary in focus, scope, and time horizon.** An important distinction in objectives is whether forecasts should generate projections on the expected number of jobs (quantitative demand), on the particular skills and competencies that are required for jobs (qualitative demand), or on both. Another important aspect of the objectives concerns the appropriate scope of the forecasts. This relates among others to the geographic scope, as forecasts can be carried out on an international, national, regional or local level. The scope can be further defined through a focus on particular segments of the labor market, such as a focus on employment within a particular economic sector (e.g. the construction or mining sector), or demand for persons with particular qualifications or occupations (e.g. engineers). Lastly, depending on whether the objective of the forecasting exercise is to influence decision-making for the shorter or longer term, forecasting exercises may vary in the time horizon of their projections. The following examples demonstrate of how particular objectives may determine the focus, scope and time horizon of the forecasting exercise:

• A Ministry of Education which wishes to use forecasts to inform the development of a long term national education strategy may develop projections for nationwide growth in the number of jobs, by educational qualification, for a relatively long time period of ten to twenty years.

• Industry associations which want forecasts to inform the development of training strategies to ensure that appropriately skilled staff is available to work in the sector, may produce nationwide forecasts of expected job growth and changes in required competencies for key jobs within the sector, for a time horizon of five to ten years.

• Education and training institutions wishing to ensure that their education and training offer matches local demand for labor and skills, may want to produce more detailed projections on specific skill requirements for particular occupations with nearby employers in the coming two to five years.

**The forecasts’ objectives are an important determinant of what is the most appropriate methodology to carry out the forecasts.** For example, international practice shows that broad nationwide forecasts of trends in the number of jobs are generally generated through a quantitative model, whereas more detailed regional or local level forecasts of skill requirements may be better generated through employer surveys or expert consultations, possibly in combination with a quantitative model. In addition to the particular objectives of the forecasting exercise, other important elements which determine the appropriate methodology include ‘practical matters’ such as the presence and reliability of secondary data that can be used as input, the funding and time available to develop the forecasts, and the possible existence of third-party forecasting models which can be used as a basis for projections.
**Projections do not need to be perfect to serve their objectives.** Just like forecasting activities focusing on other areas (such as economic growth), it is not assumed that labor and skill demand forecasts predict the future with absolute certainty. Recognizing that perfect foresight is impossible, forecasts should have *sufficient predictive validity to serve their objectives*. This implies that the margin of error of the projections should be acceptable to those stakeholders who intend to base decision-making on the forecast’s findings. For example, if a forecast projects an increased demand for Technical Education graduates of 50 percent in 10 years’ time, the government may use this information to justify investing in substantially increasing the capacity of technical education institutions. This would likely be considered a worthwhile investment, even if the actual increase in demand turned out to be 40 or 60 percent (rather than the projected 50 percent), which implies that the forecasts in this case had sufficient predictive value. If, on the other hand, the actual demand for Technical Education graduates fell rather than increased in the 10 year period, then government funds could have been better spent on other expenditures, and the predictive value of the projections would clearly be insufficient.

The level of accuracy that is required from projections depends on the objectives of the forecasting exercise. For example, industry or professional associations may intend to use forecasting results for advocacy purposes to influence policy-making. In that case, the main objective of forecasts is for example to demonstrate an expected substantial increase in demand from a particular economic sector or for workers with particular qualifications, and a relatively large margin of error of the projections could be acceptable. On the other hand, demand forecasts that are used by a ministry of education to plan the expansion of training capacity for particular courses require a greater level of accuracy, to ensure that investments are targeted in an efficient manner.

c) The institutional framework and the role of the government in forecasting demand

An appropriate institutional setting is essential for the generation of reliable and useful labor and skill demand projections as well as for their effective use. The institutional setting of demand forecasting exercises can be defined as the collection of stakeholders who are responsible for and involved in the generation of forecasts and the dissemination of forecasting outcomes, and the way in which these stakeholders interact. To achieve their objectives of effectively and systematically informing decision-making processes of key stakeholders, the institutional settings of forecasting exercises are of crucial importance. Forecasts which apply an appropriate, consistent, systematic, well-documented approach and which are repeated periodically have the advantage of replicability and comparability, and are thus expected to be more informative and valuable to stakeholders than forecasts which are carried out ad hoc. Therefore, the institutional setting should be conducive to ensuring that:

- Forecasts provide *relevant information* to stakeholders. This entails ensuring that the forecasting objectives are properly defined, including the particular aspects of demand (qualitative, quantitative) to be forecasted and the scope and time horizon of projections.
- Forecasting results are of *high quality*. This implies that the most appropriate forecasting methodology is applied, taking into account the objectives of the forecasting, as well as the available
data, funding and time that are available for executing the forecasting exercise. In many instances, an approach in which various methodologies are combined will allow the generation of well-informed and multi-faceted forecasting results which are most useful to the end users.²

- **Forecasting results are appropriately shared with stakeholders.** This includes making available the findings of the forecasts in a clear and user-friendly manner, as well as making public the methodology and data that were used to develop the projections to ensure stakeholders of the reliability of the projections.

- **Forecasts are carried out regularly.** To achieve a dynamic and comprehensive picture of future labor and skill demand, taking into account changing economic conditions and technological development, forecasts ideally are carried out regularly and at different levels.

- **Promote consistency and comparability** between different forecasts that are carried out at different geographic levels, for different sector and occupations, or at different points of time. For results of different forecasts to be comparable, it is important to ensure that forecasts use consistent methodology and data. At a minimum, this requires that information on the methodology and data used for individual forecasting exercises is preserved and accessible to all relevant stakeholders.

- **The quality of forecasting results is improved over time,** by regularly reviewing the predictive value of projections and incorporating lessons learned in subsequent forecasting exercises.

**Sound institutional arrangements are structural, and promote collaboration between key stakeholders.**

Formalized, permanent or semi-permanent bodies or forums which bring together key stakeholders can play a substantial role in promoting the relevance, quality, consistency, and effective dissemination of forecasting exercises. Participants in such a forum would usefully include public, private, and educational sector stakeholders, ensuring an appropriate balance of representatives of both the demand and the supply side of labor and skills. Members of the forum could include representatives of various ministries, the private sector, public and private education and training providers, and a bureau of statistics and/or research institutions. When well-established, this type of forum can itself execute or commission forecasting exercises. In various countries, forecasts are indeed increasingly developed through collaboration of various stakeholders, among others through Sector Skills Councils which include representatives of employers, employees, and the government.³ In countries or economic sectors where well-structured multi-stakeholder collaboration is still emerging, forecasting exercises can be carried out by a single actor – usually the government. In this case, the government should ideally make an effort to seek strategic guidance and input from the private sector in the design, execution, and dissemination of the projections. Moreover, it could use the communications on the forecasting exercise as a means to forge stronger linkages between relevant public and private sector stakeholders, with the aim to work towards forging a well-functioning and structural collaboration between all parties.

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² Chapters III and IV describe various case studies of such a ‘combined approach’, in which two or more methodologies (e.g. a quantitative model and an employer survey) are applied to generate demand forecasts.

³ See Chapter 3.b.6 (and Annex 2) for details on forecasts by the UK Construction Sector Skills Council, and Chapter IV.b.4 (and Annex 3) for a case study on strong institutional settings in the Netherlands (demand for technicians).
The government’s role in forecasting may include coordination, financing, and execution. Unless and until forecasts are carried out by non-government stakeholders or through public-private collaborations, the government may choose to take responsibility for developing labor and skill demand forecasts. Once other (multi-stakeholder) forums or bodies are able to carry out forecasting, the role of the government would include establishing and participating in emerging multi-stakeholder forum(s); coordinating collaboration between parties that may be involved in carrying out different forecasts (e.g., promoting comparability of forecasting results that are developed for different economic sectors, or for different regions within the country); and (co-)financing of the forecasting exercise. Another important role for the government can be ensuring proper documentation and dissemination of forecasting results, through maintaining a depository of forecasting results (including information on the methodology and data that were used), and making it available to key stakeholders and the general public.

Various government departments can take on primary responsibility for labor and skill demand forecasting. As there tend to be many departments with an interest in the availability of a well-skilled workforce, there are various options for which one could be primarily responsible for carrying out forecasts, such as those responsible for education, industry, labor, or planning. In those case studies presented in the following chapters in which the government plays a leading role, this task was mostly assigned to the department responsible for labor or employment.4 Chapter II contains a description of a model that has been specifically developed for use by departments of education in Sub-Saharan African countries, which was recently piloted in Tanzania. Within a ministry, the team responsible for carrying out forecasts might be well-placed in a unit responsible for strategy and planning, with sufficient access to high-level management and the ability to ensure effective collaboration with other ministries.

Government’s role in forecasting requires a small, but capable and consistent team. While the team size would depend on the number, scope, and frequency of forecasting exercises, in principle the human resources required for managing and commissioning forecasts are relatively limited. Considering that the value of forecasts depends among others on the consistency and comparability of methodologies that are applied, it is important that there is continuity in the team, and that sound operating procedures exist and are well-documented to minimize the disruptive effect of staff-changes. Broadly, skills required in the team include:

- Communication and coordination skills, to promote multi-stakeholder involvement and ensure effective dissemination of results;
- Expertise on labor and skill demand (e.g. an experienced labor economist) to prepare terms of reference and monitor the technical aspects of the forecasting exercise;
- Statistical skills, for quality assurance and to promote consistency between forecasting exercises;
- Archiving and documentation skills: to ensure that a comprehensive and up-to-date database on forecasting results and methodologies is maintained and accessible.

