

Skills supply and demand in Europe: methodological framework

Not for dissemination

Foreword

The European labour market is lately challenged by mega-trends interacting with shocks. Demographic developments such as ageing and migration affect the structure of the labour force. Widespread ICT and shifting to sustainable growth impact on skill needs. The repercussions of global economic crisis are still to be overcome while austerity measures affect growth and employment.

Being aware of current and of future labour market developments, understanding its functioning and anticipating future supply and demand for skills is necessary to develop adequate policy responses.

Cedefop skills demand and supply forecast forms one of the pieces of the puzzle to understand and anticipate labour market needs. Forecast does not offer a crystal ball but it signals trends and flags up likely tensions, thus supporting the design of long term policy strategies.

Cedefop forecast does not intend to replace national or regional skills anticipation efforts. On the contrary, Cedefop is strongly supportive of Member States' anticipation activities and provide assistance and guidance to national experts.

Cedefop's forecasting results are the most visible outputs of the Centre's activities. But a substantial part of our effort goes into developing a robust and reliable methodology which is explained in detail in this publication. By giving detailed insight into Cedefop's forecasting method as well as into the latest accuracy tests, we hope not only to demonstrate the quality of our findings but also to receive input for further developments. At the same time this publication can inspire those who are about to start such exercise on national or regional level, or those who already possess similar tools but are searching for new ideas or possible improvements.

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1. Introduction

1.1. Background and rationale

Equipping the labour force with the right skills is one of the key policy focus of the European Union's strategy for smart, sustainable and inclusive growth. Skill needs anticipation has received increased attention in the EU as can be illustrated by several policy documents such as the *Integrated guidelines for growth and jobs* (2008-10) ⁽¹⁾, the Council resolution on *New Skills for New Jobs* ⁽²⁾, and the Spring 2008 Council conclusions ⁽³⁾, where EU Member States asked the European Commission to report on future skills requirements in Europe up to 2020. *New skills for new jobs: action now* (European Commission, 2010), a report prepared by an expert group set up by the European Commission, also emphasised the need for an overall coordinated approach to improve Europe's capacity to anticipate change. After a wide consultation among stakeholders, the Commission included the New Skills and Jobs agenda as flagship initiative in the EU 2020 strategy (European Commission, 2010b) ⁽⁴⁾.

It is in this context that Cedefop is engaged in regular, coherent and systematic skill demand and supply forecast. In 2008 the first pan-European skill needs forecast by Cedefop was released, i.e. employment projections by sectors, occupations and qualification levels across Europe until 2015. In 2009, Cedefop forecasted skills supply by gender, age groups and qualification levels. Finally, in 2010 the first parallel forecast of skills supply and demand up to 2020 was presented.

The methods to be used for forecasting are wide ranging. There is a necessity to test the accuracy of methods and to compare with any available alternatives to increase the quality of results. At the same time new data are published regularly by statistical authorities. Finally, forecasting is an ongoing exercise, affected by changing reality. This makes it necessary to rely on most up-to-date information and stresses the importance for reflecting trends and changes to achieving the most reliable results.

This publication presents the complex methodological framework used by Cedefop to forecast skills supply and demand as well as some current attempts for improvement. It does not intend to promote the Cedefop methodology as the one and only correct and available. It should also be emphasized that the Cedefop forecast does not intend to replace those conducted at the national level. Instead, it presents problems that we have faced and the solutions we have adopted to produce a unique pan-European skills supply and demand forecast.

⁽¹⁾ http://ec.europa.eu/growthandjobs/pdf/european-dimension-200712-annual-progress-report/200712-annual-report-integrated-guidelines_en.pdf

⁽²⁾ <http://ec.europa.eu/social/BlobServlet?mode=redirLinks&url=http://eur-lex.europa.eu/ChangeLang.do?lexlang=en&URL=/JOhtml.do?uri%3DOJ%3AC%3A2007%3A290%3ASOM%3ADE%3AHTML>

⁽³⁾ http://www.consilium.europa.eu/uedocs/cms_Data/docs/pressdata/en/ec/99410.pdf

⁽⁴⁾ <http://ec.europa.eu/eu2020/>

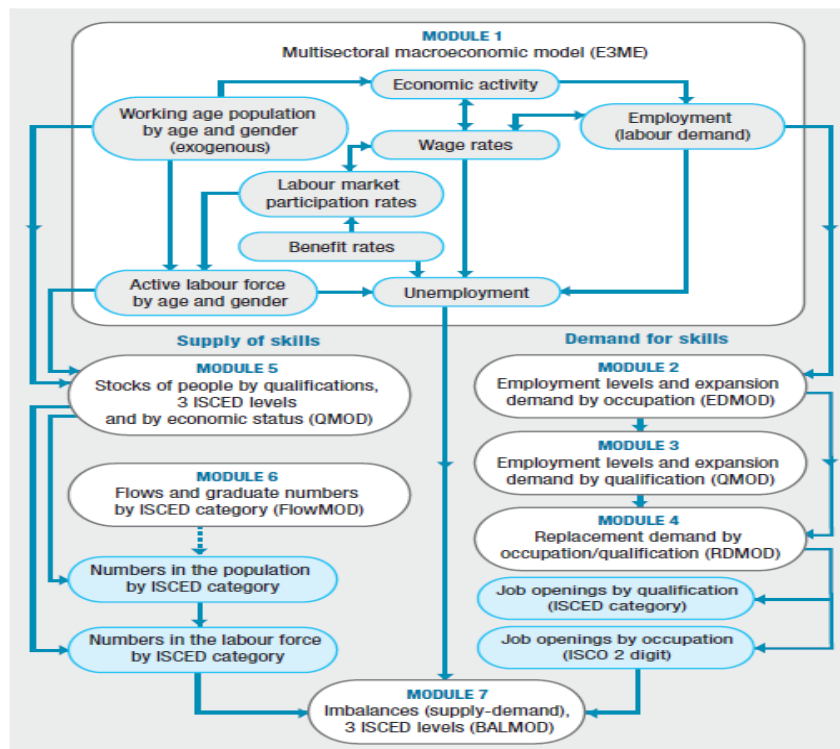
1.2. General overview of the methodological framework

Europe's pan European forecast of skill needs requires complex methods, relying on long term research and drawing on the expertise of several high level European research institutions. The modelling tools have been designed to enable further development and customisation. The general framework consists of methods developed in two pilot studies on *Future skills needs in Europe* (Cedefop, 2008) and *Future skill supply in Europe* (Cedefop, 2009). These were combined to produce the first pan European forecast of *Skills supply and demand in Europe* (Cedefop, 2010). As forecasting is a dynamic process, important developments took place in 2010. These have been made possible due to the modular approach adopted, which enables independent improvement of the different parts of the system. As shown in Figure 1, the model breaks down into the different building blocks and into a number of inter-related components.

Even though the modelling framework has proven to be rather robust, establishing a dialogue with experts from European countries who are likely to have much greater knowledge of employment trends and data sources within their own countries is necessary. The modelling framework provides an opportunity for expert's knowledge and input to be built in efficiently and transparently, as it makes it easy to incorporate new data and alternative or additional assumptions.

The project involved developing consistent databases and related tools to produce a comprehensive and consistent set of skill projections for all EU member countries plus Norway and Switzerland (EU-27⁺). The system, models and modules rely upon official data sources, drawing primarily on Eurostat sources, in particular on Eurostat demographic data, national accounts (NA), the European labour force survey (LFS), as well as additional data on flows of qualifications. Compilation and harmonisation of the best possible data available for measuring employment was a major achievement of the project. Historically, most countries have invested considerable resources in developing data for their NA. In many respects estimates of employment on this basis are to be preferred as they are consistent with other key economic indicators, such as output and productivity. On the other hand, the European LFS has the advantage of providing measures of employment structured by skills (occupation and qualification), as well as by gender and age, which are not available from NA-based estimates.

Figure 1: Interaction within the forecasting system



Source: Cedefop (2010)

1.2.1. Supply of skills

The projections of skill supply produce consistent pan-European projections broken down by age, gender and formal qualifications ⁽⁵⁾. The results indicate the future skill supply by highest qualification held as well as by age groups and gender for the population and labour force aged 15 and over. The projections of skill supply are compatible with the projections of skills demand (when focusing on qualifications).

The historical analysis and projections of overall labour supply by age and gender is provided by an extended version of the existing pan-European macroeconomic model E3ME developed by Cambridge econometrics ⁽⁶⁾, which incorporates a new demographic and labour-supply module. E3ME models labour supply as a function of economic activity, real wage rates, unemployment and other benefit rates. At present, the model parameters are estimated for labour market participation in each country by gender and separately for different age groups. This is of key importance for modelling educational participation and attainment since these are known to be gender and age specific. This expanded model framework is then used to create a detailed set of baseline projections for labour supply, disaggregated by country, age groups and gender and covering a 10-15 year period. This model forms a key input to the analysis

⁽⁵⁾ Skill supply is not measured by occupations as it is not possible to attribute people to different jobs after acquiring particular qualification: the occupational decisions of individuals vary significantly and cannot be predicted. Moreover, employment in occupations will change in the life course of individuals.

⁽⁶⁾ Detailed model description is available at:
http://www.camecon.com/suite_economic_models/e3me.htm.

of the supply of qualifications and provides the link between economic activity and labour market supply. Finally these links can be used to provide a range of projections of available skills through scenario-based analysis formed around the baseline forecast, indicating areas that are most sensitive to the economic climate and change.

The modelling and forecasting of the supply of qualifications ideally requires a detailed and comprehensive stock-flow model, with behavioural links which can be used to predict the distribution of people in the total population and labour force (employed and unemployed people) by highest qualification held ⁽⁷⁾. In practice, this ideal is hard to realise, as a detailed demographic or educational and labour market accounting system is still lacking at EU level.

The methods currently used for modelling forecasts are less ambitious. They range from rather simple models, based on fitting trends of aggregate qualification patterns amongst the population and/or labour force, to more sophisticated approaches based on econometric analysis of micro data on individuals, mainly using LFS data. All focus upon overall stocks rather than flows.

1.2.2. Demand for skills

The demand side involves four main elements or modules. Each module contains its own database and models. The results focus on future demand trends at a pan-European level (EU-27⁺); by sector (up to 41 industries based on NACE classification); by occupation (up to 27 occupations based on ISCO classification); by qualification (three broad levels based on ISCED classification); plus replacement demands by occupation and qualification. Together these produce estimates of the numbers of job openings (net employment change plus replacement demand) by skills (as measured by occupation and by qualification). Detailed classifications and aggregations used are provided in Annex II.

The forecast of employment by economic sectors is provided by a module which is based on results from the existing pan-European multi-sectoral macroeconomic model (E3ME). This model delivers a set of consistent sectoral employment projections, which are transparent in terms of the assumptions made about the main external influences on the various countries (including technological change and the impact of global competition).

E3ME combines the features of an annual short- and medium-term sectoral model, estimated by formal econometric methods, with the detail and some of the methods of the computable general equilibrium (CGE) models that provide analysis of the movement of the long-term outcomes. It can be used also for dynamic policy simulation and for forecasting and projecting over the medium- and long term.

The LFS conducted in all countries provides a source of information for the construction of occupation-industry matrices of employment. These surveys have the advantage of being regularly conducted. They also adopt standardised sets of questions and systems of classification. While there are still some differences across countries, LFS provide a broadly consistent set of data which can be used for producing occupational employment projections within the industries identified in

⁽⁷⁾ This kind of model is used in many national projections of skill supply, see for example Wilson and Bosworth (2006) for the UK.

macroeconomic models such as E3ME. The forecasting module designed to calculate changes in employment (expansion demand) by occupations (EDMOD) based on these data works out the implications for occupational employment.

Occupational employment patterns are only one way of measuring skills. An occupational category can be understood as broadly describing a particular job (related tasks, requirements, position etc.). Qualifications represent the characteristics of people filling these jobs as well as one of the selection criteria when filling a particular job. From the education and training policy and planning point of view, the types of qualifications typically required are very important. Even with only weak data for (formal) qualifications, it has been possible to develop the module (QMOD) which allows inferences to be made about implications for qualifications.

In addition to changes in overall occupational employment levels it is important to consider replacement demand arising from outflows out of a job/occupation, such as retirements/deaths, transition to non-employment, net migration, and inter-occupational mobility. Estimating replacement demand is not straightforward and is quite sensitive to the data sources used. Ideally, detailed data on labour market outflows and transitions (mainly retirements and occupational mobility) would be required to analyse replacement demand more accurately. However, these are not currently available and therefore this forecast relies on a methodology that is based on stocks of age-cohorts by occupations and qualifications, and excludes transitions from one occupation to another.

From the LFS, it is possible to analyse the demographic composition of each occupation. This makes it possible to estimate specific rates of retirement for each occupational class (but still not taking account of inter-occupational mobility). LFS data can also be used for making estimates of rates of outflow. The replacement demand model (RDMOD) has been developed based on similar data sources to the occupational model (EDMOD). It is driven in part by the occupational and qualification employment levels projected from EDMOD and QMOD, in combination with models and information on the probability of leaving employment due to retirements, migration and other reasons (e.g. transition to inactivity).

1.2.3. Comparing skill supply and demand

To provide information on possible labour market imbalances and skill mismatches a further module (BALMOD) has been added. This module confronts the skill demand and skill supply projections (focussing on qualifications) and attempts to reconcile the two.

The possibility to analyse potential skill imbalances in the labour market is a very important matter from a policy and individual perspective. Such information can, in conjunction with corresponding demand estimates, shed light on possible future developments in European labour markets, highlighting potential mismatches and thus help inform decisions on investments in skills (especially in formal qualifications) made by individuals, organisations and policy-makers.

However, simply comparing current demand and supply projections is problematic for both practical and theoretical reasons. Although the two sets of results are based on common data and are carried out simultaneously, they do not incorporate direct interactions between supply and demand and therefore cannot be directly compared.

Cedefop has started to work on modelling interactions between supply and demand, but due to its complexity it might be incorporated only in the medium- to longer-term. There are various other conceptual and methodological issues regarding imbalances that need to be considered to avoid misleading inferences and interpretations.

A final adjustment has been made to the estimates of employment by qualification (demand side) to take into account the labour market accounts residual. This residual measures the difference between employment as measured for the NA estimates (workplace based, jobs) and the corresponding LFS estimates (heads, residence based). Both measures are used in the project ⁽⁸⁾. The difference between the NA and LFS can be quite significant and needs to be taken into account, especially when comparing demand and supply.

Differences between skill demand and supply can include:

- double jobbing (some people have more than one job) or one full-time job is shared by two or more people;
- distinction between residence and workplace (many people do not live in the same country as they work; this is especially significant for some small countries such as Luxembourg);
- participants in training and related schemes who are also working in parallel (they may be included in the labour force as well as in education statistics – double counting);
- different definitions of unemployment (e.g., ILO definition versus restriction to unemployment beneficiaries);
- statistical errors (in measures of employment, unemployment and related indicators, including sampling and measurements errors);
- other differences caused by the use of different data sources such as treatment of nationals working abroad.