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4 See for example the case study on the forecasting of demand for Engineers in New Zealand in Chapter IV (Department of Labor in collaboration with engineering associations); or the demand projections for the European Unions’ Pharmaceutical sector in Chapter III (European Commission’s Directorate General for Employment),
• Procurement and financial management capacity, to ensure due process related to the recruitment and operating of the third party that will execute the forecasting exercise.
II. FORECASTING METHODOLOGIES – AN OVERVIEW

a) Introduction

Numerous forecasting methodologies for labor and skill needs exist. They can be roughly categorized in quantitative models, stakeholder surveys, and consultations such as expert and focus group interviews and discussions and scenario development exercises, but also including secondary data and literature review. Each approach can be used separately, but they can also be combined to generate more informed projections. This combined approach, while generally more time-consuming than using just one methodology, allows the exploitation of the advantages of each separate methodology to arrive at multi-facetted and potentially more credible projections than when only applying a single methodology.

As indicated in the previous chapter, the selection of the most appropriate methodology – or combination of methodologies – depends largely on the particular objectives that the forecast aims to achieve, including its scope and level of the desired projections. In addition, the determination of the appropriate approach should be informed by the availability of data and existing models, as well as the financial resources and time that can be allocated to developing the forecasts.

Using surveys or consultations can be particularly appropriate when the required level of detail or the elements of demand that are under review cannot be (fully) captured by a quantitative model. This can be the case in relatively data-scarce environments (as found in many countries in Sub-Saharan Africa) or when forecasts aim to focus in relative detail on particular segments of demand such as economic sectors (see Chapter I II) or workers with specific occupations or qualifications (Chapter IV). Relying solely on qualitative information such as obtained through consultations is generally only recommended if appropriate, reliable quantitative data is not available at all. As will be illustrated in the case studies in the remainder of this report, secondary quantitative data tend to be used to provide a contextual description even when they do not serve as input in the actual forecasting exercise.

The key features of various well-established methodologies are described below. This includes a description of their data needs, the type of results that they produce and the type of policy decision that they can inform, and their advantages and disadvantages, including attention to the extent to which approaches lend themselves to replication. While some examples of particular approaches are summarized in this chapter, the case studies presented in the subsequent chapters III and IV (and the associated annexes) will illustrate the various approaches in more detail. Additional descriptions of various methodologies can be found, among others, in Wilson and Zukersteinova (2011).

b) Quantitative models

Methodology and data needs: Quantitative models use historic data and a set of assumptions about expected economic and labor force trends to arrive at projections of labor and skill demand. Various types
of models exist, and both the data used and the model’s design can be of varying complexity. Generally, the level of complexity of a model can increase as the availability, level of detail and quality of data improves. Data incorporated in the model tends to primarily originate from national accounts and labor force surveys, complemented by additional available data sources which may include data on for example exports, foreign direct investments, or vacancies. A very simple model in a data-scarce environment can consist of a straightforward extrapolation of historic sectoral output and employment trends. More sophisticated models in contexts where data are collected at shorter intervals and at a greater level of detail can consider aspects such as labor productivity and wage trends, the occupational composition of sectoral employment, the movement of labor between economic sectors or into retirement, inflation and price/wage effects, and foreign direct investments and capital investments, as well as expected deviations from trends due to forthcoming substantial investments or policy changes.

Generic types of models that can be applied include inter-industry macro-economic (‘input-output’) models, and dynamic applied general equilibrium models. The former focuses particularly on linkages between economic sectors, i.e. they consider that output from one sector is used as input for another, and derive aggregate macroeconomic projections from adding up projected sectoral developments. A dynamic applied general equilibrium model places greater emphasis on assumptions related to the underlying structure of the economy, including the relation between producer and consumer behavior on the one hand, and price and wage development on the other. While conceptually more elegant, a dynamic applied general equilibrium model generally has higher data requirements than an input-output model.5

Table II.1 below provides key features of these two quantitative models, as applied in two different settings: one is an input-output model which was recently piloted in Tanzania, specifically for the Ministry of Education; the other is a well-established general equilibrium model in the data-rich environment of The Netherlands.6 In both countries, the model comprises just one of various forecasting activities that are carried out to generate a comprehensive picture of future labor and skill demand. In Tanzania, the model will be complemented with a study to identify priority growth sectors, sector-specific studies on skills needs and gaps, an employer survey, and a review of skill needs in the informal sector. In the Netherlands, frequent forecasting exercises of different scope and applying varying methodologies are regularly carried out by a wide range of stakeholders including for example employers’ and university associations.7 A more detailed description of both examples can be found in Annex 1.

<p>| Table II.1 Key features of economy-wide quantitative models in Tanzania and the Netherlands |
|---------------------------------|-----------------|
| Tanzania | Netherlands |
| 5 Compared to an input-output model, the dynamic general equilibrium model tends to require more data for any given year as well as data for a larger number of years, the latter to improve the predictive value of the production and consumption functions that are included in the model. |
| 7 See for example the case studies on the Dutch Technical Sector (Chapter III) and Technicians (Chapter IV). |</p>
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Inform structural policy reforms and interventions to align education and training provision to labor/skill demand.</th>
<th>Inform decision-makers on short term labor mismatches to facilitate the targeting of employment services.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institutional setting</td>
<td>Commissioned by the World Bank for application in Sub-Saharan African countries, and piloted in Tanzania.</td>
<td>A well-established model, updated each year by the Ministry of Social Affairs &amp; Labor, based on macroeconomic model by Ministry of Economic Affairs.</td>
</tr>
<tr>
<td>Focus</td>
<td>Labor demand by sector and occupation</td>
<td>Labor demand by sector and region</td>
</tr>
<tr>
<td>Time span of projections</td>
<td>12 years (2012-2023)</td>
<td>1 year (2014)</td>
</tr>
<tr>
<td>Model applied</td>
<td>Inter-industry macroeconomic model</td>
<td>Dynamic applied general equilibrium model</td>
</tr>
<tr>
<td>Principal data used</td>
<td>Demographic data (up to 2010); integrated labor market surveys (1991, 2001, 2006); input/output data originating in 1992; annual national accounts.</td>
<td>Detailed national accounts &amp; labor force data collected at annual or shorter intervals; data from other sources incl. on sales, vacancies, R&amp;D; third party labor market &amp; economic analyses; projected impact of future government reforms.</td>
</tr>
</tbody>
</table>

Data generation and applications: As they generate numeric findings, quantitative models produce findings related to quantitative demand (“an expected 5% increase in demand for labor in the construction sector”) rather than qualitative demand (“construction workers need stronger ability to work independently”). The level of detail of the forecasts that can be produced depends both on the level of detail of the data that incorporated in the model, and on the design of the model itself. This is illustrated in table II.2 below, again for the examples of the models from Tanzania and the Netherlands.

Notable differences between the findings from the two models are due to differences in objectives, data availability and model design. Corresponding to the different objectives of both models, the Tanzania projections cover a time span of 12 years to allow the results to inform structural policy reforms and longer term interventions, while the Netherlands model has a time-span of 1 year to inform the targeting of short term employment service provision. The results from the Tanzania model focus on labor demand by sector and occupation, while those from the Netherlands model focus on demand by sector and region. Due to the relative data scarcity in Tanzania, the model’s findings are presented by broad economic sector (e.g., ‘transport, storage, and communication’), while the data-rich environment in the Netherlands allows forecasts on a disaggregated level (e.g. for ‘child care’ as a sub-sector of the sector ‘healthcare and care’). Lastly, unlike the Tanzania model, the Netherlands model incorporates assessments of the impact of forthcoming large reforms, as is included for the example of home and child care in the table below.

The Tanzania model illustrates how a quantitative model can be applied in a data-scarce context. Even though data constraints cause the projections to be generated on a rather aggregated level, they provide useful guidance for broad policy interventions that can be considered appropriate even when considering that there may be relatively large margins of errors in the projections. For example, based on the expected increase in demand for technicians of 50 percent by 2023, authorities may decide to target interventions to increasing their number, which would be a justified investment even if the actual increase turns out to
be ‘only’ 40 percent. Nevertheless, to well-align training interventions with expected labor demand in particulars sector and/or occupations, the findings of the economy-wide model would ideally be complemented by further analyses. This can be achieved either by using an economy-wide model or its findings as a basis for developing a more detailed quantitative model for specific sectors or occupations, or by using a combined approach within which the findings of a quantitative model are complemented with projections from alternative forecasting methodologies. As described above, in Tanzania the latter approach is applied, and the model’s findings will be complemented with the results from an employer survey, several sector-specific studies, and an assessment particularly focusing on skills needs in the informal sector.

Examples of both approaches are provided in the case studies in Chapters III and IV: cases in which a nationwide model serves as a basis for a more detailed sectoral or occupational model include the Dutch Technical Sector (Chapter III), and STEM (Science, Technology, Engineering, and Mathematics) and SET (Science, Engineering, and Technology) occupations in the UK (Chapter IV). Examples which combine the findings of a quantitative model with other forecasting approaches include the UK Construction Sector, in which projections are further informed by sector export consultations (Chapter III), and Engineering occupations in New Zealand, for which the forecasts from a quantitative model complement projections derived from a secondary data and literature review and stakeholder consultations (Chapter IV).

Table II.2 Examples of findings from quantitative models applied in Tanzania and the Netherlands

<table>
<thead>
<tr>
<th>Tanzania Economic Model for Understanding Human Capital Development Needs*</th>
<th>Netherlands Labor Market Prognosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall employment:</strong></td>
<td><strong>Overall employment:</strong></td>
</tr>
<tr>
<td>Between 2012 and 2023, total employment is expected to increase by 40% from 22.7 million to 31.7 million.</td>
<td>Despite positive GDP growth, employment is expected to fall by 0.7% in 2014, due to rising labor productivity (1.2%), cautious recruitment, and the negative impact of government reforms on public employment.</td>
</tr>
<tr>
<td><strong>Employment by sector:</strong></td>
<td><strong>Employment by sector:</strong></td>
</tr>
<tr>
<td>From 2015-2023, demand in the transport, storage and communications is expected to rise by around 17% (from 356,000 to 418,000 persons), and demand in the mining and quarrying sector by approximately 15% (from 121,000 to 139,000 persons).</td>
<td>A 1.6% fall in employment in the health and care sector in 2014 is expected to be driven by decreases in the sub-sectors home-care (5.8%) and child care (3.0%), as these will be particularly affected by decentralization reforms and budget reductions.</td>
</tr>
<tr>
<td><strong>Employment by occupation:</strong></td>
<td><strong>Employment by occupation:</strong></td>
</tr>
<tr>
<td>From 2015-2020, demand for technicians/associated professionals and plant and machine operators is expected to rise by almost 50% (resp. from 528,000 to 780,000 persons and from 430,000 to 641,000 persons).</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Employment by region:</strong></td>
<td><strong>Employment by region:</strong></td>
</tr>
<tr>
<td>N/A</td>
<td>Some (semi-)urban areas are expected to see higher employment, but it is expected to fall in regions at a distance from urban economic activity.</td>
</tr>
</tbody>
</table>

* The reflected findings are preliminary, from the model’s pilot phase, and provided for illustrative purposes only.
Advantages of quantitative models: With the appropriate inputs, quantitative models can be a sound and consistent approach to forecasting quantitative labor and skill demand. Models can be adapted to fit specific objectives and available data. Forecasting accuracy can be tested and models can be periodically adjusted to adapt to changing circumstances and improve accuracy.

Disadvantages: Quantitative models are not appropriate to forecast qualitative aspects of labor and skill demand (e.g. skill and competency requirements). Also, even for a rudimentary model, the methodology is data intensive. Considering the costliness of collecting primary data, regular and comprehensive data collection exercises are unlikely to be initiated for the sole purpose of facilitating labor and skill demand forecasting. Rather, strengthening economic and labor data collection systems would rely on the general recognition that the availability of such data enables better informed decision-making on a wide range of areas related to economic development and poverty reduction, including skills development but also for example infrastructure investments and well-targeted social protection mechanisms. In a data-scarce context where quantitative models only provide relatively broad findings with an acceptable level of predictability, it is recommendable to complement them with alternative methodologies which are less data-intensive, such as expert consultations and employer surveys.

d) Stakeholder surveys

Methodology and data needs: Stakeholder surveys to gauge labor and skills demand are mostly targeted toward employers but may also focus on employees or graduates. The selection of the survey sample and the design of the questionnaire are informed by the particular objectives of the forecasting exercise. Depending on the objectives, stakeholder surveys can generate quantitative and/or qualitative data.

While data requirements to carry out stakeholder surveys are relatively limited, the predictive value of stakeholder surveys depends on the sample selection and size. It is therefore important that a sufficiently accurate data base of relevant employers (or employees, or graduates) exists, to ensure that a representative sample can be selected. This is not always easy, and can require preparatory activities well in advance of the actual survey activities. For example, depending on the intended scope of the forecasts, it will be important to capture informal enterprises or informal sector employees, including the informally self-employed, household enterprises and those active in agriculture. Similarly, graduate tracer studies can only be meaningfully conducted if there is a functioning system in place to contact former students for a substantial period of time after their graduation.

In addition to the importance of ensuring an appropriate sample and sampling size, there needs to be a sufficient level of confidence that the surveyed stakeholders are willing and able to provide accurate information. This consideration should guide the design of the questionnaires as well as the interpretation of the survey findings. For example, employers are generally better able to predict short term than longer term recruitment needs (e.g., predictions of staff needs over a period of six months are more accurate than those for a 5-year period), and their response rate on questions related to income and profit margins tends to be relatively low.
Date generation and applications: Stakeholder surveys can provide valuable information in addition to data that is generated through quantitative models, or when sufficiently reliable quantitative data to apply a model do not exist. Surveys can for example generate sector-specific information with a relatively high level of detail, include data on employer or employee expectations, and focus on qualitative aspects of demand. Stakeholder surveys — as well as the consultative approaches described below - are also appropriate in contexts where quantitative models are unlikely to produce reliable results, for example when external shocks or policy changes are expected to cause substantial deviations from historic trends which are unlikely to be captured in quantitative models.

Table II.3 summarizes the stakeholder surveys which are included in case studies that are described in Chapters III and IV of this report, and the type of findings that they generate. The table includes examples of self-standing surveys (Chile; USA) and of surveys of which the findings are complemented with results of other forecasting methodologies to generate a comprehensive set of projections (Netherlands; India). The case studies illustrate how surveys can be used to generate projections on quantitative demand (Chile), qualitative demand (USA IT workers), or both (USA manufacturing sector; Netherlands; India). Finally, while most surveys target employers, the approach to forecast demand for technicians in the Netherlands incorporates the findings of a series of annually repeated graduate surveys.

Table II.3  Summary of stakeholder surveys included in case studies

<table>
<thead>
<tr>
<th>Country</th>
<th>Survey type (sample size)</th>
<th>Survey focus</th>
<th>Survey only or combined approach</th>
<th>Type of findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector forecasts:*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>Employer survey (31)</td>
<td>Mining sector</td>
<td>Survey only</td>
<td>Quantitative demand, incl. by occupation</td>
</tr>
<tr>
<td>USA</td>
<td>Employer survey (1,123)</td>
<td>Manufacturing sector</td>
<td>Survey only</td>
<td>Quantitative and qualitative demand, incl. by occupation and operational profile</td>
</tr>
<tr>
<td>STEM worker forecasts:**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>Employer survey (502)</td>
<td>IT workers</td>
<td>Survey only</td>
<td>Qualitative demand and priority operational &amp; subject areas</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Graduate survey (55,000)</td>
<td>Technicians</td>
<td>Combined with quantitative model</td>
<td>Quantitative and qualitative demand, incl. by qualification</td>
</tr>
<tr>
<td>India</td>
<td>Employer survey (N/A)</td>
<td>IT workers</td>
<td>Combined with literature review and expert consultations</td>
<td>Quantitative and qualitative demand, incl. by region, industry sub-area, business area, and firm size</td>
</tr>
</tbody>
</table>

* See Chapter III and Annex 2 for more information on sector forecasting case studies
** See Chapter IV and Annex 3 for more information on STEM workers forecasting case studies

Of the above summarized case studies, three particularly merit further attention, as both the nature of the forecasting results and the institutional setting within which they are produced concretely facilitate the alignment of education and training provision with labor and skill demand. First, in the India example, the applied combined approach producing forecasts on quantitative and qualitative demand provides
clear entry points for adjustments in the capacity and content of training supply. The forecasts are carried out periodically and their methodology is improved systematically based on lessons learned from previous forecasting exercises. Furthermore, the industry association which carries out the forecasts is strongly engaged in working with public and private partners to translate the findings of the analyses into better aligned education and training provision, among others through assessing existing curricula on the extent to which they are aligned with the findings of the projections.

Second, the Chilean mining sector forecast demonstrates how a sector-specific employer survey can generate quantitative labor demand projections with a level of depth and detail that cannot be generated from existing economy-wide surveys in the country. In addition, it collects data from employers on forthcoming large investment projects, which is a type of information that is not captured by other sources. In terms of institutional settings, the effective use of forecasting results is promoted through the collaboration of the Chilean Mining Skills Council - which produced the forecasts – with training providers and government with the aim to align training provision with labor and skill demand.

Third, the graduate survey of the Netherlands example offers the option to participating education institutions to add questions to the survey questionnaire that are of particular relevance to them; it also provides each educational institution with school-specific survey results, benchmarked against comparator schools. This tailor-made approach substantially enhances the applicability of the survey's findings.

Advantages: Stakeholder surveys can be adapted to the specific forecasting objectives and available resources, and therefore can be applied in many different circumstances and contexts, including in a data scarce environment. They are able to capture qualitative aspects of demand, and can provide valuable insights in volatile environments.

Disadvantages: Depending on the sample selection findings derived from surveys may not be representative, which impedes their predictive value. Furthermore, depending on the survey design, survey findings may be subjective and non-numeric, which complicates the translation of the survey results into clear forecasts of labor and skill demand. If there is indeed a strong risk of representation or interpretation challenges, alternative methodologies could be considered. In this case, stakeholder or expert consultations could be particularly appropriate approaches complementary to or instead of a stakeholder survey.

e) Consultations

Methodology and data needs: For the purpose of this report, consultative forecasting methodologies are considered to include forecasts which are informed by the views of experts and stakeholders, collected through individual interviews, group discussions, or literature review. Expert and stakeholder views can be collected in person, in writing, or virtually (online). Interviews and discussions can follow a systematic approach (e.g. by using questionnaires or particular discussion techniques), aim for a particularly
structured outcome (e.g. scenario development), or be mostly free-flowing. The data needed to engage in expert or stakeholder consultations are limited. It is important that the focus and objective of the consultations are well-defined, that appropriate experts on the topic are identified, and that their sample is broad and varied enough to avoid generating biased findings. A review of secondary literature, including of secondary quantitative data, is another type of consultation. When relevant and credible literature exist to aid the development of forecasts, the use of these data can substantially decrease the time and resources needed to generate useful projections.

Table II.4 includes the case studies presented in Chapters III and IV which include consultations as part of the applied methodology. Overall, findings from consultations relatively often include a focus on qualitative aspects of demand. The case studies include both examples where the findings draw mainly from consultative approaches (e.g. the case studies for Swaziland agribusiness and for engineers in New Zealand), and those for which consultations play a smaller role and are mostly applied to fine-tune the findings generated through other approaches (e.g. the case study for the UK construction sector). An example of the use of a very comprehensive set of consultative methods is the forecasting report on the chemical and pharmaceutical sector in the European Union (EU) which includes, among others, a value chain analysis and the development of future scenarios.