1.3. Structure of the publication

This publication presents a compilation of background technical reports which were submitted to Cedefop as part of the research project *Skills needs and supply in Europe*. The main aim is to provide an outlook on the methodology rather than presenting the results. Therefore results are not provided systematically and all results which will be eventually presented are only of illustrative character and may differ from the actual forecasting results. More detailed information is available at the list of references or by visiting the Skillsnet members' area on the Cedefop web portal ⁽⁹⁾.

The second section of this publication presents the construction of the database used in the Cedefop model. High quality of data which are consistent over time and comparable across countries are a vital prerequisite for such a modelling exercise and for provision of reliable and relevant results. Section 3 gives a detailed overview of

⁽⁸⁾ For a detailed discussion see Kriechel and Wilson (2010) and Livanos and Wilson (2007a).

⁽⁹⁾ <http://www.cedefop.europa.eu/EN/about-cedefop/projects/forecasting-skill-demand-and-supply/membership.aspx>.

the key features and extensions of the underlying macroeconomic model (E3ME). Section 4 describes the key elements of the labour supply models and attempts to move closer to the stock-flow model. Labour demand is considered in two dimensions in Cedefop's methodology. The modelling of net changes in employment, so called *expansion demand*, is described in Section 5. The demand for labour created by the outflow of workers from their occupations for various reasons, *replacement demand*, is the scope of Section 6. Even though the skills supply and skills demand modules are developed under the same general framework, the comparison between these two sides of the labour market is not straightforward. Section 7 is hence dedicated to the description of how to reconcile the supply and demand as well as the imbalances indicators developed within the project. The final two parts of the publication focus on the evaluation of the previous pilot forecasts. Section 8 is focussed on the quantitative assessment of the accuracy of the forecasts. Section 9 is dedicated to the quality of the forecast based on stakeholders' satisfaction. The conclusions in Section 10 summarize all important findings from each section and outline the next steps.

2. Historical data foundation

A coherent and consistent database containing historical time series is an essential prerequisite for forecasting skill supply and demand. Without data that are consistent over time and reasonably comparable across countries, the forecasts generated, irrespective of the sophistication of the model and plausibility of the assumptions adopted, will have a little practical relevance.

At the start of skills supply and demand forecasts at European level, a consistent database comprising the key statistics used as a sound basis for the development of the model. Currently was developed. Current work is focused on dealing with various data issues as well as exploring further detailed breakdowns by occupational and educational categories.

The general issue with labour market data concerns the sample size, missing observations and small numbers in particular cells, for both the demand and supply side of the labour market capturing the main job characteristics as well as the relevant characteristics of working age population. Another important issue concerns the implementation of (regular) revisions and updates of international classifications experienced during the process of the methodology development. We appreciate the valuable support from Eurostat, who provided us with additional information necessary to successfully deal with such issues.

This section is based on working papers by Stehrer, Ward (2010) and Stehrer, Ward (2011). It describes the key adjustments made to construct the improved general database. A key question is which methodological data set is the best to use. The Labour Force Survey (LFS) provides more detailed data that is better tailored to the needs of Cedefop's exercise while National Accounts (NA) data are more suitable for general economic modelling. This issue is tackled in Section 2.1. The development of a consistent database for cross country analysis is discussed in Section 2.2. The adjustments of demand and supply data are the focus of Section 2.3. The cross-country heterogeneity in education and even classification systems makes the production of a harmonised database even more complicated. This is illustrated in Sections 2.4 and 2.5 which analyse the differences by education levels and fields of study in the most common occupations across countries.

2.1. Labour force surveys versus national accounts estimates: strengths and weaknesses

The Labour Force Surveys (LFS) conducted across the EU provide an invaluable source of information on employment broken down by industry and occupation. They have the advantage of being conducted on a much more frequent basis than a typical census. They also adopt much more standardised sets of questions and systems of classification. While there are still some differences across countries, this source provides a broadly consistent set of data across Europe which can be used for producing occupational employment projections within the industries identified in macroeconomic models.

However, as described in more detail in Livanos and Wilson (2007a), the LFS is not without its faults. In many respects estimates of employment based on national accounts (NA) are more robust and more compatible with other economic indicators. Estimates of employment in NA may differ from the results found from other statistics and surveys, in particular the LFS. These differences arise mainly due to the integration of other sources and due to conceptual reasons.

Specifically, national accounts integrate information from many sources. All sources available (including LFS) are assessed and, subsequently, the best way of integrating them is decided. Each source may shed light on a different part of the economy. Some countries make minor use of LFS in national accounts. The information is combined to provide the most complete and consistent estimate. As a consequence, each individual basic source may provide results that are different from the integrated NA estimates. In NA, employment figures must be consistent with other variables such as output and compensation of employees (i.e. wages, salaries and social contributions).

The European system of accounts (ESA95) acknowledges two employment concepts depending on the geographical coverage: resident persons in employment (i.e. the so-called national concept of employment) and employment in resident production units irrespective of the place of residence of the employed person (i.e. domestic concept). The difference between them corresponds mainly to the net number of cross-border workers. The domestic concept is more appropriate when examining employment and gross domestic product together. LFS, on the other hand, covers resident households. Hence, the LFS gives information on a major subset of the national concept. This means that:

- LFS data must be adjusted, mainly for cross-border workers, to align with the domestic concept normally used in national accounts;
- coverage differences: LFS does not cover persons living in institutional or collective households (e.g. conscripts), unpaid apprentices and trainees and/or persons on extended parental leave. They are all covered by ESA95 employment. Appropriate adjustments are therefore needed;
- recording thresholds: LFS results exclude persons below 15 years old from the definition of employment (in some countries the exclusion boundaries are below 16 years old and/or above 75 years old). National accounts do not exclude individuals from employment because of age. The difference is small in developed economies.

The size of these conceptual adjustments is modest, with the possible exception of conscripts, and cross-border workers for small countries.

The LFS data from Eurostat are sample data. For many countries the time series are short and the number of respondents within a particular cell is often low. This means that the estimates of occupational structure within sectors are not always precise or robust. These problems are even more serious when it comes to making estimates of replacement demand, which asks even more from the data. Nevertheless, LFS data are often the only data available for breaking down employment by specific sub-groups of the population. Moreover it has become well established in the analytical and political discourse (e.g., European benchmarks and indicators), so that survey results are becoming more familiar in general public than those based on the national accounts.

2.2. Developing a consistent database for cross-country comparisons

There are two major issues with the LFS series as a source of detailed employment and labour supply characteristics. These issues are important in the process of building a consistent database comparable across countries.

The first issue derives from the sample nature of the data and the fact that the people surveyed are both relatively small in number and subject to changes in terms of their characteristics between one year and the next. In other words, the survey data are only approximately representative of the population as a whole when dealing with certain level of details (sector, occupation, education). At the same time the degree of 'sample variability' varies between countries. It means that at the very detailed level which is required for detailed analysis, there are likely to be inevitable variations in the employment recorded in the smaller-sized occupations and sectors, especially in the less populated countries where the relatively limited size of the sample is most problematic.

The second issue derives from changes in the method of collecting data, and in the sampling frame in particular, but also in the systems of classification used and the way data are collected on the basis of a national classification system which is mapped onto the EU one. The latter applies especially to the occupation data, where many countries have their own traditional system which continues to be used.

The problem with sample nature is difficult to overcome because the discontinuities in the data series which result are an inherent feature of the LFS data and are, therefore, undocumented. To deal with changes in method is in principle easier to deal with because in many cases it is documented. However this does not make it any easier to find viable solutions to build a consistent series. Arriving at a consistent database that allows for easy cross-country comparisons of detailed employment structures, or at least one which is disturbed by a minimum amount of statistical noise, is a challenging procedure.

One more source of discontinuity in data series is even more problematic to deal with. This refers to the changes that occur in the classification of jobs because of changes in their nature over time. Many jobs tend to involve a changing mix of tasks as technological advance and changes in the organisation of work alter the nature of the production process. A job that, therefore, required a certain combination of skills in the past may, accordingly, require a different combination in the present. The difference in some cases is so great that it can alter the appropriate classification of a job within the ISCO system⁽¹⁰⁾. These types of change tend to happen gradually over time rather than all at once, and tend to come to light only in the course of periodic reviews of the classification system. In some cases, the changes in question are universal and affect all countries, as in the case of the revision of ISCO (from ISCO 88 to ISCO 08). This has principally involved a shift of a few occupations from one category to another because of the change in skill-set requirements. In other cases,

⁽¹⁰⁾ For example newly introduced ISCO 08 introduced new category of occupation 3122 Manufacturing supervisors within broad category 3 – Technicians and associate professionals. The workers classified within this group were in ISCO 88 categorised in category 8 – Plant and Machine operators and assemblers with no difference.

they are specific to a particular country and reflect the difficulties of classifying many jobs which potentially could be included in different parts of ISCO. In these latter cases, there tends not to be a uniform classification and, accordingly, certain occupations are liable to be shifted from one category to another in some countries as particular aspects of the job become more or less important. Whether they affect one country or many, the common characteristic of such changes is that the jobs in question, and the people performing them, are suddenly shifted from one category to another, or more typically, from one category to several others, making any adjustments problematic.

The difficulty is compounded by the fact that the same type of change does not necessarily occur at the same time across countries, because of differences in both the pace of technological advance and in the nature of jobs between countries. The position of the country in the international division of labour (or in the activities in which the country tends to specialise) implies further that not only does the mix of tasks involved in a particular sector differ across countries, but that the tasks associated with a particular job within the sector differ as well. Moreover, areas of specialisation are not static but change over time, though not necessarily at the same pace, or even in the same direction, across countries. To complicate things further, changes in occupational classification systems are not harmonised across Europe, except when Eurostat decides to initiate a common change in ISCO. Since many countries have their own national systems of classification, changes in these can happen at any time, which are then reflected in the mapping to ISCO.

This can be applied for practical purposes in a uniform way across countries, irrespective of the underlying cause of the discontinuity. Given the sheer volume of the data which need to be harmonised, such a general approach is the only viable one. Moreover, even if one wanted to distinguish between different causes of discontinuities, in order to apply different methods of adjustment to them, the information is simply not available for him to be able to do so.

2.3. Approach to adjusting the data

Intensive demands are put on the database which needs to be constructed for the modelling. It requires a level of detail which cannot be readily provided in a coherent way. A significant amount of adjustment of the basic data received from Eurostat is therefore required. The difficulty arises mainly from the number of indicators to be combined. The data quality is not confined to one or even two series. Instead, the data assembled need to be made simultaneously comparable across countries and over time as well as to be internally consistent. Detailed breakdown of occupational and educational categories for each country also required additional work.

Combining the data for different years in this way is possible with the LFS since the people surveyed in each year are largely different. In some cases we can face certain degree of overlap because in order to increase the consistency of the quarterly data, a small proportion of the sample surveyed remains the same between quarters. Even though these individual observations can therefore be treated as independent of each other.

The first step of this process was to develop a consistent raw dataset that accounted for the dimensions to be included in the demand and supply-side models. This allowed for a flexible use of the data at later stages of the project (including adjustments to the data). As emphasised below, there is no unique way to deal with methodological breaks over time and methodological differences across countries in the series, in a manner that guarantees consistency. Though the time dimension is less relevant due to the fact that the approach focuses only on a few and more recent number of years (for which fewer breaks occurred), there is still the problem of having inconsistent and incomparable detailed data across countries.

To obtain data from the real microdata of the EU LFS ⁽¹¹⁾ in such detail required a particular extraction procedure by statisticians in Eurostat covering the dimensions needed. Apart from a negotiation process and agreement to the actual extraction itself, the data obtained had to be processed and analysed in an appropriate way. The historical data were, therefore, first collected for each year from 1995 to 2008 offer annual averages of the quarterly data ⁽¹²⁾.

The data extracted covered:

- the demand for labour by gender, by broad age group and by educational attainment level (based on ISCED-97). It could also be divided by ISCO-88 3-digit occupational group, and by NACE, Rev 1, 2-digit sector of activity together with the field of study;
- the potential supply of labour, defined as the population of working-age (i.e. those aged 15 and over), by employment status, by broad educational attainment level (based on ISCED-97), and by ISCO 3-digit (for those in employment) for each year for those aged 15-69 and those aged 70+.

2.3.1. Labour demand data

The necessary historical data, as noted above, were extracted from the European Labour Force Survey (LFS) and came from the full micro-dataset maintained by Eurostat. These cover the current EU27 Member States plus Norway and Switzerland. As far as employment is concerned (i.e. the data to be used as the basis for projecting the demand for labour), the data relate to each year between 1995 and 2008 for which LFS data are available, and cover (not including missing categories)

- 60 sectors (NACE Rev 1 2-digit),
- 149 occupations (ISCO 3-digit),
- 7 educational categories (ISCED categories 0-1, 2, 3 short, 3 other, 4, 5 and 6),
- age groups (15-54, 55-64, 65-69, 70+),
- gender variables.

In addition, the variable ‘field of study’ includes 15 categories listed in Annex II Table V.

⁽¹¹⁾ The microdata delivered by Member States containing all of the detail included in the survey, as opposed to the published version in which many dimensions are included only in aggregated form.

⁽¹²⁾ Annual averages were collected from 2002 onwards when the quarterly series began, since before the data was collected in the second quarter of each year.

Potentially, therefore, the data consist of 500,640 cells per country per year (not considering the variable ‘Field of study’ which is treated separately) ⁽¹³⁾. For efficient further use, the original dataset was split into one file for each country, together with a harmonisation of codes and variable names. The data were also organized such that the resulting country files included the whole set of potential cells with respect to the characteristics described above (i.e. the above mentioned 500,640 cells per year per country). This enables a better comparison to be made across countries and over time as well as facilitating further processing. For the analysis place in 2011, the data have been restricted to include years starting from 2004 onwards.

The next step was to take account of missing information with respect to some categories (e.g. educational attainment, occupation) because of non-response. These observations are referred to as ‘randomly missing’ information. In these cases, the number of persons with ‘No response’ were allocated pro rata on the basis of the distribution of the missing information over other dimensions. For example, when the information on educational attainment was not available for a particular employed individual, this was imputed according to the educational structure within other dimensions, such as industry (NACE 2-digit), occupation, age group and sex. Some other problems occurred for earlier years. For example, for occupation categories there was a further problem since for some countries and for some years (especially earlier ones) only the 1-digit information level was provided and information on some dimension was missing at all. However, these problems are no longer present in the data from the time period 2004-08 ⁽¹⁴⁾.

There are a number of further data problems that needed to be tackled. First, the small sample size of the EU LFS (see Table 1) raises issues of data reliability, in particular for cells with low numbers of people employed. This becomes more problematic as one considers further detailed breakdowns.