**Table II.4 Summary of consultations included in case studies**

<table>
<thead>
<tr>
<th>Country</th>
<th>Focus area</th>
<th>Type of consultations</th>
<th>Consultations only / combined approach</th>
<th>Type of demand forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sector forecasts:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swaziland</td>
<td>Agribusiness value chain</td>
<td>Literature review Expert consultations</td>
<td>Consultations only</td>
<td>Qualitative, incl. skills for priority occupations and within sub-industries</td>
</tr>
<tr>
<td>UK</td>
<td>Construction</td>
<td>Expert consultations</td>
<td>Combined (mostly based on quantitative model)</td>
<td>Quantitative, incl. by occupation and region</td>
</tr>
<tr>
<td>EU</td>
<td>Pharmaceuticals</td>
<td>Expert consultations Stakeholder cons. Literature review</td>
<td>Combines various consultative approaches</td>
<td>Quantitative and qualitative, incl. by job function and for various scenarios</td>
</tr>
<tr>
<td><strong>STEM worker forecasts:</strong>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>Technicians</td>
<td>Literature review</td>
<td>Combined (mostly based on survey and quantitative model)</td>
<td>Quantitative and qualitative; literature review identifies broad future scenarios</td>
</tr>
<tr>
<td>India</td>
<td>IT workers</td>
<td>Literature review Expert consultations</td>
<td>Combined (with employer survey)</td>
<td>Quantitative and qualitative, incl. by business area</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Engineers</td>
<td>Literature review Stakeholder cons.</td>
<td>Complemented with quantitative model</td>
<td>Quantitative, incl. by level of qualification</td>
</tr>
</tbody>
</table>

8 An example of a structured approach is the ‘Delphi technique’, in which a group of experts agrees on predictions through a reiterative process with which, supported by questionnaires, gradual consensus on a pre-determined topic is gradually developed. This is one of the methods applied in the case study on the EU’s pharmaceutical industry (see Chapter III of this report).
Data generation and applications: Consultative methods can be used in addition to, or instead of, quantitative models and stakeholder surveys. They tend to generate more subjective findings than quantitative models and surveys, and are particularly appropriate to generate medium to longer term forecasts. Compared to other methodologies, they can be usefully applied in fast-changing environments where the predictive value of quantitative models is limited, when there is a need to capture qualitative aspects of skill demand, and/or when stakeholder surveys are not expected to generate reliable findings. Expert consultations can also be appropriate when the objective is to not only forecast, but also influence labor and skill demand. For example, expert consultations can guide the development of interventions by identifying endogenous drivers of growth and assessing the implications for labor and skills demand when interventions effectively target these drivers.

Advantages: Consultative methods can be applied in a relatively short period of time, with relatively limited financial resources, and do not depend on the availability of extensive data. They can capture qualitative aspects of demand, forecast developments in volatile environments, and provide useful entry-points for effective interventions.

Disadvantages: There is a large subjective element involved in forecasts from expert consultations. While this is intentional and inherent to the methodology, it also implies that the validity of the forecasts is hard to predict. Compared to quantitative models and stakeholder surveys, the consistency and comparability of forecast generated using a consultative approach is limited.

* See Chapter III and Annex 2 for more information on sector forecasting case studies
** See Chapter IV and Annex 3 for more information on STEM workers forecasting case studies

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9 As described above, surveys may not generate reliable findings if a representative sample cannot be identified, or if surveyed stakeholders are not willing or able to provide sufficiently accurate information.
III. FORECASTING SECTORAL LABOR AND SKILL NEEDS – CASE STUDIES

a) Introduction

Sectoral labor and skill demand forecasts serve to assess future demand for labor and skills in a particular sector of an economy. Sector forecasts are used, among others:

- by Governments to identify labor or skill related constraints that need to be addressed to develop sectors which are considered to be important contributors to economic growth or job creation;
- by sector employers and associations to determine recruitment and training strategies, and promote policy-decisions that support sector growth;
- by education and training providers to adapt quality and quantity of education and training to expected labor and skill demand in sectors in which their graduates are expected to be employed.

This chapter summarizes several case studies of sectoral labor and skill demand forecasting exercises (see Table III.1). The studies illustrate different methodologies, carried out in both data-rich and data-scarce environments, and executed by different stakeholders. As the case studies illustrate, a sector can be defined as broad or as narrow as is deemed appropriate, ranging for example from the ‘large scale mining sector’ (case study on Chile) to a broad cluster of industries defined as the ‘technical sector’ (case study on the Netherlands). The case study on the European Union’s chemical sector further illustrates that the scope of the forecasting exercise is not bound by national borders.10

Table III.1: Case studies for sectoral labor and skill demand forecasts

<table>
<thead>
<tr>
<th>Approach:</th>
<th>Country/Region:</th>
<th>Sector:</th>
<th>Initiated by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quantitative model</td>
<td>Netherlands</td>
<td>Technical Sector</td>
<td>Collective of technical sector employer &amp; employee associations</td>
</tr>
<tr>
<td>2. Employer Surveys</td>
<td>Chile</td>
<td>Mining</td>
<td>Mining Skills Council</td>
</tr>
<tr>
<td>3. Employer Surveys</td>
<td>USA</td>
<td>Manufacturing</td>
<td>Manufacturing Institute / Deloitte</td>
</tr>
<tr>
<td>5. Consultative (expert and stakeholder consultations + literature review)</td>
<td>European Union</td>
<td>Chemicals, Pharmaceuticals, Plastic and Rubber</td>
<td>European Commission</td>
</tr>
<tr>
<td>6. Combined Approach</td>
<td>United Kingdom</td>
<td>Construction</td>
<td>Construction Industry Training Board</td>
</tr>
<tr>
<td>(Quantitative + Expert Consultations)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10 Further case studies on sectoral skill forecasting in transition and developing countries can be found among others in ETF, ILO, CEDEFOP (2014, forthcoming).
The descriptions below present the main characteristics of each case study, including their specific objectives, the applied methodology, the type of findings that they generate, and key observations that should be taken into account by governments which may consider replicating the approach. Table III.2 provides a summary of all these elements. More elaborate descriptions of each case study are presented in Annex 2.
Table III.2: Key characteristics of sector case study examples

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Objectives (Type of Findings)</th>
<th>Methodology</th>
<th>Observations for replication</th>
</tr>
</thead>
</table>
| Technical Sectors     | Quantitative demand (incl. by sub-sector, education level, technical nature of jobs)          | Quantitative Model               | - A quantitative model may be the most robust approach for quantitative forecasts (provided that sufficient data and resources are available).  
  - The case study relies on an extensive secondary data base and sophisticated macroeconomic model, but a simple quantitative model can be developed even in a relatively data-scarce context.  
  - Reliance on an already existing model can greatly reduce the costs and time needed to develop forecasts.                                                                                                                                                                                                                                           |
| (Netherlands)         |                                                                                              |                                  |                                                                                                                                                                                                                                                                                                                                                               |
| Mining                | Quantitative demand (incl. by occupational profile)                                          | Employer Survey                  | - This approach can be appropriate when a quantitative model cannot (sufficiently) forecast quantitative demand.  
  - For a sector dominated by a limited number of large employers, the survey can be carried out relatively quickly and at moderate cost.  
  - Data generated through a survey may be more subjective than findings from a quantitative model.  
  - The validity of the forecasts’ findings are enhanced by its execution within a multi-stakeholder institutional setting (Mining Council)                                                                                                                                                                                                                     |
| (Chile)               |                                                                                              |                                  |                                                                                                                                                                                                                                                                                                                                                               |
| Manufacturing         | Assessment of which quantitative and qualitative labor and skill shortages will be key constraints to output growth (incl. by occupation and operational area) | Employer Survey (online)         | - The focus on key bottlenecks from the firms’ perspective is useful to identify priority areas for intervention, and/or when quantitative demand forecasts are already generated through other approaches (e.g. a quantitative model).  
  - Online surveys can reduce required funds and time, but may harm sample representativeness.                                                                                                                                                                                                                                                               |
| (USA)                 |                                                                                              |                                  |                                                                                                                                                                                                                                                                                                                                                               |
| Agribusiness          | Quantitative and qualitative labor and skill demand (and overall constraints to sector growth) | Consultations (Expert & Literature) | - A VCA is particularly appropriate when the objective is to identify overall key bottlenecks to sector growth (i.e., including but not exclusively focused on labor/skills)  
  - The study relies mostly on consultative approaches, but a VCA can also include quantitative models and stakeholder surveys, which could increase predictive value but also be more cost and time intensive.                                                                                                                                                                                                 |
| (Swaziland)           |                                                                                              |                                  |                                                                                                                                                                                                                                                                                                                                                               |
| Chemicals & Pharma    | Quantitative and qualitative demand (incl. for various job functions and for several future sector scenarios) | Consultative (expert and stakeholder consultations + literature review) | - This approach is appropriate when sector labor and skill demand need to be thoroughly reviewed making maximal use of available expertise, and when projections are for the medium or longer term.  
  - While the comprehensive consultative approach applied in the case study is data, time and financial resource intensive, resource needs                                                                                                                                                                                                                               |
| Construction (UK) | Quantitative demand (incl. by sub-sector, region, and occupation) | Combined (Quantitative with Expert Consultations) | can be reduced by limiting the scope and/or depth of the various consultations to arrive at an approach which is ‘as comprehensive as possible’ within a given context.  
- The availability of a well-documented, reviewed and public structure of the methodology increases credibility and allowed consistent application across 16 sectors.  
- This approach can be appropriate when a quantitative model exists but is not considered to be sufficiently accurate or detailed.  
- The combination of a model with expert views can improve the forecasts’ overall predictive value, but also jeopardize its credibility unless there is sufficient transparency on the applied methodology (e.g., through a strong institutional setting such as the Sector Skills Council Observatories in the case study). |
b) Sector forecasts: Case Studies

1. Quantitative model – Technical Sectors in the Netherlands\textsuperscript{11}

\textit{Methodology.} This quantitative model, commissioned by the technical sectors’ employer and employee’s association to project recruitment needs in the technical sectors, is based on extensive and detailed secondary data as well as on an existing quantitative macro-economic forecasting model maintained by the Dutch Government.\textsuperscript{12} The purpose is to inform stakeholders of expected trends and recommend ways to address or mitigate potential skills shortages. Data incorporated in the model include, among others, information on gross domestic product (GDP), export volume, research and development (R&D) expenditures, firm size, job profiles, demographic trends, employment patterns, educational attainment of the labor force and labor market entrants, labor productivity, and vacancies.