Table 1: *Sample size of EU LFS, 2007*

	Avg. Number per quarter	% Population 15-74		Avg. Number per quarter	% Population 15-74
BE	22100	0.3	LU	4000	1.1
BG	26000	0.4	HU	60100	0.8
CZ	49300	0.6	MT	5600	1.8
DK	20700	0.5	NL	83400	0.7
DE	131300	0.2	AT	37900	0.6
EE	4800	0.5	PL	40000	0.1
IE	59100	1.8	PT	33100	0.4
EL	56100	0.7	RO	49900	0.3
ES	126300	0.4	SI	13900	0.9
FR	63900	0.1	SK	21900	0.5
IT	127200	0.3	FI	34400	0.9
CY	7300	1.3	SE	51300	0.8
LV	7500	0.4	UK	86900	0.2
LT	12400	0.5	CH	43400	0.8

Source: EU LFS

⁽¹³⁾ In practice the number is even larger when also including the ‘No answer’ category and additional NACE categories for some countries (e.g. NACE 97 and NACE99).

⁽¹⁴⁾ The data are made available to other participants in the study in the form of Excel files with dimensions broken down by NACE 2-digit, occupation, education, sex and age.

Secondly, as noted above, there are documented breaks in the series raising the issue of comparability over time and, apart from these documented breaks, there are also a number of other breaks which become only visible when examining the data in some detail. This was documented in Stehrer and Ward (2009) in detail.

In addition, there is a problem of missing numbers for particular observations. In many cases a cell (meaning a cross combination of NACE industry, education, occupation, age and sex) is reported for only one year over the whole period considered.

It should be reiterated that there is no clear solution to the discontinuities since there are no data present to provide a link. Only in very few cases is it possible to detect offsetting shifts of a particularly large change in one dimension – in particular, a large increase in a particular ISCO 2-digit occupation group might coincide with a large decrease in another. However, in most cases such offsetting shifts tend to be spread across sectors or occupations and in some cases both sectors, occupations and educational attainment levels are affected. An adjustment for pair-wise shifts might, therefore, work in some cases but cannot be a general strategy.

As previously shown, in the case of occupation data the incidence of discontinuities and, therefore, the need for adjustment, was particularly high, reflecting the difficulty of determining the appropriate ISCO category to which to classify particular jobs⁽¹⁵⁾. Moreover, the nature of jobs tends to change over time, so adding to the chances of discontinuities in the series. As in the case of other dimensions, the extent of discontinuities in the occupation series varies markedly across countries. In some, it is a relatively minor problem, while in others it is a major flaw affecting a significant share of total employment. However, most or all of the breaks occurred prior to 2004 (the year in which this analysis starts), so this problem is less relevant. However, a relatively wide scope still exists for differences in classification across countries, which is hard to deal with.

2.3.2. Labour supply data

The historical data for this task have been extracted from the same source as the data for demand and cover the same countries for the same years. The data cover the following dimensions:

- employment status (employed, unemployed, inactive);
- 149 occupations (ISCO 3-digit) for the employment status ‘employed’;
- 7 educational categories (ISCED categories 0-1, 2, 3 short, 3 other, 4, 5 and 6);
- 56 age groups (55 individual years of age 15-69 and 70+);
- gender variables.

The age groups have been combined into 5-year age cohorts 15-19, 20-24, ..., 65-69, 70+) resulting in twelve groups. This gives 25032 potential cells per country per year

⁽¹⁵⁾ The combinations used for demand were those of NACE – ISCO – EDU (4 categories) – AGE – SEX and in the case of labour supply the combinations used were (ISCO – EDU – AGE – SEX and EDU – AGE – SEX).

for those employed and 168 potential cells for those unemployed and inactive. Data have been processed and adjustments made for non-responses as described above.

An important exercise is to examine the provision of more details with respect to educational and occupational categories (from ISCO 2-digit to ISCO 3-digit). To get reliable estimates of the respective shares of the combinations considered ⁽¹⁶⁾ information only for the years 2004-08 was used. As mentioned above, these waves seem to be more reliable as the methodological breaks are limited. The average of employed persons over these years was calculated for each combination. A question arises whether missing values in particular years for observations with positive values in other years should be treated as missing or as zero values.

Another strategy would give less weight to irregularly observed cells (as means are calculated including the zero values) though maintaining the overall average; it would give more weight to those irregularly observed cells but would result in an increase in the average overall number of persons employed. Further it would be more consistent with the approach taken for the adjustments over time. Calculations are done for both cases; the results reported below are based on the first strategy (differences have still to be checked in detail).

2.4. Variations in the education level of occupations between countries

The current information on the qualification level on both demand and supply sides of the labour market is restricted to three broad level of formal qualification. There is justified demand from the stakeholders for more detailed information on educational level and fields of study across occupation. As it was mentioned before the key precondition of such exercise is to have appropriate data which are consistent across countries and within time. As we are facing the similar problems as already mentioned initial analysis which assess feasibility of finding some general pattern which could help to have the data in the required form.

The nature of the variations in the education level of those performing particular jobs is illustrated by considering the differences between specific countries and how far they are related to the supply of people of working age with particular educational qualifications. Five ISCO 3-digit occupations in which a significant number of people are employed in all countries and 6 Member States with different features and different levels of economic development are selected here for illustrative purposes. The five occupations are Managers of small businesses (ISCO 131), Business professionals (ISCO 241), Administrative associate professionals (ISCO 343), Building frame and related trades workers (ISCO 712) and Motor vehicle drivers (ISCO 832). The 6 countries are Germany, Spain, Italy, the UK, the Czech Republic and Bulgaria.

First, however, it is instructive to examine the relative number of people of working age (15-64) with different levels of educational attainment, defining this in terms of

⁽¹⁶⁾ The combinations used for demand were those of NACE – ISCO – EDU (4 categories) – AGE – SEX and in the case of labour supply the combinations used were (ISCO – EDU – AGE – SEX and EDU – AGE – SEX).

the main ISCED categories, which indicates in broad terms the potential work force from which employers can draw from ⁽¹⁷⁾.

It should be noted that by taking the 15-64 age group, we are including people who are still in the process of completing their education and initial vocational training even though they may be in work. Their inclusion, it should be noted, may give a misleading impression of the education levels which are required to perform a particular job, in that some of the workers included will be recorded, for example, as having only basic schooling whereas in practice they are in the process of completing an upper secondary level training programme which they need to do in order to acquire the necessary skills and competences. The same may apply to some of those with upper secondary education who are in the process of undertaking a tertiary-level programme. This may again be required as a means of acquiring the skills needed for the job.

The implication of this is that there is a need to be able to distinguish young people in the employment dataset who might be in this position, though at present it is not possible to do so. (In the dataset at present, the focus is on distinguishing the older members of the work force in employment). A more disaggregated dataset will, therefore, be requested from Eurostat to enable this aspect to be taken into account in future analyses.

2.4.1. Working-age population by detailed level of education

The potential work force differs markedly across the 6 countries in terms of the relative numbers with different education levels. In particular, the proportion of those with no qualifications beyond only basic schooling (ISCED 1, 2 and 3c) varies from close to 50% in Italy to around 30% in the UK and Bulgaria to under 10% in the Czech Republic. Equally, the proportion with tertiary qualifications varies from around 27-29% in Spain and the UK (countries in which the relative number of people with only basic schooling is also relatively large, indicating a strongly diversified work force) to only 13% in the Czech Republic and 11% in Italy (countries with very different numbers of low educated individuals).

Table 2: Working age population (15-64) by educational attainment, in %

	BG	CZ	DE	ES	IT	UK	EU-27
1	5.4	0.8	5.9	19.5	14.2	0.3	9.5
2	24.8	9.1	17.5	26.2	34.2	14.8	21.3
3c	0.0	0.0	0.0	0.5	0.5	13.8	1.7
3o	51.4	75.0	49.4	24.4	39.0	43.7	44.2
4	0.6	1.8	6.3	0.2	1.1	0.1	2.7
5	17.5	12.8	19.7	28.5	10.8	26.4	19.8
6	0.3	0.5	1.2	0.7	0.1	0.9	0.7

Source: Stehrer, Ward (2011)

⁽¹⁷⁾ It is arguable that a wider definition of the work force than the one conventionally used, namely the employed plus the unemployed, is more meaningful, since a significant number of those labelled as inactive tend in practice to be ready to take up employment if work is available. This explains why those previously recorded as inactive and unemployed take up the additional jobs created when employment grows. It also explains why the number of self-reported unemployed individuals tends to be markedly larger in some cases than the number recorded as unemployed according to the standard ILO definition – i.e. available for work and actively seeking work.

Accordingly, the proportion of the working-age population with upper secondary education, which in practice predominantly means those who have successfully completed a training programme of at least three years for a particular vocation, is particularly large in the Czech Republic (almost 80%) and especially small in Spain (only around 25%). The figure in the other countries ranges from around 55% in Germany to slightly less in Bulgaria, 40% in Italy and slightly more in the UK.

2.4.2. Detailed education levels within selected occupations

Small business managers (ISCO 131) have on average a relatively high level of education. The proportion with tertiary education is above the EU average in Spain and the UK (23-24%), where a relatively large number of people of working-age have this level of education. However, it is much larger than average in Bulgaria (39%) where the share of the working-age population with tertiary education is below average. It is also larger than average in the Czech Republic (28%) where the share of the working-age population with this education level is even smaller. Moreover, in both countries almost all of those employed in this occupation who do not have tertiary education have upper secondary qualifications. This contrasts with Italy and Spain, where around half only have basic schooling. Italy stands out with only a small proportion (6%) of those employed as small business managers who have tertiary education, which is in line with the small proportion of working-age population with such qualifications.

Indeed, it is evident that there is a relatively strong correlation across these 6 countries between the educational breakdown of those employed as small business managers and that of the working-age population. Much the same applies across all EU countries.

Table 3: Educational levels of occupations

Occupation	ISCO	BG	CZ	DE	ES	IT	UK	EU-27
Small business managers (131)	1	0.2	0.0	2.0	20.6	8.6	0.2	10.0
	2	3.0	1.5	12.8	31.3	37.5	12.3	20.3
	3c	0.0	0.0	0.0	0.2	0.3	14.0	2.0
	3o	56.7	68.1	58.1	25.2	47.1	49.1	45.0
	4	0.7	1.6	8.5	0.1	0.7	0.1	2.7
	5	39.1	28.4	18.2	22.5	5.7	23.8	19.8
Business professionals (141)	6	0.3	0.4	0.5	0.1	0.0	0.5	0.3
	1	0.0	0.0	0.3	0.0	0.4	0.3	0.3
	2	0.1	0.3	3.4	0.0	3.4	0.8	2.0
	3c	0.0	0.0	0.0	0.2	0.0	4.4	0.8
	3o	13.4	50.9	24.7	1.1	41.6	28.3	23.1
	4	0.2	2.5	10.4	0.0	1.0	0.1	3.8
Administrative associate professionals (343)	5	86.3	45.9	59.1	96.9	53.3	65.8	68.6
	c6	0.0	0.4	3.2	1.8	0.3	1.1	1.4
	1	0.0	0.0	0.1	1.4	0.3	1.1	0.5
	2	0.5	0.6	6.6	8.6	7.4	1.1	6.2
	3c	0.0	0.0	0.0	0.3	0.2	8.5	0.3
	3o	65.1	81.3	60.0	33.3	75.7	39.8	55.6
	4	2.0	3.1	15.4	0.1	2.5	0.5	6.8
	5	32.2	14.8	19.4	56.0	13.7	48.2	30.4
	6	0.1	0.2	0.3	0.2	0.0	0.8	0.2

	1	2.6	0.0	2.7	31.0	24.0	0.1	17.7
	2	33.5	5.0	13.9	44.8	56.1	12.7	27.7
Building frame	3c	0.0	0.0	0.0	0.2	0.2	11.0	1.4
and related trades	3o	62.0	94.6	68.8	16.5	18.8	69.4	47.0
workers (712)	4	0.6	0.1	1.8	0.1	0.1	0.0	1.3
	5	1.4	0.2	11.3	7.3	0.8	6.6	4.7
	6	0.0	0.0	0.0	0.1	0.0	0.1	0.0
	1	0.2	0.0	1.9	22.2	12.6	0.2	9.7
	2	14.4	6.6	17.9	46.0	58.9	18.7	26.6
Motor vehicle	3c	0.0	0.0	0.0	0.2	0.5	18.6	2.7
drivers (832).	3o	81.9	92.6	73.9	23.5	27.0	57.4	55.6
	4	0.3	0.2	2.6	0.1	0.4	0.1	1.5
	5	3.3	0.6	5.2	8.0	0.7	4.7	3.9
	6	0.0	0.0	0.1	0.0	0.0	0.1	0.0

Source: Stehrer, Ward (2011)

Business professionals (ISCO 241) have a much higher level of education than small business managers. As with the latter, however, there is some variation between the 6 countries in the proportion employed who have tertiary education, which is not entirely in line with the variation in the educational breakdown of the working-age population. The proportion with tertiary qualifications is virtually 100% in Spain, much larger than in the UK (67%), which has a similar share of working-age population with this level of education. It is also very large in Bulgaria (86%), which again is out of line with the relatively small share of highly-educated in the potential work force. On the other hand, the proportion with tertiary education is relatively small in the Czech Republic as well as in Italy. In all countries, only a very small proportion have only basic schooling, so that virtually all of those employed as business professionals have at least upper secondary qualifications. The big difference between countries is in the split between those with upper secondary qualifications and those with tertiary level.

A smaller proportion of administrative associate professionals (ISCO 343) have tertiary level education in all countries and a slightly larger proportion has only basic schooling. In this case, therefore, the majority of those employed across the EU have upper secondary qualifications. This is the case in four of the 6 countries, the exceptions being Spain and the UK, both of which have a relatively large share with tertiary education and in both of which the share of the working-age population with this level of education is also large. Indeed, for this occupation, the division of employment by education level is more in line with the division of the working-age population, with both the Czech Republic and Italy having a relatively small share with tertiary education, though this is also the case for Germany. Bulgaria again has a larger share of people employed in this occupation with tertiary qualifications than the EU average and a much larger share than in Germany, despite having a smaller proportion of the potential work force with such qualifications to call up on.

Most building frame and related trades workers (712) also have upper secondary level qualifications in most countries, but in this case, relatively few have tertiary education. The exceptions are Spain and Italy, where the great majority of workers (76-80%) have no qualifications beyond basic schooling, in line with the relatively large share of the working-age population with low education. In Germany, there is a relatively large proportion of workers who have tertiary education, even though it is almost certainly not a requirement for carrying out the tasks involved in the job. On

the other hand, in this occupation, the proportion with tertiary education in Bulgaria as well as the Czech Republic is particularly small (almost zero in the Czech Republic and only just over 1% in Bulgaria), in contrast to the situation in the higher level occupations, especially in Bulgaria. As in the case of managers of small businesses, there is a strong correlation between the educational breakdown of those employed in this occupation and the educational composition of working-age population.

As in the case of building frame workers, the majority of motor vehicle drivers across the EU have upper secondary education. This, however, is not the case in Spain and Italy, where around 70% of those employed in this occupation have only basic schooling. This is smaller than in the case of building frame workers, but still substantial, and in line with the large number of people of working age with low education. Indeed, the variation in the educational division of this job between the 6 countries is very much in line with that in the working-age population, though it should be noted that in both Bulgaria and the Czech Republic a smaller proportion of those employed in this occupation have only basic schooling than is the case for the working –age population. This reflects the disproportionate numbers of people with this level of education who are not in employment at all in these two countries.

It is evident from the above that the relative number of people of working age with different levels of education, which constitutes the potential work force that employers have to recruit from, plays an important part in influencing the division of employment between workers with different educational qualifications in particular jobs. This, however, is much more the case for some jobs than others. Nevertheless, it is also evident, that especially for some jobs, this is far from being the only factor at work. The question then is to what extent the variations indicated above are due to differences in the nature of the jobs in question as opposed to differences between countries in the educational profile expected of workers to do a particular job and in the training programmes they are expected to complete.

2.5. Variations in the field of study in selected occupations

The second analysis focused on examining the differences in fields of study within selected occupations. It should also provide deeper insight into the educational profile required in particular jobs. This can be obtained by examining the fields of study which those who are employed undertook when completing their upper secondary or tertiary education. However, as in the case of education levels, it is instructive to consider the division of the potential work force that is defined in the same way as above, between broad fields of study.

Based on the results in Table 4, the most common field of study of those with upper secondary and tertiary education is Engineering, manufacturing and construction, which was undertaken by around 20% of all those of working-age across the EU. This was followed by Social Sciences, Business and Law, undertaken by 16%, General programmes, undertaken by 7%, Health and Welfare, undertaken by 6% and Services, undertaken by 5%.

There are, however, substantial variations across countries in the relative numbers completing the different programmes. In particular, in both the Czech Republic and Bulgaria a large number of people of working age studied Engineering, manufacturing

and construction (42% and 31%, respectively), while the number was also well above average in Germany (25%). By contrast, only 8% of the working age population undertook this programme of study in Spain and 11% in Italy. In Germany, a larger proportion than average (21%) completed Social Science, Business and Law programmes, which was also the case in the Czech Republic, and the UK. In Bulgaria especially and to a lesser extent in Spain, a much smaller proportion of the working-age population has completed these types of programmes. In both of these countries, a larger proportion than elsewhere has completed General programmes.

Table 4: Working age population by field of study

	BG	CZ	DE	ES	IT	UK	EU27
1 Agriculture and veterinary	2.9	4.6	2.0	0.7	1.1	1.2	2.2
2 Computer science	0.3	0.3	0.7	1.6	1.0	1.8	1.0
3 Engineering, manufacturing and construction	31.4	42.0	25.0	8.2	11.1	14.9	19.6
4 Foreign languages	0.3	0.2	0.6	0.0	1.5	1.1	0.7
5 General programmes	14.7	6.2	5.4	16.3	3.7	0.6	7.4
6 Health and welfare	2.9	4.8	7.3	4.4	2.3	9.9	5.5
7 Humanities, languages and arts	1.5	2.1	2.3	2.8	4.2	7.1	3.4
8 Life science (including Biology and Environmental science)	0.2	0.3	0.3	0.5	0.6	1.7	0.6
9 Mathematics and statistics	0.2	0.2	0.2	0.3	0.3	0.8	0.4
10 Physical science (including Physics, Chemistry and Earth science)	0.4	1.0	0.6	1.1	0.4	2.0	0.8
11 Services	2.9	8.0	6.3	2.0	2.1	5.2	4.9
12 Social sciences, business and law	8.5	17.0	21.4	11.7	15.3	18.1	16.0
13 Teacher training and education science	3.5	3.3	4.1	3.1	3.8	4.9	3.4
14 Computer use	0.0	0.1	0.3	0.0	0.1	1.0	0.3
15 Science, mathematics and computing	0.0	0.0	0.0	1.0	3.6	0.9	1.2
N							
A	30.2	9.9	23.5	46.2	48.9	28.9	32.6

Source: Stehrer, Ward (2011)

The other main points which stand out when comparing fields of study across countries are the relatively large numbers in the UK (as compared with the EU average) completing Health and Welfare programmes and Humanities, Languages and Arts, compared to the relatively small numbers in Bulgaria, and the relatively large number completing Science, Maths and Computing programmes in Italy. Otherwise, the proportion of working-age population that has studied the different programmes is relatively similar across countries (more detailed division of fields of study within selected occupations and countries find in Annex III).

As in the case of education levels, it is evident that the education and/training programmes which people who work in particular occupations have undertaken reflects to a large extent the relative number of people of working age who have completed the different types of programme in the country in question. Because the latter varies across countries, so does the former. Nevertheless, it is also the case that for certain occupations, a particular type of programme predominates, so that most people working in the jobs concerned have completed the programme in the same field of study, irrespective of the country concerned.

3. Modelling general macroeconomic and sectoral trends

The pan-European skills demand and supply forecast is based on the macroeconomic multi-sectoral and multi-country model E3ME developed by Cambridge Econometrics (CE) ⁽¹⁸⁾. It is designed to provide a consistent forecast of economic trends which results in the basic labour demand and supply predictions. It is a large-scale econometric model with coverage of each EU Member State, plus Norway and Switzerland (EU27+) ⁽¹⁹⁾, and a detailed disaggregation of 42 economic sectors, consistent with the NACE 2-digit classification (see Annex II). Interaction between economic sectors takes place through input-output relationships and links between countries are formed through international trade equations.

The Section 3.1 describes the general characteristics of the model. The focus on labour market within the framework of E3ME is described in the Section 3.2, which is based on the work of Pollitt et al. (2010). Technological progress and skills upgrading are considered to be important factors influencing skills demand in the model (Pollitt and Chewpreecha (2010b) and Dupuy and Sauermann (2011)). The attempts to incorporate these variables into the modelling exercise are described in the last two Sections, i.e. 3.3 and 3.4.

3.1. General characteristics of the model

The structure of the model is based on the ESA95 (Eurostat 1995) system of national accounts and includes detailed two-way linkages between European economies, energy systems and the environment. The economic system is closely tied to the model's treatment of Europe labour markets.

The econometric specification of the model makes it suitable for short and medium-term forecasting and policy analysis. E3ME is estimated and solved on an annual basis, with historical databases covering the period starting in 1970 up to the most recent year that data is available.

E3ME uses a hierarchical system of data sources with preference given to those that use definitions which are consistent with ESA95 and across national boundaries.

The primary source of economic data is the Eurostat National Accounts branch. Even when Eurostat data are incomplete or believed to be of poor quality, the Eurostat definitions are adopted and the data are completed via other sources. The main example of this is the OECD Stan database, which allows additional disaggregation of some sectors. Other data sources include the European Commission's Annual Macroeconomic (AMECO) database, as well as information available from the World Bank and the IMF. All time-series data are collected on an annual basis with gaps filled in using custom algorithms developed with the Ox software package (Doornik,

⁽¹⁸⁾ For more information see (<http://www.e3me.com>). A full online technical manual is available at http://www.camecon-e3memanual.com/cgi-bin/EPW_CGI.

⁽¹⁹⁾ The construction of the model allow for extension to a range of countries and currently the possibility to include Iceland, FYROM, Croatia and Turkey are piloted.

2007). For the EU15 (plus Norway and Switzerland) the historical database covers the period from 1970, for the 2004 accession countries data cover period from 1993, and for Romania and Bulgaria the period of coverage starts in 1995. The model uses permanently updated databases so the upper demarcation of the time series depends from the vintage of the actual use. The main cross-section data consist of input-output tables and bilateral trade matrices, which are sourced from the most recent OECD publications (Yamano and Ahmad, 2006).

The parameters of the model are estimated empirically using formal econometric techniques. In particular, the method utilises developments in time-series econometrics, in which dynamic relationships are specified in terms of error-correction models (ECM) that allow dynamic convergence to a long-term outcome. The specific functional form of the equations is based on the econometric techniques of co-integration and error-correction, particularly as promoted by Engle and Granger (1987) and Hendry et al (1984).

A shrinkage technique is used to model the long-run transition of recently accessed countries so as to match behavioural patterns with the rest of Europe. This effectively fixes long-run parameters in these countries to match EU15 averages, reducing the reliance on relatively short time series. For further details see Spicer and Reade (2005).

3.2. Treatment of the labour market

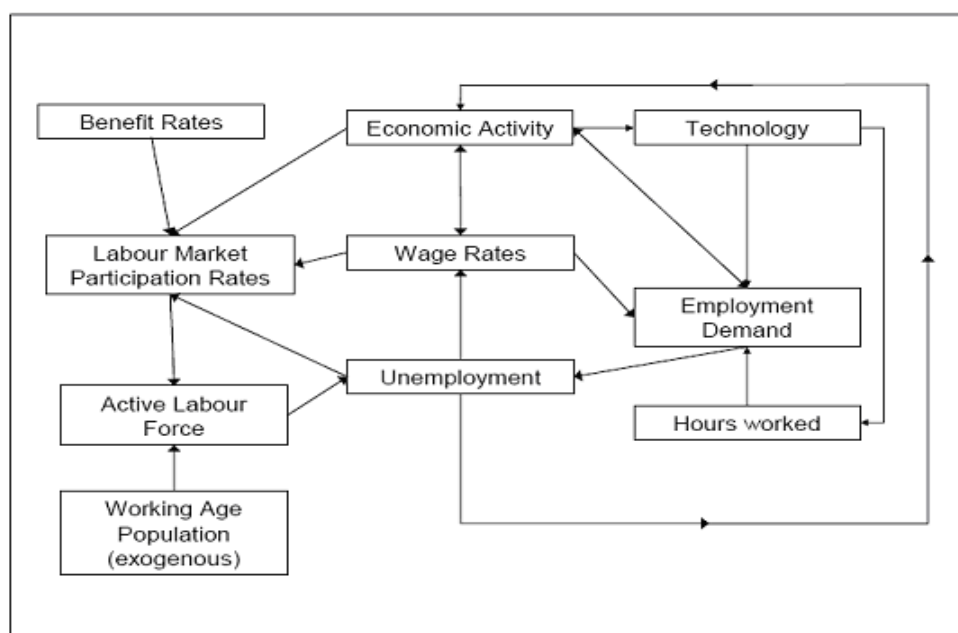
The main role of E3ME in the forecasting project is to describe the links between the labour market and the wider economy. However, because of its detailed sectoral disaggregation, the model is also able to include a relatively complex treatment of the labour market, although it does not directly address skills and qualifications requirements or availability.

The labour market module is made up of four sets of equations: employment demand, average wages, average hours worked and participation rates. Figure 2 shows the key interactions within the module. For a detailed specification of the equations see Annex B in Pollitt et al. (2010).

The original version of E3ME only had a fairly crude treatment of labour supply. This distinguished the supply of labour by gender but not age. This gap was filled by new modelling work conducted by Cedefop as described in detail in Pollitt and Chewpreecha (2008). E3ME has now been augmented to include a detailed treatment of labour supply by age and gender.

E3ME enables the production of a set of benchmark projections of labour supply and demand that provide a coherent European perspective. The use of the macroeconomic model sets the aggregate context for the overall skill demand and supply projections.

Figure 2: Interactions of labour market in E3ME



Source: Pollitt et al (2011)

Employment is modelled for each industry and region as a function of industry output, wages, hours worked, technological progress and energy prices. Industry output is assumed to have a positive effect on employment, while the effect of higher wages and longer working hours is assumed to be negative. The effects of technical progress are ambiguous, as investment may create new jobs or replace labour by automated processes; this varies between sectors.

Hours worked is defined as an average across all workers in an industry, so it incorporates the effects of higher levels of part-time employment in certain regions and industries. Hours worked is a simple equation, where average hours worked by industry and region is a function of ‘normal hours-worked’ (the employees’ expected hours based on hours worked in other industries and regions) and technological progress. It is assumed that the effects of technical progress gradually reduce average hours worked over time as processes become more efficient. The resulting estimate of hours worked is an explanatory variable in the employment equation.

In E3ME *wages* are determined by a complex union bargaining system that includes both worker productivity effects and prices and wage rates in the wider economy. Other important factors include unemployment, tax rates and cyclical economic effects. Generally it is assumed that higher prices and productivity will push up wage rates, but rising unemployment will reduce wage demands. A single average wage is estimated for each region and sector.

The estimates of average wages are a key input to both the employment equations and the price equations in E3ME. If output does not increase, rising wages increase overall unit costs and industry prices. These prices may get passed on to other industries (through the input-output relationships), building up inflationary pressure.

E3ME includes a set of equations for labour market participation rates. When these are multiplied by the exogenous projections of working age population we get a measure of labour supply. The participation rates are affected by economic output,

wage rates, hours worked, unemployment, benefit and pension rates, qualifications and the ratio of service activity to manufacturing. As there is little historical precedent, changes in official retirement ages are not directly included in the equations but are taken account of exogenously. At present there is no direct link with official retirement ages. Equations are estimated and solved for each country, disaggregated by gender and by five-year age bands. The separate results for males and females indicate different patterns of activity rates between the two genders, with the activity rate for males being, in general, considerably higher than for females.

E3ME does not assume market clearing in the labour market and unemployment arises when labour supply is greater than labour demand. The model database contains time series of unemployment data that are consistent with ILO definitions.

Unfortunately the differences in definitions (between National Accounts and LFS) mean that unemployment cannot simply be taken as the difference between labour supply and demand, and a residual value must be used to make the results consistent with the historical figures. This topic is elaborated more in the Section 7 of this publication.

3.3. Involving technological changes into the model

In recent decades the technological progress has intensively affected the labour market. Initial way of how to incorporate the technological progress to the modelling framework is via the ICT technological progress indicator which appears in nine stochastic equations and interacts with a skill variable. These indicators are complementary in that new ICT technology requires ICT skills to operate. However, since the skills variable reflects ICT skills only, it is insufficient for the analysis of the Cedefop forecasting project, which aims to establish links between a wider definition of skills and technologies.

In most age groups a higher level of skills indicates a higher propensity to work. However, for some age groups the reverse is true, for example in the youngest age groups a higher level of skills naturally obliges people to stay longer in education. Skills are currently treated as exogenous in E3ME. The similar exogenous treatment of technology progress is often presented also in other types of models mostly because of its non-measurable nature. There is, nevertheless, scope to endogenise the variable by completing the loop of skill-supply modelling in the model structure within Cedefop's framework.

The approach used to model technological progress in E3ME is adapted from that of Lee et al. (1990). It adopts a direct measure of technological progress by using cumulative gross investment, which is altered using data on R&D expenditure. There are two types of technological progress estimated, ICT and non-ICT.

The equation for the technological progress indicator (ICT – in the equation denoted by T) is written as,

$$T_t = c + \alpha \partial_t(\tau_1) \quad (1)$$

where $\partial_t(\tau_1)$ satisfies the following recursive formula

$$\partial_t(\tau_1) = \tau_1 \partial_t - \tau_1 + (1 + \tau_1) \log(GI_t + \tau_2 RD_t) \quad (2)$$

where

GI_t = the level of gross ICT investment;

RD_t = constant-price research and development expenditure;

τ_1 = a measure of the impact of past-quality adjusted investment on the current state of technical advance; while

τ_2 = a measure of the weight attached to the level of R&D expenditure.