\textit{Data generation and applications.} The robust basis of data incorporated in the model allows the projection of quantitative recruitment needs (for the period 2013-208) for the technical sectors as a whole and disaggregated by cluster and specific sector, by education level, and by the technical or non-technical nature of employment. Examples of forecasting results are summarized in Box III.2. As the findings point mostly to expected increased shortages of high skilled technical personnel, the recommendations in the report include increased attention to promoting students to embark on technically oriented higher level technical education; retraining of the existing workforce; attracting appropriately skilled personnel from abroad; and providing incentives to staff to delay retirement.

\textbf{Box III.1: Examples of findings – Forecasting demand for the Netherlands Technical Sectors}

\begin{itemize}
  \item Total employment in the Technical Sectors is expected to fall by 0.9 percent per year between 2015 and 2018. Employment in Technical Services is expected to increase 1.2 percent per year from 2015-2018, while employment in Construction is expected to fall by 1.7 percent annually in the same period.
  \item A net recruitment need of 1.5 percent of total employment in the sector is expected, due to the flow of labor out of the Technical Sector, among others due to retirement.
  \item Net recruitment demand for low-skilled (technical and non-technical positions) is expected to be negative between (i.e. there is a surplus of 11,000 of these workers), while net recruitment needs for medium/higher educated staff are expected to amount to 65,000 and 53,000 for technical and non-technical positions, respectively.
\end{itemize}

\textit{Observations for replication.} The systematic and replicable nature of this methodology, and its detailed quantitative findings, are clear advantages of this approach, especially when the objective of the

\textsuperscript{11} The Technical Sectors are considered to include the following clusters: Automotive and Transport, Chemicals, Construction, Electro and Machinery, Food, Metal, Other Manufacturing, and Technical Services, and Utilities.

\textsuperscript{12} SEO Economisch Onderzoek (2013).
forecasting exercise is to generate information on the quantitative aspects of demand. Although the predictive value and the level of detail of projections depend on the quality and availability of data, this approach can nevertheless be applied in contexts where data availability is limited, as long as a basic level of reliable data exists. When applying this approach, it is advised to let the level of sophistication and detail of the model be guided by the extent to which reliable data is available. The resources required to carry out this approach will be substantially lower if the forecasts can be based on an existing quantitative macroeconomic model.

2. **Employer Survey – Mining in Chile**

*Methodology.* This study, by the Chilean Mining Skills Council, relies on data provided by a sample of mining companies and their suppliers, which is then extrapolated to generate a sector wide labor forecast. The survey collected data on the current labor force, such as age and occupational profile, as well as on forthcoming large investment projects, to forecast labor demand based on both staff replacement and expansion requirements. To assess labor shortages, the study also includes forecasts of *supply* (which is not further discussed in this report).\(^{13}\)

*Data generation and applications.* Box III.2 provides examples of the findings of the Chilean mining sector study, which forecasts the quantitative aspects of labor demand, disaggregated by fifteen occupations profiles. The findings serve as input for the mining sector strategy which aims to address both short and long term skills gaps through a comprehensive package which includes the design and provision of specific (re)training programs, increasing the capacity of Technical and Vocational Education and Training (TVET) institutions, strengthening TVET qualification and accreditation frameworks for occupations which are of particular importance to the mining sector, and continuous improvements to the mining sector labor market information system.

**Box III.2: Examples of findings – Forecasting demand for the Chilean Mining Sector**

- The net recruitment needs of qualified human capital between 2012 and 2020 are forecasted to be 37,638 workers. This amounts to approximately one quarter of the current work-force operating within the main value chain. One third of this number is expected to be needed to replace retiring workers; two thirds are expected to be needed to work on new projects.
- Of the total identified recruitment needs, 39 percent are expected to be needed by mining firms, and 61 percent by their suppliers.
- Almost two thirds of total recruitment demand is expected to be for the occupational profiles of mechanical maintenance (15,434) and mobile equipment operators (8,589).

\(^{13}\) Consejo de Competencias Mineras (2012).
Observations for replication. A survey can generate data that is otherwise unavailable, for example when other data collection systems are not sufficiently developed to provide the required detailed level of data (e.g. in the case study, data collected on the current workforce in the sector was likely not available from conventional, nationwide labor force surveys). Surveys can also generate data that is generally not collected through other means, for example the qualitative, and somewhat speculative, projections of future investment projects in the Chilean case study. Employer surveys can be executed in a resource-scarce environment. When, as in the case of this example, the objectives and the scope of the survey are narrowly defined and the sample is small, the survey can be executed with fairly limited resources and in a relatively short period of time. The reliability of the findings depends on the appropriate selection of the sample survey, and on the willingness and ability of survey participants to provide accurate information. Concerning the latter, as firms are known to have difficulties to predict labor demand, particularly on the longer term, the predictive value of forecasts are likely to be stronger for a time horizon not exceeding six months or one year. In addition, questionnaires should be designed in such a way that they take into account potential incentives of participants to provide inaccurate information.

3. Employer Survey – Manufacturing in the United States

Methodology. Sponsored by the Manufacturing Institute and Deloitte, this approach uses data collected through an online survey of firm executives to forecast manufacturing firms’ future labor and skill demand challenges, to inform training, education and recruitment strategies. The survey includes both quantitative and qualitative labor and skill demand aspects. It focuses on firms’ perceptions on the key bottlenecks to overall firm performance in the coming 3-5 years.  

Data generation and application. The survey assesses, among others, the occupational profiles and operational areas which are expected to pose the greatest recruitment challenges (taking into account labor replacement and expansion needs), and the most important expected skill deficiencies in workers. (See Box III.2 for examples of the findings of survey). With the most constraining staff shortages expected for skilled production workers, and technical and problem solving skills considered to be the most deficient among current workers, recommendations drawn from the survey’s findings include the adoption of more creative recruitment approaches and improved workforce planning by manufacturers, and increased collaboration between enterprises and the government and educational institutions to increase the relevance of education and training provision for employment in the manufacturing sector.

Box III.3: Examples of findings – Forecasting demand for the USA Manufacturing Sector

- 56 percent of surveyed firms expect that overall labor and skills shortages will increase in the coming 3-5 years. Only seven percent of firms expect decreased shortages.
- A large majority of firms (80 percent) expects that in the coming 3-5 years the recruitment of skilled production workers will be the greatest challenge. Substantially fewer firms expect particularly strong challenges in the recruitment of management and administration staff (20 percent of firms), unskilled production workers (17% of firms), and customer service staff (7 percent)
- Problem solving skills and technical training are most often considered the key skill deficiencies in current employees (by 52 percent and 43 percent of employers, respectively), as opposed to for example mathematics or communication skills (20 percent and 19 percent of employers, respectively).

Observations for replication. Conducting a survey online can substantially reduce the time and resources required for its execution. It can, however, be problematic in terms of firm response rate and representativeness, particularly in a context where many (smaller) firms are not connected to the internet or where online contact details are not readily available. A distinctive difference compared with the Chilean case study is that the USA’s manufacturing survey does not aim to generate a quantitative projection of labor demand, but instead aims to assess the labor and skill constraints that will be the largest impediment to increasing firm output and productivity. This approach can be appropriate i) when the objective of the forecast is to identify the areas for priority labor and skills related interventions with the aim to promote firm output and productivity; ii) when numeric forecasts can be generated through other available data (as is likely the case in the U.S); or when iii) employer surveys are not expected to generate numeric forecasts with sufficient predictive value, as may be the case when a representative sample of firms cannot be reached, or when firms are not expected to be willing or able to provide sufficiently accurate information.

4. Consultations – a Value Chain Approach for Agribusiness in Swaziland

Methodology. The World Bank and the Swaziland Ministry of Education and Training applied a Value Chain Approach (VCA) to assess the labor and skill requirements to facilitate improvements in productivity and income generation opportunities within Swaziland’s agribusiness sector. A distinctive feature of the VCA is that it aims to provide a comprehensive picture of all key challenges and opportunities affecting the development of a sector along its value chain.\footnote{In the case of agribusiness, the value chain is roughly defined as all activities to get a product ‘from farm to table’, including R&D, inputs, cultivation, packing, processing, and distribution and marketing.} As such, even when the key objective of the analysis is to forecast labor and skill demand, it places this analysis within the broader context of other constraints to sector growth (such as access to land or finance). While scarcely available secondary quantitative data is used to describe the context within which the sector operates, the Swaziland approach mostly relies on expert consultations with identified ‘industry drivers’ to inform the review of quantitative and qualitative aspects of current and future labor and skill demand (as well as overall potential constraints to sector}
growth) along the value chain; a review of national and international literature is used to identify opportunities and challenges for agribusiness development; and government documents are used to collect information on public sector strategies which are expected to affect sector growth.\textsuperscript{16} \textsuperscript{17}

Data generation and applications. Box III.4 provides examples of findings from the value chain analysis related to the projected demand for labor and skills, which include the concrete identification of key job profiles in the agribusiness value chain, as well as key identified gaps in skills within these profiles. Combined with an assessment of the training programs that are currently offered in the country, the report issues recommendations that relate to (i) introducing training programs for job profiles for which currently no training programs exist; and (ii) improving the quality of existing training programs for key job profiles. Concrete recommendations include the establishment of training programs for technical supervisors for the horticulture, sugar, and beef agribusiness value chains; redesigning engineering programs to ensure that graduates acquire the skills most relevant for agribusiness; and establishing an advisory committee consisting of private sector and training provider representatives to ensure continuous dialogue to ensure that TVET supply is responsive to demand.

**Box III.4: Examples of findings – Forecasting demand for the Swaziland Agribusiness Sector**

- There are seven job profiles of key importance for the agribusiness value chain: business manager, finance/accountant, technical manager, technical supervisor, industry technician, and food quality/safety controller. For each of these profiles, a set of key required abilities and knowledge is identified.
- Particularly strong skill gaps include weak knowledge on agricultural practices and new production methods among cotton producers; lacking management capacity within medium-sized horticulture enterprises; and low skills in pasture management and poor breeding practices of livestock producers.

Observations for replication. A VCA is particularly appropriate when a (group of) stakeholder(s) aim(s) to promote productivity and growth of a particular sector by holistically addressing its key bottlenecks, regardless whether these are found to be related to labor and skill demand or to any other area. Depending on the extent to which labor and skills are emphasized within the VCA, the level of detail in which labor and skill demand are assessed may be limited compared to other methodologies which solely focus on labor and skill demand. Compared to an employer survey, the expert consultations may have been quicker and cheaper to conduct, and generated richer, subjective information, but no sector-representative data. A VCA can be applied using a variety of methodologies, depending on the specific objectives of the analysis and the available resources. In the Swaziland study, the applied methodologies were largely consultative. In a context where detailed and reliable data, time, and financial resources are more readily available, quantitative modelling can comprise a larger part of the VCA.

5. Consultations – Chemicals and Pharmaceuticals in the European Union

\textsuperscript{16} World Bank and Swaziland Ministry of Education and Training (2014).
\textsuperscript{17} While not discussed in this note, the paper also reviewed the relevant segments of Swaziland’s education and training system, and provides options for public-private partnerships to ensure demand-responsive labor supply.
**Methodology.** The European Commission (EC) commissioned a series of sector studies forecasting trends related to innovation, skills, and jobs up to the year 2020, spanning all countries of the European Union (EU). One of these studies, published in 2009, focused on the Chemicals and Pharmaceuticals sector. All sector studies apply the same comprehensive approach, which includes the extensive use of quantitative data from a variety of sources, relevant literature, and regular consultations with a wide range of experts and stakeholders including to aid the development of a Value Chain Analysis, an Institutional Assessment, a SWOT analysis; the identification of key Drivers of Change; and the development of future scenarios for the sector, including their implications for jobs, occupational profiles and skills, and innovation. The approach used is well-documented, and consists of ten steps where the results of each steps subsequently serve as input for the following steps. As the study covers a large region (27 countries), uses a variety of sources and methodologies, and covers both quantitative and qualitative aspects of labor and skill demand, the findings are substantive both in scope and level of detail. They include, among others, an assessment of how technological changes will affect the quantitative and qualitative aspects of labor and skill demand, as well as predictions of changes in quantitative and qualitative skill requirements for various job functions in each of the four future identified sector scenarios.

**Data generation and use.** As illustrated in Box III.7, the forecasts project both quantitative and qualitative aspects of labor and skill demand, by job function and for various different future scenarios on developments of the sector.

**Box III.7: Examples of findings – Forecasting demand for the EU Chemicals and Pharmaceuticals Sector**

- Labor related weaknesses and threats include high labor costs for low skilled jobs; and the ageing workforce combined with declining labor supply, particularly of high skilled technical personnel
- Technological changes are expected to have a substantial impact on the composition of employment and on required new skills, but not on the overall level of employment
- For each of four identified future scenarios, the analysis forecasts the expected volume changes by job function (e.g. the Green and Global scenario is expected to result in an increase in demand for R&D engineers), and the emerging skills and knowledge needs by job function (e.g. in the European Retreat scenario, IT Professionals will require increased knowledge on system integration, stronger social networking skills, and increased capability to take initiative).

The report also takes on a structured approach to determine the optimal approaches to mitigating particular skill gaps, and applies this approach for a range of key occupations in the sector including for managers, engineers, IT professionals, and production workers. Interventions that are recommended for particular occupations include, among others, retraining current staff, training new labor entrants, and redesigning pre-service TVET programs, but also actions that are not directly training-related such as improving career counseling and changing organizational structures and processes within enterprises.

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18 See Rodrigues (2007)
19 European Commission, Directorate General Employment, Social Affairs and Equal Opportunities (2009)
Observations for replication. There are strong merits to using a well-defined and well-documented methodology for various sectors, as it promotes consistency and comparability of findings across sectors and over time. The comprehensive consultative approach makes optimal use of available data and knowledge, and basically reviews the topic of future and labor demand from every relevant angle. The approach to carry out the analysis on a supra-national level is appropriate in an increasingly global economy, particularly when countries may be planning to tackle particular constraints collaboratively. The drawback of the comprehensive consultative approach is that it is data, time and financial resource intensive, and requires a relatively large core team of experts to execute. In case any of these elements are in short supply, but there is nevertheless a preference to apply a comprehensive approach, then it may be recommendable to limit either the scope or the depth of the various methodologies that are included in the EC approach, to arrive at an approach that is ‘as comprehensive as possible’ under the circumstances. A supra-national (e.g. multi-country) approach can also be considered as a means to pool funding to carry out the analysis.

6. Combined Approach - Construction in the United Kingdom

Methodology. The United Kingdom’s (UK) Sector Skills Council for Construction produced a forecast of output and employment growth in the construction sector for the period 2014-2018, using a quantitative model of which the design and assumptions are partly informed by expert views. The model incorporates, among others, general and sector wide economic and labor force data originating from the Office for National Statistics. The model is informed by expert views based on regular consultations with industry experts through a national and regional Observatory Groups. Stakeholder consultations through these groups use a consistent and structured approach (the Delphi method) to arrive at output and employment related forecasts. The model predicts output and recruitment requirements within the construction industry for a range of occupational groups, disaggregated by sub-sectors and regions.\(^\text{20}\)

Data generation and applications. Box III.5 provides examples of findings from the UK construction sector’s forecasts, which are all quantitative and include projected labor demand for a five-year period for the sector as a whole, for particular occupations, and for particular regions within the UK. Actions that can be derived from the report’s findings could include, for example, increasing the capacity of to train students in occupations for which demand is expected to increase most, like for scaffolders or plant mechanics.

Box III.5: Examples of findings – Forecasting demand for the UK Construction Sector

\(^{20}\) Construction Industry Training Board (2014).
Employment in the UK construction sector is expected to rise on average by 1.2 percent annually from 2014-2018.
- The annual recruitment requirement from 2014-2018 is expected to include 2,680 painters and decorators, 1,880 plant mechanics/fitters, and 1,170 civil engineers.
- The strongest employment growth is expected in the East of England (2 percent/year), driven among others by strong output growth in industrial construction (8 percent/year). Growth in labor demand is expected to be particularly strong for scaffolders, construction process managers, and plant mechanics/fitters (between 4.7-4.9 percent/year for each of these occupations).

Observations for replication. This approach may be appropriate when there is sufficient data to generate forecasts through a quantitative model, but when the predictive value of the models’ findings without additional expert input is considered insufficient, for example in volatile economic contexts or when either the model or the data are not considered sufficiently accurate or detailed. The inclusion of subjective expert views in a quantitative model risks opening the door to criticism that this jeopardizes the objectivity of the quantitative approach. This risk can to an extent be mitigated by a level of formalization of consultative process and the inclusion of a wide range of stakeholders, as in the UK example is achieved through the Observatory Groups, and a transparent and consistent methodology to incorporate expert views in the quantitative model.
IV. FORECASTING LABOR AND SKILL NEEDS IN STEM FIELDS – CASE STUDIES

a) Introduction

In addition to nationwide or sector-specific forecasts, demand projections are also made for workers with particular qualifications or for specific occupations. Due to concerns for gaps and mismatches of skills that are considered essential drivers of knowledge- and innovation based economies, this type of forecast often focuses on skills in science, technology, engineering and mathematics (STEM), with a particular focus on workers' skills in information technology (IT). This type of forecast is used, among others:

- by Governments, to identify labor or skill related constraints that need to be addressed to promote innovation and the knowledge-based economy, which in turn are expected to spur growth, productivity, and earnings levels;
- by employers, e.g. in industries relying heavily on staff with STEM skills, to determine recruitment and training strategies and promote policy-making to increase the supply of STEM workers;
- by education and training providers to adapt quality and quantity of education and training in particular subjects and programs to expected labor and skill demand, and advocate for policy-making to promote investment in the supply of STEM workers;

This chapter summarizes case studies of labor and skill demand forecasting exercises for STEM workers.\(^{21}\) The case studies apply different methodologies, include projections of both quantitative and qualitative aspects of skills demand, and are carried out by a variety of actors, including public institutions, associations of education providers, STEM workers, or industry associations, or by partnerships between these various actors (see Table IV.1 below).

When assessing demand for STEM workers, projections can focus on the demand for workers with particular qualifications (‘educational approach’) and for workers in particular occupations (‘occupational approach’). Most of the case studies described below include both of these angles in their forecasts, with exceptions being the projections for UK STEM workers and Netherlands’ technicians (which focus exclusively on the educational approach) and those for USA engineers (which includes only the occupational approach).