To initialise the recursive process for $\hat{\partial}_t$, the assumption is made that in the pre-data period the process generating $\log(GI_t)$ is characterised by a random walk. Under this assumption the first value of t can be written as:

$$\hat{\partial}_0 = \log(GI) \quad (3)$$

where the right-hand side represents the average of gross investment over the first five-year sample period. The value of τ_1 (the path of technical progress) was set at 0.3 and τ_2 , (the relative importance of R&D (RD) compared to gross investment (GI)) was set at 1.0 (noting that more sophisticated procedures could have been adopted, i.e. a grid-search method based on log-likelihood values). The series $\hat{\partial}_t(\tau_1)$ is then calculated by working the recursive procedure forward given the initial value 0.

The calculation for the non-ICT technological progress indicator is similar to equation (2) above with two exceptions, namely GI_t is replaced with non-ICT investment and there is no τ_2 term.

Table 5: Relationship of technological progress indicators with main E3ME variables

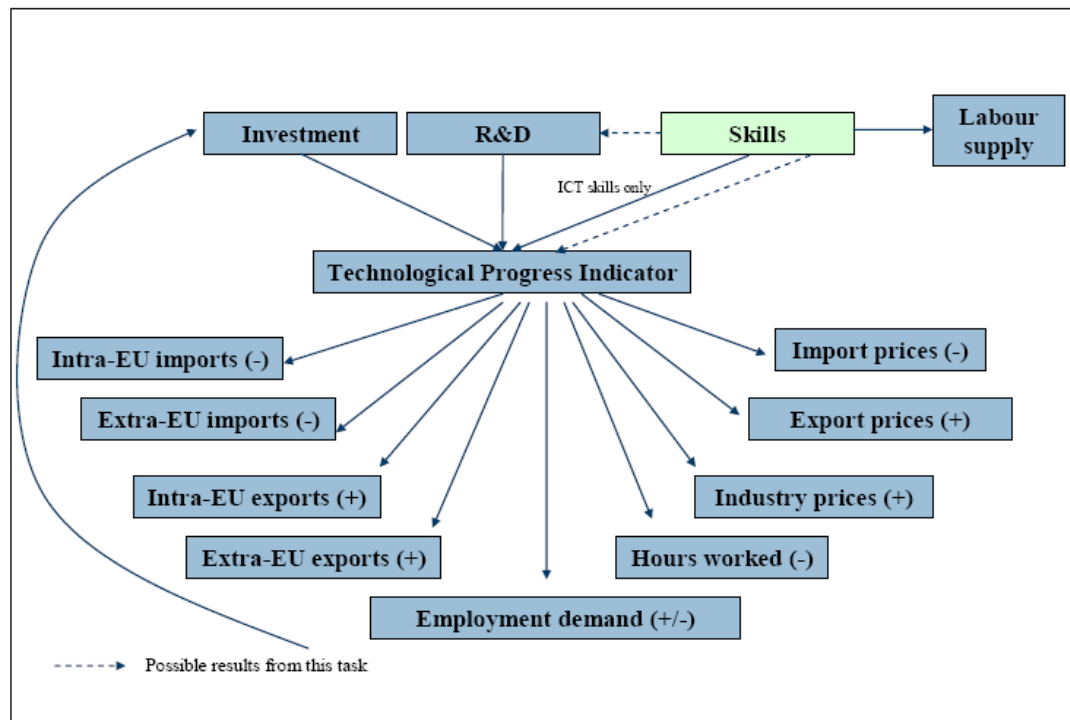
E3ME's stochastic equation	Relationship with technological progress indicator	Rationale (other things being equal)
Employment demand	+/-	New technology can be either labour saving or labour creating (e.g. requires skilled worker to operate)
Hours worked	-	New technology increases productivity therefore less hours are required
Industry prices	+	Technology increases the quality of goods, allowing firms to charge more for their products
EU-internal imports	-	High technology in the domestic country implies goods are of better quality than elsewhere and therefore there is less demand for imports
EU-external imports	-	As above
EU-internal exports	+	High technology in export country implies goods are better quality than elsewhere and therefore increases demand for the country's exports
EU-external exports	+	As above
Import prices	-	Imports are of lower quality than high-technology domestically produced goods, implying lower prices
Export prices	+	Vice versa to above

Source: Pollitt, Chewprecha (2010a)

Because E3ME already contains a link between skills and technology, the methodology employed first seeks to improve the current treatment and secondly it tries to achieve a better modelling of skills with technological progress.

The diagram below shows how skills feed into the technological progress indicator in the existing E3ME framework.

Figure 3: Interactions of skills and technology progress indicator in E3ME framework



Source: Pollitt, Chewpreecha (2010a)

The skills (YRKS) variable that currently appears within the technological progress indicator (YRKC) in E3ME's stochastic equations is initially replaced with a similar skills variable in the E3ME's labour participation rate equation, i.e. a proxy based on the qualification mix (YRKN).

The following function specifications are hence estimated with the new definition of the skills variable in order to test the relationship between skills and technology:

- same as existing specification $YRKC * YRKS$ (with different definition of skills);
- as a separate explanatory variable i.e. $b_x YRKC + b_y YRKS + b_z YRKN$.

The existing external-EU export equation is also used to test the relationship between skills and technology. There are two good reasons for this:

- technology is not something that is measurable. In E3ME the technology terms YRKC are constructed. Therefore the impacts of skills on technology cannot be directly assessed;
- exports have been shown to be highly responsive to technological change. This relationship is highly documented in international trade theory (see, for example, Barker et al., 2006).

The main drawback of using the export equation to test the link between skills and technology was that it does not provide insight to non-traded sectors such as utilities. A newly developed R&D equation can also be used to test the effect of skills on technology. This is because R&D is highly correlated with new technologies and therefore can be used as a proxy for technology. The R&D equation should be able to give us some insight into the non-traded sectors which the export equation fails to capture.

3.4. Involving skills upgrading into the model

Another way to incorporate improvements of technology and skills into the forecasting exercise was tested. It differs from the above in two main aspects: First, different data are used to assess demand shifts between different types of workers and different types of capital; second, the main aim is identifying to identify structural breaks at a low level of aggregation, i.e. at the country-sector level. It is based on the work of Acemoglu (2002), who regards technical change as the ignition, whereas institutions, trade liberalization and organizational change are seen as complementary factors determining the magnitude of the impact of technical change.

Since technology differs across industries and countries, we measure the speed of skills upgrading separately by country and industry. We are interested in the speed at which demand for skills changes over time. Structural breaks occurring in the period 1970-2005 are also analyzed. This allows to recover potential structural changes and to identify the direction of change in the speed of skills-upgrading over time. This analysis is performed separately for countries and sectors as not only the speed but also the timing of the structural break may be dependent on the type of sector and the economic development of the country.

To this aim, the EU-KLEMS data set is used for 9 European countries, Australia, Japan and the US to estimate the speed of skill-upgrading for three skills groups (low, medium and high educational levels), within 11 sectors of industry. The data contain detailed information on labour inputs (low-, medium-, and high-skilled labour), capital inputs (IT and non-IT related capital) and intermediate inputs. These variables are collected at the sector level for the period 1970-2005. This information enables the estimation of the parameters of a production function at the sector level within each country, allowing for sector and country specific production parameters.

In the next section, the theory and empirics lying behind the estimation of the skill composition of the workforce is described. An overview of the data is also given in the following section. Results are then presented followed by conclusions.

3.4.1. Modelling skill upgrading

The analysis of skill upgrading requires estimating the demand for skills. We do so by formulating a parametric cost function that captures (changes in) technology used within industries and countries. While various parametric forms have been used in the literature (see Berndt and Christiansen, 1973 among others), we start by applying the translog cost function that has the most flexible function form. This functional form can be seen as a second order approximation of the true cost function. An advantageous feature of such a specification is that it nests the Constant Elasticity of Substitution (CES) cost function and the Cobb-Douglas cost function as special cases ⁽²⁰⁾.

⁽²⁰⁾ We have also experimented with other flexible cost functions and, in particular, the generalized Leontief shape. While empirical estimation of the magnitude and sign of the Allen Elasticity of Substitution (AES) gave similar results for the translog cost function and the generalized Leontief cost function, the magnitude and sign of the estimates of the trend parameters (upon which the speed of skill upgrading depends) using the generalized Leontief function were unrealistic.

Let gross output Y in one industry of a country at time t be produced with $K=6$ different inputs: 3 types of labour (low-, medium-, high-skilled), 2 types of capital (information and communication technology (ICT) related capital and non-ICT related capital), and intermediate inputs. Considering heterogeneous labour and capital inputs allows us to test, for instance, how far the use of ICT-technology substitutes for low-skilled labour.

Based on the translog cost function, share equations of each input can be derived. Using the traditional stability restrictions on the parameters of the cost function, this system of K equations can be reduced to $K-1$ equations without loss of generality (with the K -th input factor being excluded). For each of the $K-1$ inputs, the share equation can be written as (we drop the indexes for industry, country and time for notational simplicity):

$$S_i = \alpha_i + \sum_{j=1}^{K-1} \gamma_{ij} \ln \left(\frac{P_j}{P_K} \right) + \gamma_{iY} \ln Y + \gamma_{iTR} TR \quad (4)$$

Where P_i is the price for a unit of input factor i , Y is total output, and the variable TR is a linear time trend. The dependent variable S_i is defined as the costs of particular input (also ICT) relative to total costs. For any input j , it is defined as:

$$S_j = \frac{P_j X_j}{C} \quad (5)$$

Where P_j is the price of input j , X_j its quantity, and C the total costs of production, i.e. the sum of costs of all labour, capital, and intermediate inputs.

The model of $K-1$ equations can be estimated using ‘Seemingly Unrelated Regression’ (SUR) techniques (Zellner, 1962). This technique allows us to model the contemporaneous correlation between idiosyncratic shocks in the demand for each input ⁽²¹⁾.

The model is estimated for each country-industry time series of output and inputs. This leads to 132 separate regressions (11 industries x 12 countries). Based on the estimated regression coefficients, we can calculate the own-price elasticities (σ_{ii}^{AES}) and the elasticities of substitution between inputs i and j (σ_{ij}^{AES}). We use the Allen partial elasticity of substitution (AES) which is defined as

$$\sigma_{ii}^{AES} = \frac{\gamma_{ii} + S_i^2 - S_i}{S_i^2} \quad \text{and} \quad \sigma_{ij}^{AES} = \frac{\gamma_{ij} + S_i S_j}{S_i S_j} \quad (6)$$

The time trend variable TR captures trends in the demand for inputs over time and therefore accounts for shifts in demand which are unrelated to changes in the level of other inputs. This type of skill upgrading would therefore occur if the coefficient is

⁽²¹⁾ If current shocks in the demand for each input are correlated with past shocks in the demand for other inputs (i.e. endogeneity of prices), however, SUR estimates will be inconsistent. To account for this problem, one could attempt to apply Instrumental Variable techniques using internal instrumental variables as suggested by Krusell et al. (2000).

larger for skilled labour than for unskilled labour. The speed of skill upgrading will depend on the relative magnitude of these coefficients across skill groups. A change in the speed of skill upgrading would occur if the relative magnitude of the time trend coefficients across skills groups changes over time. We test for changes in the speed of skill upgrading by testing for structural breaks in the time trend coefficients.

$$speed_{skillupgrading_j} = \gamma_j - \gamma_{LS} \text{ for } j=HS,MS.$$

3.4.2. Data

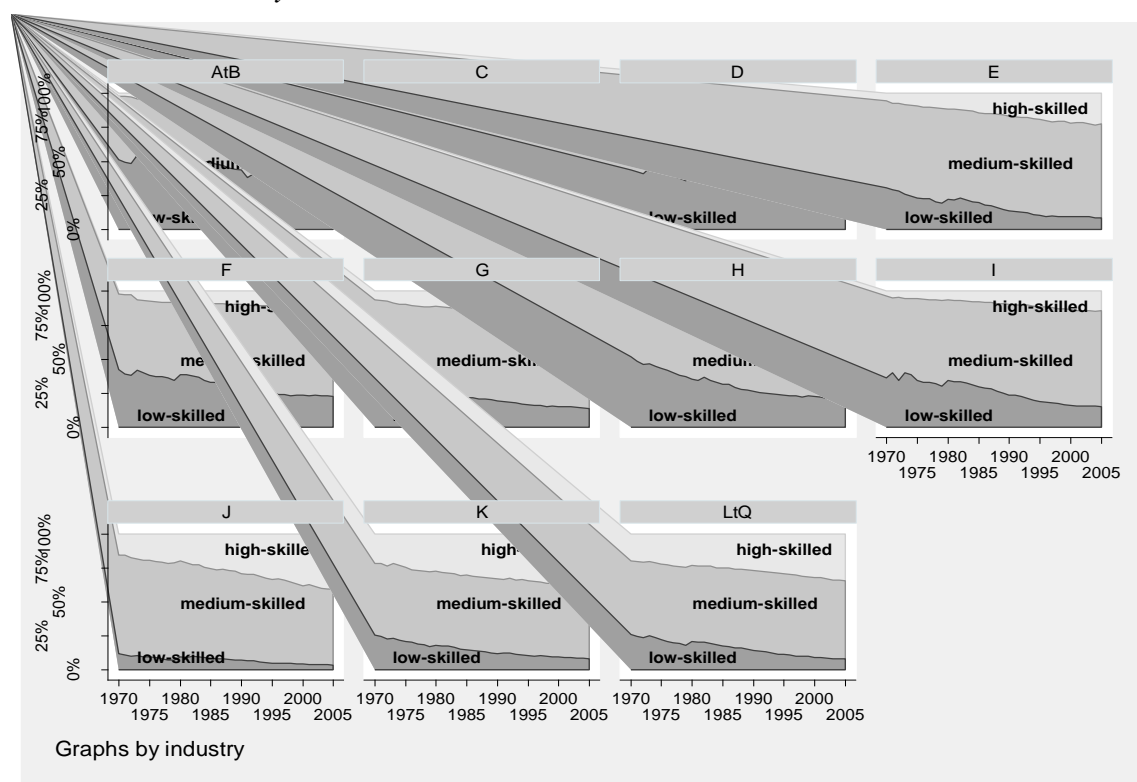
Data from the EU KLEMS project is used which contains information on growth accounts from 28 European and non-European countries (Timmer et al., 2007). The data considers 21 industries over a maximum period from 1970 to 2005. It contains input measures on capital (differentiated by information technology-related capital (ICT) and non-information technology-related capital (NICT)), labour (differentiated by low-, medium-, and high-skilled labour groups), and intermediate inputs (differentiated by energy, material, and service inputs).

Not all of the countries were suitable to be included in the estimation sample. Some of the countries were not included because the span of observations was too short or because important information to generate the required variables (input and prices) was missing. Only nine EU (Austria, Belgium, Denmark, Spain, Finland, France, Italy, Netherlands, United Kingdom) and three non-European countries (Australia, Japan, USA) provided satisfactory data which was sufficient for running the regressions. More details in Dupuy and Sauermann, 2011.

3.4.3. Implication for the forecasting model

Over the last decades the skill composition of labour inputs has changed substantially. The general pattern is that the relative importance of low-skilled labour has decreased while the share of high-skilled labour has increased. Figure 4, which is based on the EU-KLEMS data used for this exercise, shows the share of low-, medium-, and high-skilled labour inputs in total labour inputs. The input of labour is measured as number of hours worked and can be split according to the contribution of each of the three labour inputs. Since all three shares sum up to unity, the lines shown in Figure 4 clearly indicate that the share of low-skilled labour decreased in all sectors over the period 1970 to 2005. While medium-skilled labour remained at a constant level, the share of high-skilled labour substantially increased over this period.