Table IV.1: Case studies for labor and skill demand forecasts in STEM fields

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\(^{21}\) The presented approaches can equally be applied to forecast labor and skill demand for persons with particular qualifications or occupations outside of the STEM field.
<table>
<thead>
<tr>
<th>Approach:</th>
<th>Country</th>
<th>Skills focus</th>
<th>Initiated by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quantitative model</td>
<td>UK</td>
<td>STEM</td>
<td>Council for Industry and Higher Education (CIHE); Engineering Technology Board (ETB); Department for Innovation, Universities and Skills (DIUS)</td>
</tr>
<tr>
<td>2. Quantitative model</td>
<td>UK</td>
<td>SET</td>
<td>Royal Academy of Engineering</td>
</tr>
<tr>
<td>3. Employer survey</td>
<td>USA</td>
<td>IT Skills</td>
<td>Computing Technology Industry Association (ComptTIA)</td>
</tr>
<tr>
<td>4. Combined Approach</td>
<td>Netherlands</td>
<td>Technicians</td>
<td>Netherlands Association of Universities of Applied Science</td>
</tr>
<tr>
<td>(Graduate Tracer Survey and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative Model)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Combined Approach</td>
<td>India</td>
<td>IT workers</td>
<td>NASSCOM (Industry Association)</td>
</tr>
<tr>
<td>(Employer Survey + Literature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review + Expert Consultations)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Combined Approach</td>
<td>New Zealand</td>
<td>Engineers</td>
<td>Department of Labor; Institution for Professional Engineers of New Zealand (IPENZ); Association of Consulting Engineers New Zealand (ACENZ)</td>
</tr>
<tr>
<td>(Literature Review, Quantitative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model and Stakeholder Consultations)</td>
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</tbody>
</table>

Similar to the structure of Chapter III, the descriptions below focus on the forecasts’ specific objectives, the applied methodology, the type of findings they generate, and key observations to take into account when considering replicating the approach. Table IV.2 provides a summary of all these elements. More elaborate descriptions of each case study can be found in Annex 3.
Table IV.2. Key characteristics of STEM workers’ case study examples

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Objectives (Type of Findings)</th>
<th>Methodology</th>
<th>Observations for replication</th>
</tr>
</thead>
</table>
| STEM workers (UK)    | Quantitative demand for degree and post-degree qualifications, by discipline and sector       | Quantitative model                    | - This study demonstrates how an existing macroeconomic model, complemented by specific occupational-level data, can be applied to generate rather detailed forecasts for workers with particular (STEM) qualifications.  
                      |                                                                                               |                                       | - Replication of this approach requires the existence/development of a macroeconomic model, and availability of sufficiently detailed data to develop forecasts specifically for STEM-qualified workers. |
| SET workers (UK)     | Quantitative demand by occupational level and sector                                           | Quantitative model                    | - Using the same macroeconomic model as in the case study for UK STEM workers (above), this study focuses on demand both for workers with SET qualifications and in STEM occupations.  
                      |                                                                                               |                                       | - Compared to the STEM worker study (above), findings in this report are less detailed, but serve the stated objective of highlighting the importance of SET/engineering skills in the UK economy  
                      |                                                                                               |                                       | - The credibility of forecasts is at risk if the impartiality of the initiator is not beyond question. When replicating the approach, this risk can be reduced through partnership between various parties, and strong transparency and replicability of the applied methodologies. |
| IT Skills (USA)      | Qualitative demand, including identified priority operational & subject areas                   | Employer Survey (online)              | - This survey produces findings which cannot be generated for example through a quantitative model, such as which business processes are most affected by gaps in IT skills, and employer perceptions on which will be major skill bottlenecks in the future;  
                      |                                                                                               |                                       | - The survey also contains questions related to current (rather than future) skill needs. While these do not constitute forecasts per se, they can nevertheless be used to guide skill development interventions;  
<pre><code>                  |                                                                                               |                                       | - When replicating the survey approach, any report with findings should include information on the representativeness of the sample, to promote the perceived credibility of the forecasts. |
</code></pre>
<p>| Technicians (Netherlands) | Quantitative and qualitative demand, incl. by qualification                              | Combined (Graduate Tracer Survey and Quantitative Model) | - The graduate tracer survey included in this approach provides extensive data on quantitative and qualitative labor market outcomes and trends that cannot be generated through other methodologies. Replication of the approach requires the availability of graduate contact details; in an emerging system, the capacity to trace graduates may best be built on a gradual, school-by-school basis. |</p>
<table>
<thead>
<tr>
<th>IT workers (India)</th>
<th>Quantitative and qualitative demand, incl. by region, industry sub-area, business area, and firm size</th>
<th>Combined (online Employer Survey + Literature Review + Expert Consultations)</th>
<th>- The sound institutional setting of this example greatly reduces the time and costs required for producing the report. The development of such a framework system can be facilitated by promoting strong stakeholder collaboration and ensuring consistency between various forecasting exercises.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers (New Zealand)</td>
<td>Quantitative demand, including by level of qualification</td>
<td>Combined (Literature Review, Quantitative Model and Stakeholder Consultations)</td>
<td>- The study combines different approaches and multiple forecasting exercises with different levels of detail and time-horizon, which allows creating multi-faceted projections of labor and skill demand; - The institutional setting in place for the forecasts, including regular repetition of forecasting exercises, allows tracking trends over time and incorporating lessons learned in later forecasting exercises to gradually improve their predictive value. In low income settings, replication may be most successful for occupations which are concentrated in a small number of sectors and firms (e.g., mining), since lower numbers of actors will lower the transaction costs of establishing sound coordination. - Features of this case study are (i) extensive use of literature review to generate forecasts; (ii) use of a quantitative model to complement findings from literature review (rather than the other way round); and (iii) reflection of results from different forecasting approaches alongside each other, rather than merging them into a single, consolidated forecast. - Replication of this approach requires the existence of a rather significant body of relevant and credible secondary literature. - Displaying different forecasting results alongside each other has the advantage that it highlights the uncertainty with which forecasts are surrounded and allows readers to draw their own conclusions from the available information. On the other hand, if discrepancies between forecasts are too substantial, it becomes too difficult to distill conclusions from them and may be a sign that the predictive value of one or more of the applied approaches is inadequate.</td>
</tr>
</tbody>
</table>
b) STEM field forecasts: Case Studies

1. Quantitative model – STEM skills in the United Kingdom

Methodology. This model, commissioned by a partnership of business, education and government stakeholders, projects quantitative demand for workers with graduate and post-graduate qualifications in STEM subjects, to provide insights on future mismatches between the demand and supply of skilled labor in STEM fields. The analysis uses an existing macroeconomic model and data, complemented with labor force survey data to allow forecasts specifically for workers with STEM qualifications.

Data generation and applications. Projections are for the period 2007-2017, and are disaggregated by the level of qualification (degree and post-degree), by discipline, and by broad economic sector. The analysis also includes an assessment of the extent to which projected changes in demand are due to changes in scale (i.e. the size of overall employment), sectoral composition of the economy, the occupational structure of employment, or the qualifications structure of employment. Examples of forecasting results are summarized in Box IV.1

Box IV.1: Examples of findings – STEM-qualified workers in the UK

- The share of graduate and post-graduate STEM workers of total employment is expected to increase from 11% in 2007 to 14 percent in 2014, due to both increased demand and supply.
- At the post-degree level, particular strong employment increases are expected for agricultural scientists (87%). The highest expected recruitment need in 2007-2017 is in degree-level medicine (1.0 mln), mathematical sciences and computing (0.6 mln) and biological sciences (0.6 mln).
- The number of degree and post-degree STEM workers in the business and other services sector is expected to grow by 44%, with high projected recruitment for degree and post-degree level mathematical and computing scientists (270,000 and 69,000 respectively), and degree-level biologists (146,000).
- The main driver of projected increased demand in STEM workers are increases in the share of STEM workers in sectors and occupations across the labor market. The impact of shifts in industry structure (e.g. strong growth in sectors which employ large shares of STEM workers) are generally small.

Observations for replication. An advantage of this study is its level of detail, which allows disaggregation by qualification level and discipline. Replication of this level of detail requires labor force data capturing worker characteristics at this level. Another strong point of this approach is that it includes a clear assessment of the causes of projected changes in employment and recruitment needs (i.e. replacement needs or effects of scale, industry, occupation, or qualification). Replication of this aspect of the approach

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22 Wilson, R. (2009). The Demand for STEM Graduates: Some Benchmark Projections. For the Council for Industries and Higher Education; Engineering Technology Board (ETB); Department of Innovation, Universities and Skills.
23 STEM disciplines are considered to include medicine, biological sciences, agricultural sciences, physical environmental sciences, mathematical sciences and computing, engineering, and technology.
requires a sufficiently sophisticated model design. (The model used in this case is a multi-sectoral macroeconomic model combining time-series econometrics with an input-output model.)

2. Quantitative model - SET workers in the United Kingdom

Methodology. The Royal Academy of Engineering produced a report in 2012 on the demand for Science, Engineering and Technology (SET) workers, with the aim to demonstrate the importance of SET workers for economic growth and the existence of quantitative shortages of SET workers in the UK economy. The applied approach is a quantitative model, based on a pre-existing multi-sectoral macro-economic model of the UK economy and the latest available data on the share of SET workers in each sector as share of total sectoral employment. The report also uses secondary labor force and economic output data to describe historic trends in employment outcomes of SET workers and growth patterns of those economic sectors in which SET workers are disproportionally employed.

Data generation and applications. The applied approach forecasts quantitative demand for technical and professional level SET workers, both economy-wide and disaggregated by broad economic sector, for the period 2010-2020. Examples of forecasting results are summarized in Box IV.2. The objective of the forecasting exercise is to highlight the importance of continuing and increased investments in producing SET-qualified workers in the future, due to their importance in key economic sectors and the expected growth in demand. While the forecast’s output is relatively generic (compared, for example, to the much more detailed results of the case study on STEM-qualified UK workers described above), the findings to serve the intended objective.

Box IV.2: Examples of findings – Forecasting demand for SET workers in the UK

- From 2010 to 2020, the forecasted expansion demand for SET workers is 180,000. Including replacement demand, total recruitment need for SET workers is estimated to be 1.28 million over this period, of which 830,000 SET professionals and 450,000 SET technicians.
- Sectors which employ a large share of SET workers which are expected to grow in terms of output and employment include the Construction and the Business Services sectors.
- Economic sectors with labor productivity and wages that above the national average, generally employ a relatively large proportion of workers in SET occupations.
- There is a wage premium for workers with STEM qualifications, especially for those employed in STEM occupations (10-14 percent).

Observations for replication

- As in several other case studies, this example highlights the benefits of an existing quantitative model which can serve as a basis for forecasts for segments of the labor market, such as SET workers.

• The case study demonstrates how the applied approach can be adapted to the forecast’s objectives. E.g., the approach to including SET-specific forecasts in the existing model seems rather simple (e.g. the share of SET workers per sector seems to be assumed constant). While this disregards ongoing trends, it reduces the time and costs required to produce results, and it does not harm the exercise’s objectives since its purpose is to illustrate broad trends rather than provide accurate projections.

• This case study illustrates the importance of ensuring credibility of forecasting results. There is a risk of perceived bias in the findings considering the goals of the party which commissioned the report (Royal Academy of Engineering) and those of the forecasting exercise itself. Similar actors wishing to ensure the perceived credibility of forecasts may therefore choose to conduct the exercise in partnership with other parties (e.g. academia or employers’ associations), and ensure transparency and replicability of the applied methodology.

3. Employer Survey – IT skills in the USA

Methodology. In 2012, the Computing Technology Industry Association (CompTIA) applied an online employer survey to identify existing and future shortages in IT skills.25 The survey was conducted over a six-week period and received responses from around 500 IT and business managers involved in managing IT or IT staff in the USA. The survey questionnaire included questions related to (i) context, i.e. the importance of technology for doing business and satisfaction with current IT staff skills; (ii) IT skill gaps, including on priority ‘hard’ (technical) and ‘soft’ (behavioral) IT skills, business areas most affected by skill gaps, and perceived causes of IT skill gaps; and (iii) addressing IT skill gaps, relating to mechanisms applied by firms to upgrade IT skills.

Data generation and applications. Examples of forecasting results are summarized in Box IV.3. The report does not produce quantitative forecasts of demand, but instead identifies priority areas within the IT sector and the type of IT skills for which skill gaps are (expected to become) most pressing. In terms of application, this allows interventions – by firms, educational institutions, or government – to be targeted to those IT skills which are the most serious bottlenecks to firms’ performance.

Box A3.3: Examples of findings – Forecasting demand for IT workers in the USA

- The priority concern on skill gaps among IT-firms relates to database/information management; for non-IT firms the priority concern is skills gaps on (cyber)security.
- About half the surveyed firms seek to improve hard (technical) and soft (behavioral) IT skills in equal measures; 34 percent focus mostly/only on hard skills, 19 percent mostly/only on soft skills.
- Employers rate work ethic, motivation and initiative, and customer service as priority soft IT skills.
- Firms of all sizes report reduced productivity as the main implications of IT skill gaps.

Observations for replication
Carrying out an employer survey online can significantly reduce the time and costs required for its execution. As with other employer surveys, data requirements to initiate the survey are limited to having sufficient firm data to identify a representative sample. Particularly in low and middle income contexts with large numbers of informal firms, this may however still not be an easy task. Even in this example for the USA, the report provides no information on sample representativeness, and it is thus unclear to what extent the survey result provide a reliable picture of demand across firms in the country. An interesting feature of the survey questionnaire is that a majority of questions relates to current skill needs and gaps. This is likely to improve the reliability of results, as respondents are more likely to accurately describe their current situation than project future developments. Even though answers to these questions do not constitute forecasts, they can be applied to guide skill development interventions. For example, the finding that micro firms particularly face financial constraints in their effort to upgrade skills can be included as justification for providing financial incentives for skills development interventions to firms of this size.

4. Combined – Technicians in the Netherlands

Methodology. The Dutch Association of Universities of Applied Sciences (“Vereniging Hogescholen”) commissioned, in 2013, a report to assess the alignment between labor and skill supply and demand focused on their graduates in technical disciplines. The applied methodology includes a graduate tracer study and a quantitative model. A distinguishing feature of the applied methodology is its institutional setting: following a long history of collaboration between the public sector, educational institutions, and industry, the data used for this study on technicians could be readily drawn from a well-established quantitative model and graduate tracer survey data which have been produced regularly since 1989 (for the model) and 1998 (for the tracer survey), for a variety of purposes, including nationwide and regional forecasts, with the possibility to provide disaggregations by sector and by educational disciplines and levels. The quantitative model incorporates data and projections on economic growth and labor market trends. The tracer study sample is based on graduates’ contact details provided by the participating educational institutions.

Data generation and applications. Box IV.4 below provides examples of findings from the applied approach. Whereas the model generates quantitative forecasts of labor demand, the tracer survey is used to produce data on past and current labor outcomes. It includes data on graduates’ perceptions of the importance of particular competencies on the job, as well as on the extent to which they feel that they meet these particular requirements.

27 Technical disciplines are defined to include laboratory technology; construction, civil, and mechanical engineering; information technology; chemical technology; and transport and logistics.
Box III.4: Examples of findings – Technicians in the Netherlands

- Labor market prospects until 2016 are forecasted to be ‘very good’ for laboratory technicians and chemical engineers, and ‘fair’ for construction engineers.
- From 1998 to 2010, unemployment rates of graduates from technical disciplines have consistently been below the unemployment rate of the total of graduates from universities in applied science.
- Based on graduate’s perceptions, skill demands on technicians are generally lower than skills demanded from non-technicians; this may be due to reduced employers’ expectations concerning technicians caused by their relative shortage on the labor market.
- When comparing skills acquired through education and those that are required on the job, the largest share of graduates (34%) mentions the ability to work within a budget or planning, followed by knowledge of their own discipline (33%). Relatively few graduates perceive shortages related to ‘productive collaboration with others’ (15%) and ‘learning new things’ (14%)

Observations for replication.

- The sound institutional setting of this case study implies that the analysis for the technicians can be produced in a limited time and at limited cost, since the necessary data can be easily distilled from existing sources. In contexts where the institutional settings of a forecasting mechanism is emerging, the development of such a system can be facilitated by promoting strong collaboration between stakeholders, and ensuring consistency and transparency between various forecasting exercises.
- This case study is the only one presented in this report which applies a graduate tracer study. As it requires the availability of graduates’ contact details, it is not easy to replicate in a data-scarce context. When considering applying this approach, it may be considered to start with building the capacity to trace graduates in a limited number of educational institutions, and gradually expand the number of schools which are thus able to provide the necessary data to conduct tracer surveys.

5. Combined – IT workers in India

Methodology. In India, the National Association of Software and Services Companies (NASSCOM) regularly conducts a variety of analyses to forecast quantitative and qualitative aspects of demand for IT workers. The various demand analyses are interlinked and vary in scope and depth. For example, a comprehensive talent demand-supply analysis including forecasts for the period 2013-2020 was conducted in 2013; in 2014, these findings were enriched through forecasts for the year 2015 using an approach of more limited scope.\(^\text{28}\) The comprehensive analysis of 2013 used a variety of sources and methodologies, combining primary data from an online employer survey, expert consultations, and a review of company websites, with secondary data from research of NASSCOM and third parties. Stakeholders consulted included industry representatives, academia, regulators, and government institutions. The smaller-scope forecast

for 2014 used data from an online employer survey for a small sample (100) of firms, which was conducted in May-June 2014.

Data generation and application. The applied methodology generates data on quantitative and qualitative demand, and allows disaggregation by geographic regions, industry sub-sector, business area, and firm size. The demand analyses are integrated with analyses on labor and skill supply, and applied to develop recommendations to improve supply-demand alignment as well as recruitment practices, with the overarching objective to ensure that sufficient and adequately skilled labor is available to support firm productivity and growth.

Box IV.5: Examples of findings – Forecasting demand for IT workers in India

- Depending on trends in labor productivity, sectoral employment is expected to increase by between 2.3 and 4.0 million persons in the period from 2013 to 2020.
- Until 2020, no major deficits in quantitative supply are expected. Qualitative shortages are expected to become increasingly pressing, especially related to generic skills and in highly-specialized occupations (such as e-commerce and data science) and in particular regions including Delhi and Tamil Nadu.
- Employers will increasingly seek to hire experienced workers rather than new labor entrants, considering increased demand high level specialized skills.
- For technical skills, employers place high and increased importance on skills related to platform engineering and migration to new technology. Among soft skills, employers attach high and increased importance to skills related to English language communication, project management, and leadership.

Observations for replication. This case study is an example of how a sound institutional setting allows the development of a systematic series of forecasts, the predictive value of which is gradually improved as results and lessons learned from individual forecasting exercise are incorporated in subsequent ones.29 The alternation of forecasts for a longer time period with shorter term projections provide a balanced and multi-faceted mix or results which provide relevant information for a variety of stakeholders and purposes. The elements of the approach that rely on literature review can only be replicated when sufficient relevant secondary documentation is available.

6. Combined – Engineers in New Zealand

Methodology. The New Zealand Department of Labor collaborated with engineering associations to analyze the labor market for engineering occupations, with the aim to assist planning within the

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29 For example, data from secondary sources is updated at least every two years, and employers are requested to respond to the employer survey at least every three years.
engineering profession. The applied approach relies heavily on review of secondary literature and data, complemented by a quantitative model and expert consultations. Literature reviewed includes publications from sector ministries and agencies such as the New Zealand Transport Agency and the Electricity Commission. The review, combined with the model, was used to project industry and employment trends. It identified the main drivers and generated a general economic outlook for six industries employing a large number of engineers. The model projects employment growth for engineering occupations for high, medium and low growth scenarios. Finally, stakeholder views were sought on the validity of the analysis and included in the report.

Data generation and applications. The approach produced projections on quantitative employment for the period 2008-2013, distinguishing various engineering professions and industries. Box IV.6 provides examples of the type of findings generated through the applied methodology.

Box IV.6: Examples of findings – Forecasting demand for engineering occupations in New Zealand

- Due to expected high expenditures in the transport and railway sector, the employment forecast for road and structural engineers in this sector is positive. In manufacturing, the weak international economic climate is expected to result in continued low growth, which translates into a negative employment outlook for, for example, mechanical and chemical engineers and technicians.
- Under a medium-growth scenario, annual average employment growth of engineering professionals is projected to be 3.6%, which is more than twice the projected growth for all occupations. Jobs for engineering technicians are expected to decline by 0.4 percent per year.
- Industry stakeholders disagree with the flat employment outlook for technicians. They suggest that the lower growth in employment is due to shortages in supply rather than demand.

Observations for replication. A benefit of combining a collection of secondary prognoses and analyses from various sources is that it cost- and time-efficient to generate forecasts, provided that a sufficiently body of relevant analyses exists. A drawback is that the various approaches are likely to differ in the methodology applied, so that it may be difficult to compare the various results. In this case, these differences and possible resulting contradictory forecasts need to be highlighted and explained in the analysis.

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