Figure 4: Shares of low, medium, and high-skilled labour in total labour by industry

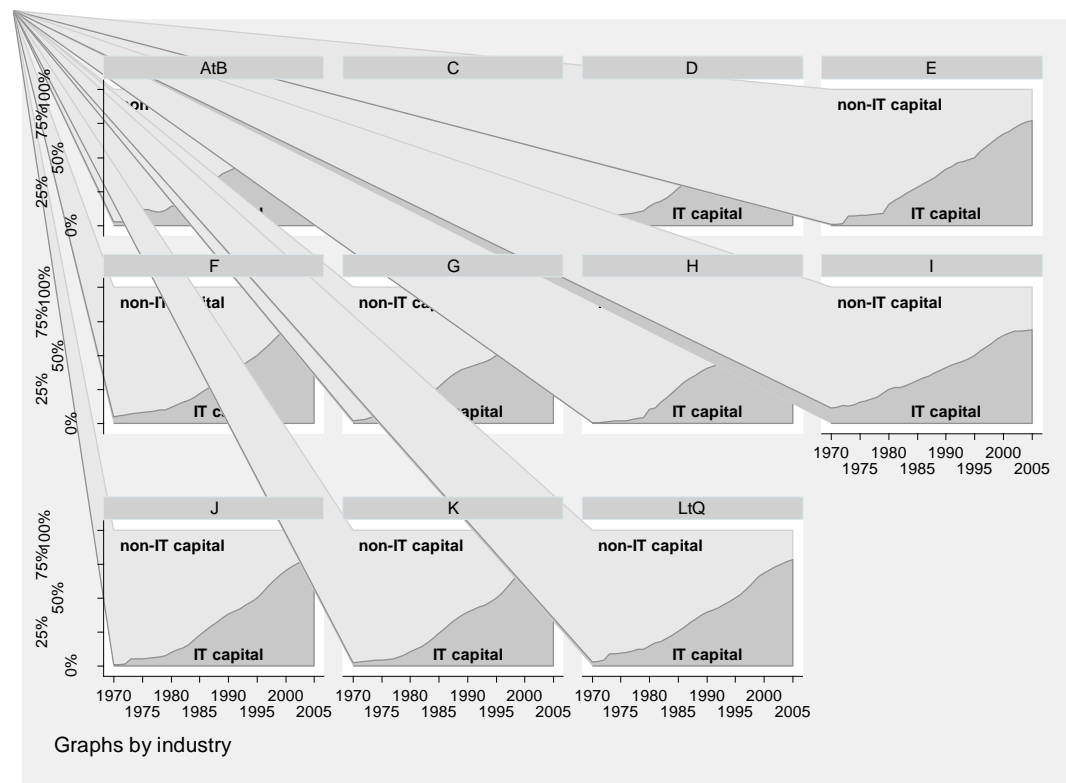


Note: Sectors are Agriculture, hunting, forestry and fishing (AtB), Mining and quarrying (C), Total manufacturing (D), Electricity, gas and water supply (E), Construction (F), Wholesale and retail trade (G), Hotels and restaurants (H), Transport and storage and communication (I), Financial intermediation (J), Real estate, renting and business activities (K), Community social and personal services (LtQ)
 Source: EU-KLEMS, calculations by ROA

The main argument put forward in the economic literature is that skill-biased technological change (SBTC) led to a change in the skill structure. The idea is that new technologies require higher levels of skills for two reasons: first to develop new technologies, and second to apply them.

Due to SBTC, information and communication technologies (ICT) were on the rise in recent decades compared to non-ICT technologies. The trend towards higher use of ICT is shown in Figure 5, which depicts the share of ICT capital in total capital inputs over the period 1970 to 2005. In all sectors, the share of ICT-capital in total capital investments rose from almost 0 to very high levels. As we will see below in the estimation of the parameters of substitution (the γ_{ij} parameters), this dramatic change in the share of ICT makes it difficult to accurately estimate the structure of substitution.

Figure 5: Shares of IT and non-IT capital inputs in total capital inputs



Note: Sectors are Agriculture, hunting, forestry and fishing (AtB), Mining and quarrying (C), Total manufacturing (D), Electricity, gas and water supply (E), Construction (F), Wholesale and retail trade (G), Hotels and restaurants (H), Transport and storage and communication (I), Financial intermediation (J), Real estate, renting and business activities (K), Community social and personal services (LtQ)
 Source: EU-KLEMS, calculations by ROA

From a theoretical point of view, the reason for this can be easily seen from the formula of own-price elasticity:

$$\sigma_{ii}^{AES} = \frac{\gamma_{ii} + S_i^2 - S_i}{S_i^2} \quad (7)$$

If the cost share of input i goes towards 0, the own-price Allen partial elasticity of substitution (AES) tends to $+\infty$ for positive values of γ_{ii} and $-\infty$ for negative values of γ_{ii} . However, when the share of the input is equal to 0.5, the own-price elasticity will be negative as long as the parameter γ_{ii} is not too high, i.e. ≤ 0.25 . This means that using data where the share of an input i changes dramatically from values close to 0 to values close to 0.5 implies that the point estimate of the γ_{ii} parameter should not be too high (either negative or positive but close to 0). While at the end of the series, when the share is close to 0.5, the elasticity is negative even for positive values of γ_{ii} . At the beginning of the series, when the share is close to 0, positive values of γ_{ii} would produce positive own-price elasticities.

The estimates of the elasticities tend to have large magnitudes compared to what economic theory would predict. From an empirical point of view, there does not seem to be enough variation around the trend for most price series to avoid multicollinearity problems in the estimation procedure. However, even though the magnitudes of the

elasticities are sometimes unrealistic (multicollinearity), their signs appear to coincide with economic intuition. For instance, most of the own-price elasticities are negative (see Table 6). This seems to indicate that although the parameters of substitution suffer from multicollinearity and should be interpreted as reduced form parameters, the time trend coefficients which are the main interest to enter E3ME model, are estimated consistently. This technique is possible use in the whole forecasting exercise.

Table 6: *Share of negative own-price AES*

Input	Share negative AES
Ls	58.0%
Ms	73.3%
Hs	55.7%
It	85.5%
Ni	51.9%
Ii	96.9%

Source: EU-KLEMS, calculations by ROA

Baseline results: The estimated coefficients from the translog cost function allow us to draw conclusions on trends in the demand for low, medium and high skilled workers as well as for ICT and non-ICT capital. (for detailed numerical results see Dupuy Sauer mann (2011))

Loosely speaking, these demand shifts are believed to capture the impact of technical change. As expected, the demand for low skilled workers is decreasing in most countries and most industries whereas the demand for high skilled labour is increasing during the same period.

Interestingly in the Agricultural, hunting, forestry and fishing industry (AtB), Mining and quarrying industry (C) and Manufacturing industry (D) the demand for low skilled workers decreases consistently in all countries, although with various magnitudes however for some industries such as, for instance, Wholesale and retail trade, the demand for low skilled workers increases in some countries, i.e. Australia and the USA.

Regarding the demand for high-skilled workers, while most estimates are positive as expected, the strongest shifts in the demand for high-skilled workers occurs in the following industries: Hotels and restaurants, community social and personal services, and real estate, renting and business activities.

Based on these estimates, we can calculate the speed of skill upgrading by taking the difference between the percentage changes of the demand for medium or high skilled labour to that of low skilled labour. The relative demand for medium and high skilled workers increased over time although there are large variations in the magnitude across countries and industries.

In the manufacturing industry, for instance, the speed of skill upgrading, as measured by the difference between the demand for high skilled workers and low skilled workers, is rather homogenous across countries and lies between 0.01% in Italy to 0.66% in Belgium. In contrast, the magnitude of skills upgrading in the sector of wholesale and retail trade varies between –countries e.g. 1.41% in Australia and 1.43% in Belgium.

4. Modelling skills supply

The methods currently used to produce the skill supply forecast were developed in the first pilot project of Cedefop (2009) and improved in the next stages of the research (Livanos and Wilson (2010a) and Bosworth and Wilson (2011)).

Although there has been a great deal of academic work on educational choice and related issues, this has only rarely focussed on the development of models suitable for developing projections of the supply of skills. Some work in individual Member States has made progress in this direction, but this has usually been based on access to specific data not generally available at a pan-European level.

Best practice involves a full analysis of both stocks and flows. Stocks in one period are related to stocks in an earlier period, plus inflows and less any outflows. The flows can be linked to demographic developments and to a range of behavioural drivers, including economic and social factors. Livanos and Wilson (2008) briefly review this research before presenting a much simpler approach, focusing solely upon changes in the average qualification patterns within stocks, which reflects the limitations of the data available at a pan-European level.

The current methodology is based on analysis of changing patterns over time on the stocks of people in the population and in the labour force, defined by highest qualification held, and by country separately. These data are taken from the European Labour Force Survey (LFS). However, it is clear from the analysis that there are still some problems in comparability across countries with respect to how qualifications are coded within the LFS, as well as difficulties within some countries in comparisons over time as a result of unrecorded discontinuities due to changes in classification or definitions used. Nevertheless, the results suggest that even with such imperfect historical data on highest qualifications attained it is possible to begin to explore implications for the future supply of qualifications in the population and the labour force. Many of the trends appear to be very robust and common across countries.

Ideally, in the longer term, this approach would be extended to include a much more sophisticated analysis of the supply side, including a greater focus on the factors influencing flows, and greater detail on the types of qualifications held.

Another important issue is the relationship between skill supply and demand. The present approach focuses on changing supply patterns, without any reference to demand side developments. In practice, the observed changes are likely to have been the result of a combination of both demand and supply influences.

As a measure of skill supply the highest formal qualification obtained by those who entered the labour force is used, disaggregated by five year age groups and gender. In general, skills supply is determined by demographic developments, labour market participation and decisions on obtaining an educational credential. As it is mentioned in Section 3, the calculations determining the volume of labour supply projections are developed within the framework of the E3ME model. This section is more related to the forecasting of the qualification patterns.

The first part of this section presents the key features of the stock model for supply by qualification currently used. The theoretical background of stock flow model is described in the Section 4.2.

4.1. Specification of stock model for supply by qualification

There are various theoretical considerations on the modelling of skills supply which include possible factors that might explain changes in the qualifications structure of the labour force and of the population as a whole. However, the estimation of complex, behavioural models is rather complicated in practice, mainly due to data restrictions.

Regarding modelling educational choices at the individual level, the available data rarely contain background socioeconomic information that is necessary for such modelling. Moreover, there is no information on abilities and other factors that are known to the individuals at the time they make their decision regarding educational attainment. These factors influence the level of education but unfortunately are not available in the LFS or other datasets, and thus any analysis that lacks this information might produce biased results. Similarly, there is no information on wages, thus the impact of economic factors cannot be estimated easily.

Regarding modelling at the aggregate level there is scope for including some behavioural elements in future stages of this project in order to help the understanding of factors affecting educational attainment. In particular, the aggregate data from all countries can be pooled together creating a unique dataset. To this dataset various explanatory variables can be considered. For instance, one variable that in theory may measure a potential motive for educational attainment is the unemployment rate broken down by age, gender and qualification level. Other possible variables that can be included in the model are expenditure on education as a percentage of GDP, and financial aid to students defined as a percentage of total public expenditure on education. These data are available at a country level, and can help capture common patterns and differences across countries. Including these variables in the model could add some behavioural insight.

Livanos and Wilson (2008) reviewed the theoretical and empirical approaches to modelling and projecting the supply of people with different levels of qualifications. Where detailed data have been available, researchers have exploited them. More often than not, however, the paucity of information available has resulted in very simple approaches based on time series methods, which themselves have often relied on a single variable (time), rather than on multivariate, behavioural approaches.

As noted above, the ideal approach would probably be to use a linked stock flow model, with future stocks being related to past ones by an accounting relationship, including separate analysis of all relevant inflows and outflows. The latter would include flows of people into education and of those obtaining formal qualifications, as well as outflows for various reasons (including mortality, migration and flows in and out of economic activity).

Given suitable data, such flows can be explained using behavioural models, such as the human capital approach. The latter argues that education can be regarded as an investment and that the decisions of people to participate in education and to acquire qualifications are influenced by the returns to such investment. Based on such theories the supply of skill (as measured by qualifications) can be related to career choices influenced by a range of economic and other determinants, including:

- pay (returns to investment in qualification);
- employment opportunities when searching for a job;
- social security and tax system;
- personal and household characteristics;
- other economic and social factors.

Previous research on these issues at a pan-European level is quite limited, especially at a detailed level. In practice, the data to build such models are not currently generally available at a pan-European level. The length of time series data available is also very short. In practice, such data only allow for fairly very simple extrapolative procedures (using linear or non-linear methods). Effectively time is the only independent variable, acting as a proxy for other factors. This creates a large gap between the ideal theoretical model and the typical specifications used in most national level skills supply projections.

In order to assess changing patterns of skill supply within each country, a simple model for developing projections of the supply of people by qualification has been developed within the Cedefop project. This model focuses upon patterns in the qualifications currently held as reported in the Labour Force Survey (LFS). These patterns are then applied to independent projections of the population aged 15+ and to the labour force, each differentiated by age and gender as taken from the E3ME model.

The propensity to hold a given level of qualification is measured either using aggregate data or at the individual level (the latter using a pooled cross sectional data set drawn from the LFS). The trends are estimated using a Multinomial logit model or something similar. Variables are introduced into the model to specifically capture ‘spatial effects’ (including country specific intercept and time trend for each qualification level, age and gender category). This modelling strategy makes maximum use of the limited sample size in the LFS. The analysis focuses upon individual qualification achievement levels (dependent variable) against a set of explanatory variables. Demographics are controlled for by including age band and gender categories, across which qualifications may be expected to vary.

The regression analysis of individual data uses a multinomial logit specification. The propensity to obtain a particular level of qualification at the individual level is given by:

$$Q_{ijk} = \alpha_{jk} + \beta_{jk}t + \gamma A_{ijk} + \phi G_{ijk} \quad (8)$$

where, i denotes the i -th individual, j refers to the j -th country and k is the k -th age group. Q takes values of 0 or 1 depending on whether the individual holds a particular qualification or not. There are 3 qualification categories, high, medium and low (one category is left out as the base group). A denotes a set of age band dummies, taking values of 1 if the individual falls into a particular age category. G is a gender dummy, taking values of 1 for females and 0 for males. Finally, a set of time trend variables t are included, capturing changes in attainment levels over time which differ by country and gender and for each age band. The model is estimated using the *multilogit*

procedure in the STATA software package, which constrains the proportion of individuals holding each qualification level to sum to unity.

The most robust results are obtained for some of the simplest models. These generally involve some form of simple time trend rather than more sophisticated models with behavioural content. Given the problems with the current data this is probably not too surprising. As the data are extended and improved it may be possible in future work to add in more economic and other behavioural content to this part of the modelling.

The projections of working age population (and the labour force) by highest level of qualification held can be obtained by applying the projected probabilities of the logistic specification to the working age population (and the labour force) projections from Cambridge Econometrics (CE) and the E3ME model ⁽²²⁾. For a discussion of the underlying methodology used to develop the projections of the working age population and the economically active labour force see Pollitt and Chewpreecha (2009).

The projected shares of educational attainment by gender and age groups are applied to the projections of the working age population for the same age and gender categories. This generates forecasts of the numbers of people in the working age population by highest qualification held, broken down by age and gender. The projections of the labour force are obtained by applying the estimated activity rates to the projections of the working age population.

The role of individual country experts is of significant importance for the project, since the results obtained need to be validated using local knowledge. In particular, the country results obtained from this stage of the project are typically examined by individual country experts in order to have their feedback incorporated into the final or updated set of results.

4.2. Building a stock flow model

The possibility to develop more sophisticated analyses using information on the flows of people through the education system has been investigated. The overall supply of people holding formal qualifications at higher level (ISCED 5 and 6) is relatively straightforward to conceptualise and model. However, there are considerable conceptual and practical difficulties in extending this to lower levels of education (ISCED 1 – 2). The main difference of these two groups is that lower qualified may increase their educational level during the working life and so initial stock may be changed in future. Conceptualising the idea of supply to cover specific dimensions such as occupation, sector and geographical area is even more difficult. This is primarily because the educational systems in most countries are not completely hierarchical (Cörvers, et al., 2008).

The key problem to be addressed in extending stock-flow models to cover the full range of qualifications is the much more limited information available at lower level qualifications (ISCED 1-2). Ideally, stock-flow modelling requires a comprehensive set of demographic accounts showing how individuals progress through the

⁽²²⁾ The population projections that CE uses to produce forecast of the labour force is drawn from Eurostat.

educational system and the labour market over time. In practice such accounts do not exist, although there is a considerable amount of information on certain flows.

If educational transitions stopped at an early age (e.g. age of 22), then it might be possible to assume that the qualification mix would stabilize for groups older than this. Under these circumstances, a stock-flow model would stand a chance of being a reasonably reliable method of saying something about the evolution of qualification levels into the future.

4.2.1. Essence of a stock flow model

The first element of the stock flow model is the knowledge that a cohort of individuals identified at time t can be largely traced at time $t+1$. In other words, a group of 16 year olds in 2007 become 17 in 2008 and so on. The example is provided in Table 7. The starting ‘stock’ comprises of individuals of working age (16-64) in 2007. Inflows are needed at the youngest age level ⁽²³⁾ (16) to fill the shaded area in the top right hand corner, as the stock ages. This is normally possible in demographic models because there is usually data on 15 year olds in 2007, who become 16 in 2008 and 17 in 2009.

Table 7: *Rolling the LFS data forward’ in a stock-flow model, UK*

	2007	2008	2009	2010	2011	2012	...	2020
16	1094678							
17	985209	1094678						
18	900975	985209	1094678					
19	843577	900975	985209	1094678				
20	884830	843577	900975	985209	1094678			
21	912422	884830	843577	900975	985209	1094678		
22	926265	912422	884830	843577	900975	985209		
23	883788	926265	912422	884830	843577	900975		
24	882461	883788	926265	912422	884830	843577		

Note: data for the UK population as a whole, 2007.

Source: European Labour Force Survey.

Assumptions also have to be made about deaths and migration from intermediate ages of the stock (e.g. deaths amongst 50 year olds in 2007 or net migration amongst 30 year olds in 2007). Normally such factors are accounted for by simply scaling the LFS ‘projections’ up to the population forecasts provided by the appropriate bodies for each country.

In general, such scaling of the data to projected population numbers only takes place after the main elements of the modelling – in the present case, educational mix – have been carried out. Thus, attention turns to modelling education and educational transitions.

⁽²³⁾ Sometimes referred to as the ‘intensive margin’ in vintage modelling.

4.2.2. Qualifications in a stock-flow setting

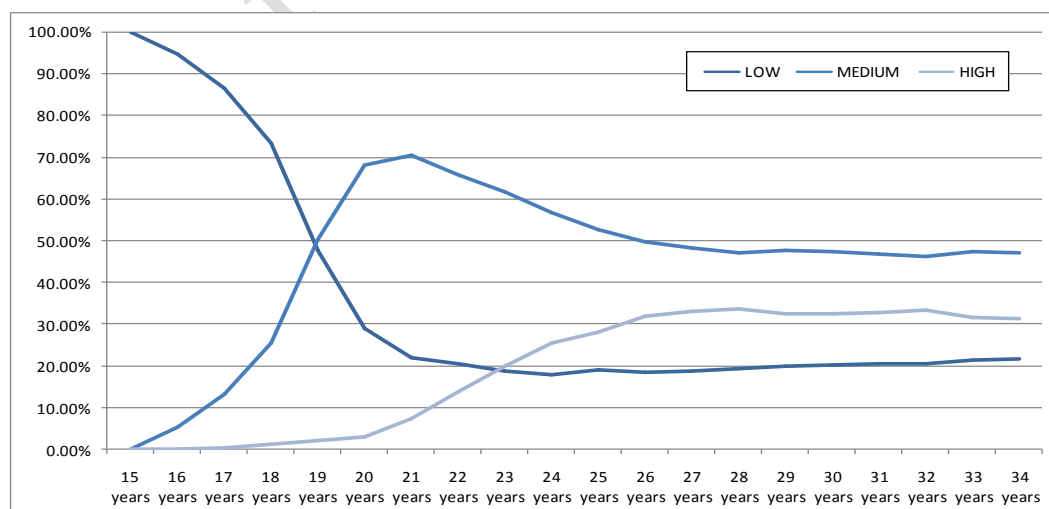
Given that the qualification levels of the population are known in 2007, then the stock flow model can be formed by qualification level in the same way as for the population as a whole. The ‘stock’ part of the stock flow model is primarily useful for those ages above which the qualification levels of each member of the population effectively become fixed. At this point, the mix of qualifications is constant.

Thus, the ‘stock’ part of the stock flow model focuses on qualification proportions. It is immediately clear that the proportions shifted forward one year from 2007 to 2008 are unlikely to reflect the true proportions of the qualification mix, at least for the younger ages. The problem is that individuals above the age of 16 undergo educational courses that eventually lead them out of a ‘low’ qualification level into the ‘medium’ category and, for slightly older individuals, out of ‘medium’ into ‘high’. If the LFS data for younger individuals is to be used at all, something needs to be done to adjust the data for educational transitions, at least amongst the younger individuals, as the 2007 cross-section is ‘rolled on’ for 2008, 2009, etc.

4.2.3. Educational transitions and trends: evidence from cross-sectional data

Educational transitions are reflected in any annual cross-sectional data for individuals, for example, the stock of individuals of working age in 2007, as shown for the EU 27 in Figure 6. The downward shift in low qualifications and the corresponding upward jump in medium qualifications between the ages 16 and 20 are mainly the reflection of the educational transition that occurs every year in the EU as individuals obtain their secondary education qualifications. Likewise, the downward shift in the medium qualification proportion and the upward jump in the high proportion around ages 21 to 28 reflect the educational transition that, again, broadly speaking, occurs every year in the EU as individuals obtain their tertiary qualifications. It is clear that similar patterns could be recognised in each Member State. They may of course vary with the intensity and time-wise.

Figure 6: Qualification proportions of a cross-section of individuals, EU27, 2009



Source: LFS

The curves in Figures 6 reflect two effects: education transitions, which occur from year to year and educational trends, which affect the size (and timing) of the transitions in the past. As educational transitions are particularly important in the early years, they tend to dominate amongst younger age groups in the cross-sectional data and, as educational transitions become less important amongst older individuals, the long term educational trends dominate the curves amongst the higher age groups. An age factor is also possible to observe as there is rising proportion of older individuals with low level qualifications and the falling proportion of those with high qualifications. This is based on fact that a smaller proportion of earlier population cohorts went on into higher education.

4.2.4. Constructing pseudo-cohorts from the LFS data

4.2.4.1. General principles of pseudo-cohort modelling

The entry level of a given cohort and the changes in qualifications for that cohort as individuals age is called a ‘within cohort’ effect, while the differences at entry (or over time from one cohort to another) is called a ‘between cohort’ effect. Both effects need to be modelled, and this is where the pseudo cohort data by level of qualification attainment become *potentially* important.

The pseudo cohort data are a potential mechanism for modelling the transitions between educational attainment levels and filling in the missing qualification information about the inflows of young people of working age that characterize forecasts based upon stock-flow modelling.

Using a pseudo-cohort constructed from the European LFS, it is possible to observe individuals of a given age in 1995 over the succeeding 13 years (i.e. 1995 to 2007). It is important to note that this is a pseudo-cohort and not a real one. It is a comparison of largely different individuals aged, say 16 in 1995, 17 in 1996 and so on. Nevertheless, if, for example, the group of individuals age 16 in 1995 is representative of the relevant population group and the same is true of those aged 17 in 1996, then it is possible to treat them as part of a ‘cohort’. By implication, individuals aged 17 in 1996 will have been through the same education experience up to 1995 as those individuals aged 16 in 1995, and the same holds for those aged 18 in 1997.

4.2.4.2. Operationalising the pseudo-cohorts

The way in which the data are organized to obtain pseudo-cohorts is shown in Table 8. The left hand column gives the year of entry of that cohort into the population of working age (assumed to be 16); the first row gives the subsequent age of that cohort; and the number within each cell is the year of the European LFS from which the data for that cohort at that age is obtained. As in the time of this analysis the most recent data were of those from 2007, only the first year for the entry cohort of 2007 was available. As 1995 is the first year of data available, it is not possible to observe 16 year olds in 1994 (only 17 year olds in 1995). Thus, all of the shaded cells in Table 8 cannot be observed.

Table 8: Year of the ELFS used in constructing pseudo cohorts

Year Of entry (age 16)	16	17	18	19	20	21	22	23	24	25	26	27	28	29
2007	2007													
2006	2006	2007												
2005	2005	2006	2007											
2004	2004	2005	2006	2007										
2003	2003	2004	2005	2006	2007									
2002	2002	2003	2004	2005	2006	2007								
2001	2001	2002	2003	2004	2005	2006	2007							
2000	2000	2001	2002	2003	2004	2005	2006	2007						
1999	1999	2000	2001	2002	2003	2004	2005	2006	2007					
1998	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007				
1997	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007			
1996	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007		
1995	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
1994		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007

Source: Kriechel (2011)

If the data would relate to a true (as opposed to a pseudo) cohort, there would be an expectation that the low qualification category would monotonically fall and the high qualification category would exhibit a monotonic rise with the age of the cohort, at least up to some point at which each of them become constant.

4.2.4.3. Shifts in the historical pseudo-cohorts

The basic hypothesis in the data analysis is that if the patterns of the shares of particular qualification levels remain unchanged across different pseudo cohorts, this might imply that the same pattern could be imposed to the new inflows of young individuals through to 2020. The analyses of data for the UK confirmed that in practice this does not appear to be the case (Bosworth & Wilson, 2011). There appears, for example, to be a marked change amongst the low qualification group in the UK pseudo cohorts for 1995-97, in particular, and in subsequent cohorts. These findings raise the crucial question of how to model the transitions through to 2020, to enable the stock-flow approach to function adequately.

4.2.4.4. The need to model the effects of migration on qualification mix

An important issue in the modelling process are the skills lost through emigration and gained through immigration, although there are a number of problems associated with this. Then the question is how the stock flow model estimates of qualifications should be adjusted for migration activity. While, in some countries, migration may be a minor issue, in others it may be much more important. In addition, while, in some countries the qualifications of the inflow may be very similar to that of the outflow, in others, the two flows may involve very different qualification mixes. Cedefop attempts to work on the estimation of qualification mixes of migrants. For more information consult Gausas et al. (2011).

It seems likely that much more could be done with the European LFS data in modelling the effects of migration on the qualification mix of each country, at least at the three main levels of qualification. This might be carried out by modelling the

historical migration transitions ⁽²⁴⁾ by qualification level and pinning the results to the Eurostat total migration information, by age and gender. The Eurostat data also give the country of origin of the immigrant population.

4.2.4.5. Linking the pseudo-cohort modelling with educational flows data

In addition to the analysis of the pseudo-cohort data, there is a strong case for linking these educational transitions results to direct evidence based upon educational flow data. In particular, the analysis of aggregate published UNESCO/OECD/Eurostat (UOE) flows data (on enrolment and graduation by ISCED level) can be used to produce a complementary analysis of participation and qualification rates by broad age groups.

These data can be used both in the context of a historical analysis of educational transitions, but also in a forecasting context. They might be the subject of time series modelling that might throw light on a variety of issues, such as the minimum proportion of low qualifications that can be achieved by each Member State

⁽²⁴⁾ Flows might be modelling modelled in a variety of ways, for example, using ‘Years of residence in this Member State (YEARESID)’, ‘Country of birth COUNTRYB’, etc. – Source: EU Labour Force Survey Database: User Guide, 2008.

5. Modelling employment growth (expansion demand)

Research on modelling employment by occupation and qualification as well as the development of relevant Cedefop module is summarised in Livanos and Wilson (2007b, 2010b). This method was used in the pilot project *Future skill needs in Europe* (Cedefop, 2008) and in *Skill supply and demand in Europe* (Cedefop, 2010). Latest developments are summarised in Bosworth and Wilson (2011).

This section describes the procedures to estimate the occupational shares. It illustrates various techniques and datasets explored to improve Module 2 (EDMOD) and Module 3 (QMOD) of the Cedefop modelling framework (see Figure 1 in the Introduction). Labour demand within sectors is the scope of the E3ME model (see Section 3).

The section reviews recent literature on occupational modelling as well as the specifications and data used in previous research to examine how the data available can facilitate the development of a ‘best practice’ approach at a pan-European level. In addition to presenting various simple extrapolation approaches, the section explores a new method proposed for estimating occupational shares using a multinomial logistic regression, rather than the simple extrapolation of past trends. The same method is also used to analyse qualification shares within occupations.

The first section focuses on relevant data specification of an ideal model. The second part is dedicated to specifications of the current model. Final part of this section describes the testing of other solutions and approaches.

5.1. Data available and the ideal specification

Most occupational forecasts are based on either fixed share coefficients or simple trend-extrapolated coefficients. For example, in Cyprus (Oxinos et al. 2005) forecasts by occupation are obtained by applying past occupational shares to future data of sectoral employment. In Ireland (see Hughes and Fox 2005) the occupational structure of employment is projected by taking account both of past trends and expectations relating to the evolution of skills and occupations. Occupational share coefficients for each sector are calculated for the data period, and linear and semi-log trend line regressions of geometric growth rates, where judged appropriate, are used to project the shares for the sectors for the target forecast year.

Similar methods to the above are used in many other EU countries, and also in countries outside the EU. For example, in Australia, the occupational share effects are treated as a type of technical change and are forecast by extrapolating historical trends in the occupational mix in each industry (Meagher, Adams, and Horridge, 2000; Meagher, 1997). In the USA, the occupational projections of the Bureau of Labour Statistics (BLS) are published in the Monthly Labor Review (e.g. Hecher 2005). Their overall approach has not changed since the late 1990s (BLS, 1997). Based on this review of the literature, the ideal specification for modelling occupational employment might be a behavioural model as shown in equation (9):

$$S_{ijt} = f(\text{Year}, \text{Technology}_{ijt}, \text{Trade}_{ijt}, \text{Wage}_{ijt}, \text{Output}_{ijt}, \text{Unemployment}, X) \quad (9)$$

Where S denotes the share of employment by occupation (j) within industry (i), and X denotes a vector of other employment characteristics.

This represents the long term relationship between the demand for skills and various key drivers. In practice it can be anticipated that there will be various lags and adjustments which require the exploration of the dynamics of this relationship.

Finding suitable data to test such a model is difficult, even at an individual country level. The data that is considered for the present occupational modelling exercise come mainly from two main sources.

First, the project utilises aggregate pan European data from the EU-LFS, as published by Eurostat. These data cover all 27 countries for the period 1993-2005, and contain information on employment by country, gender, industry (41 industries), occupation (27 occupations) and qualification (3 level qualifications). These data measure the changing pattern of skill demand ⁽²⁵⁾ and are in theory harmonised to a common classification.

In order to explore the possibility of investigating the importance of various economic indicators on the occupational structure, economic indicators by sector from the E3ME model were included in the dataset. These were included to try to find links between changing economic drivers and the pattern of employment by skills. The E3ME dataset includes many possible indicators by industry such as gross value added (GVA), hours worked, average earnings, gross output, imports and exports, as well as technological indicators such as expenditure to research and development (R&D) and investment in information and communication technologies (ICT). When combined the Eurostat and E3ME data allow for, in principle, the estimation of a detailed specification such the one outlined in equation 9 above, which includes the impact of the business cycle and of exposure to international trade. However, various technical and data problems (e.g. short time series), restrict the ability to allow for simultaneous analysis of all industries.

The second main dataset utilised is the LFS micro-dataset on individuals. These data, that cover the period 1983-2005, provide useful labour market information at an individual level. They provide a great deal of information on demographic characteristics (age, gender, nationality etc); an individual's labour market activity over the reference week (employed/unemployed etc); an individual's characteristics of his/her first job (occupation, sector, employment status, hours of work etc); flexible working patterns (evening work, overnight etc); second job; information on an individual's previous employment (if unemployed); methods of looking for a job; and, education. For a full description of the list of variables included in the LFS see European Communities (2003).

⁽²⁵⁾ Although of course It should be noted that the observed employment levels are the consequence of both demand and supply factors. The latter may be especially important with regard to the qualification dimension.

5.2. Current specifications of the model

Given the problems with the data, and while the ideal specification might look like equations (9), a number of simpler specifications have also been considered. These include a range of models of the general form shown in equation (10)

$$S_{ijt} = F(\text{time}) \quad (10)$$

Two main methods of analysis were adopted. The first is based on analysis of the employment shares in the published LFS data, and adopting specifications as in equation (10). These include a number of variations including linear, semi log and logistic forms. Such equations can be regarded as simplified versions of equation (9), where time is used as a proxy for technological change.

A number of variants are possible. These range from simple extrapolation between fixed points, to various methods based on ‘line fitting’. The latter includes fitting:

- a linear trend, $[S = a + b*Time]$, (11)

- a log linear trend $[\ln(S) = a + b*Time]$, (12)

- or a logistic equation $[\ln(S/(1-S)) = a + b*Time]$. (13)

Another method of analysing changes in the employment structure involves a probability model, estimated on individual or pseudo-individual data. The propensity to be employed in a particular occupation is modelled using a multinomial logistic regression framework, based on pooled cross sectional data from the Eurostat/LFS data ⁽²⁶⁾.

A multinomial logistic regression model can be used to estimate the probability of an individual working in occupation (OCC) j at time t . The general model is specified as follows:

$$\Pr(OCC = j | T = t) = \frac{\exp(\Omega^{(j)} X)}{1 + \sum_{i=1}^N \exp(\Omega^{(i)} X)} \quad (14)$$

and for an arbitrarily chosen base category:

$$\Pr(OCC = N | T = t) = \frac{1}{1 + \sum_{i=1}^N \exp(\Omega^{(i)} X)} \quad (15)$$

The equations state that the probability of the representative individual working in occupation j at time t can be expressed as a function of explanatory variables, normalised by the sum of probabilities for all categories. There are N occupations and the sum of probabilities is constrained to add up to one (i.e. shares of employment across occupations sum to 100 percent).

⁽²⁶⁾ For the purposes of the analysis both micro-LFS and a pseudo-individual dataset (based on published LFS) were used. However, due to lack of consistent and reliable data in the final results the micro dataset was rejected. The pseudo-individual dataset based on the published Eurostat numbers was used for the mlogit analysis reported here. This was created by generating large numbers of pseudo individual cases with the same properties (occupational and qualification shares) as the published estimates.

Similarly, the above model can be used in order to estimate the probability of an individual working in occupation (OCC) j at time t holding a qualification n .

In the model \mathbf{X} relates to a vector of regressors which are included in the model as explanatory variables for occupational or qualification structure. Potentially these might include:

- wage of occupation j ;
- unemployment rate of occupation j ;
- sectoral value added (this may be estimated as sectoral VA/ VA trend);
- export volume share (exports as a percentage of domestic value-added);
- import volume share (imports as a percentage of domestic value-added);
- sector of employment (41 industry level);
- sector of employment x time;
- country of residence;
- country of residence x time;
- individual characteristics: gender, age;
- time period of observation, t (LFS quarter and year);

The time trend variable proxies the impact of technology and other factors on changing occupational structure. Time was interacted with country and industry to allow for these effects to be country and sector specific. The regression coefficients are estimated so that the predicted model achieves ‘best fit’ to the observed data. This is done using the maximum likelihood method. Note that in the model, Ω is the matrix of regression coefficients which is used to predict the distribution of employment by occupation at each point in time, t . Note that categorical variables (SIC, country, age, gender, etc) are included in the model as an exhaustive set of dummy variables.

The primary aim of estimating such a model is to provide a behavioural explanation of changing patterns of employment structure. If a robust specification can be estimated, the model can be used to forecast shares of employment forward over time but also indicate sensitivity to a range of economic influences. Using the coefficients of the model, predicted shares of employment by occupation can be obtained.

In practice both the individual datasets (the individual data as well as pseudo data) are very large, comprising large numbers of observations for each country⁽²⁷⁾. This caused serious technical problems when it came to estimation. The initial intention was to estimate general models covering all countries simultaneously. It became apparent that, despite various efforts to get around these problems, this was not technically feasible given current hardware and software available⁽²⁸⁾. Much simpler specifications had to be adopted, focussing on estimation for just one country at a time.

⁽²⁷⁾ In order to achieve a reasonable degree of precision, the number of cases created for the pseudo individual data set had to be even larger than the micro dataset.

⁽²⁸⁾ Estimation was undertaken using the STATA package.

The final analysis was conducted for each industry separately rather than pooling all industries together. Multinomial logit (mlogit) analyses were conducted in order to estimate the shares of qualifications of each occupation, within every industry of each country. The main advantage of the mlogit method is that the sum of probabilities is constrained by the model to add up to one (i.e. shares of employment across occupations/qualifications sum to 100 percent), whereas the other methods (e.g. linear, simple extrapolation) estimate the share of each occupational/qualification group separately and then they are constrained to add up to unity. Therefore, the mlogit approach ensures a consistent picture across occupations (all probabilities summing to 100%) without having to impose an external constraint.

Despite considerable effort to develop more general models, the most robust results were obtained using simple country datasets, distinguishing occupation and qualification for each sector, based on the published LFS shares and using models that included just 'time' as the only independent variable.

For the final set of results an algorithm was developed to select the preferred models to be used for projecting occupational and qualification shares within each sector. This choice depends upon the data available and how well the model fits and predicts the shares. The default model is a logistic specification, based on the published LFS shares, with time as the only independent variable, fitted on published LFS data for the period 1993-2006.

Where data are unavailable or inappropriate (due to missing or inconsistently classified information resulting from changes in classification or other discontinuities), the estimation period is truncated accordingly. The algorithm also checks to see if the projected changes are plausible, censoring out shares that lie outside the range zero to unity and also where the projected change is exceptionally rapid (which usually arises as a result of idiosyncrasies in the data). Where there are problems of this kind the algorithm explores alternative specifications (log liner, liner and fixed shares) until an acceptable outcome is achieved. This applies to both shares of occupations within each sector and shares of qualifications within occupations.

5.3. Testing other solutions and approaches

Cedefop is continuously working on the improvements and fine tuning of methods. Recently we have explored the possibilities for refining the treatment of expansion demand using more sophisticated econometric models. The aim was to incorporate more economic drivers and to include other types of analysis that might help to develop additional behavioural explanations of skill changes in Europe. This exercise was mostly done on theoretical level. The main focus was on using data that are available in the main project database, including the E3ME database, and analysing the standard 41 sectors and 27 occupations ⁽²⁹⁾.

A number of useful conceptual underpinnings of a 'behavioural' theory of labour demand, relating occupations and education levels, already exist. This theory has its roots in production and cost functions, which have been adapted to estimate employer

⁽²⁹⁾ This exercise was developed for searching for possible improvements of the module and currently is currently not a part of the general forecasting framework.

demand for labour. Subsequent work has been carried out in extending this framework to look at skill-biased technological change (SBTC). In addition, there has been extensive testing of the conceptual elements of the literature, which has given support to both theories, namely that there is a capital-high skills complementarity and that there is SBTC in favour of higher level skills and away from lower level skills.

Given the exploratory nature of the present work, not all issues and problems have been resolved. Although many of the results were suggestive and encouraging, the approach has not offered to date a viable immediate alternative to the more simple methods for developing projections of changing skill demand patterns based on extrapolative techniques. Nevertheless, the results obtained do appear to offer some promising areas for future research, if additional resources can be made available to support it.

The databases used for this analysis can be further improved in a number of ways: first, the inclusion of other E3ME variables (such as approximations for the ICT and non-ICT capital stocks, rather than the corresponding investment variables); second, exploration of other EUROSTAT data that might be relevant to 'behavioural' modelling of labour demands (in particular, whether a measure of R&D 'spillovers' can be constructed along the lines of Scherer, 1982 and 1984).

Two particular features of the dependent variable used here create problems:

- the number of categories of occupations, coupled with education level (27x3=81);
- the fact that the data are grouped (i.e. not individual observations of a 0,1 nature).

A potential rigorous solution to the latter problem has now been identified. This is a module developed by researchers at Boston University which can work within STATA. The maximum likelihood method assumes that the proportions follow a Dirichlet distribution (a multivariate generalization of the beta distribution used to estimate fractional logits). The Dirichlet distribution ensures that each education / occupation proportion remains between 0 and 1, and also that all possible education / occupation proportions will add up to 1.

At this stage, however, it is not clear that simultaneous joint estimates of all 81 education / occupation categories could be carried out from a technical perspective. One possible strategy might be to consider the dimensions of the data sequentially (e.g. first at an occupational level and then by level of education). The regressions reported give some indication of the potential of using a two stage procedure, which models occupational demands first and then educational demands.

The initial exploration of the data suggests that interesting patterns emerge in the present results. While these patterns are largely supportive of the Skill Biased Technological Change hypothesis – that technological and organisational changes are linked to increased demand for highly skilled individuals – there is also evidence of diversity across occupations and sectors.

While it is probably premature to draw conclusions about the success of further, future work in this area in the context of forecasting, it seems certain that such efforts would add significantly to the understanding of recent and current labour demands and employment outcomes.

The technical details describing the results are available in Bosworth et al. (2011). While this confirms the experience from other countries, which suggests that it is very difficult to establish robust relationships of this nature, and that there is only so much that can be done using econometric techniques, it demonstrates that it is important to explore these alternative approaches and to ensure that best practice is being used, given the data available.

Not for dissemination

6. Modelling replacement demand

In addition to analysing changes in overall occupational employment levels, it is important to consider replacement needs arising from retirements, net migration, movement into other occupations and in-service mortality. This is referred to as *replacement demand*. In general terms, replacement demand can be seen as job openings arising because of people leaving the workforce or their occupation. Most work on replacement demand has tended to focus on what might be called ‘permanent or semi-permanent’ withdrawals from the employed workforce. The main reasons for this are retirement, emigration, and especially for women family formation and child-bearing and rearing. Next to withdrawals from the labour force, we also include inter-occupational mobility - movements of workers from one occupation to another. These movements leave a vacancy for the occupation open; hence a demand for a worker to fill in that occupation.

The concept of replacement demand is used in Cedefop’s skill demand forecast since the beginning (Cedefop, 2008). The first part of this section provides the general overview of the replacement demand concept. The second section is devoted to cohort component methods ⁽³⁰⁾ used to produce the results presented in the latest Cedefop publications (Cedefop, 2010 and Cedefop, 2011). The latest attempts to improve the cohort component methods (as in Kriechel (2011)) are reviewed in the last section.

6.1. General overview

The main data used to model replacement demand are based on the LFS. These data allows us to analyse the demographic composition of each occupation. This makes it possible to estimate specific rates of retirement for each occupational class. LFS data can also be used for making estimates of outflow rates. The replacement demand model (RDMOD from Figure 1 in the introductory section) has been developed based on similar data sources to the occupational model (ECMOD) (details in Kriechel (2010)). It is driven in part by the occupational and qualification structure of employment, in combination with information on the probability of flowing out from employment due to retirements, occupational mobility and migration. The model used builds upon the national model from the Netherlands (Cörvers et al., 2008). Similar models using variants of the methodology are employed in several other countries, both within and outside of the European Union.

Projections of occupational employment typically focus on the total numbers of people that are expected to be employed in such jobs in the future. While such estimates can provide a useful indication of areas of change, highlighting the likely net ‘gainers’ and ‘losers’, they give a misleading impression of job opportunities and skill requirements. Even where the projections indicate significant employment decline over the medium term, there may nevertheless be quite good career prospects with significant numbers of new job openings. This is because, as long as significant numbers of individuals are still likely to be employed in the future, employers will need to replace those employees who leave because of retirement, career moves,

⁽³⁰⁾ Technical details about this method are provided in Kriechel and Sauermann (2010).

mortality, or other reasons. Replacement demand may often dwarf any 'structural demand' or so called 'expansion demand', resulting from growth in employment in a particular category. It can easily outweigh any negative changes due to projected employment decline.

While the concept of replacement demand is simple enough to grasp, estimating it is a rather different matter. The main problem is that official statistics place much more emphasis on measuring stocks of people in particular states rather than flows, which is essential to estimating replacement demand.

However, use can be made of readily available statistics in order to provide indicative estimates. Ideally, one requires a full set of demographic accounts that trace people's movement from one socio-economic position (e.g. employment in a particular occupation) to another (e.g. retirement). In practice, such a complete set of accounts are rare even at national level. However, for several consecutive years now the Labour Force Survey (LFS) provides a sufficiently large sample to obtain estimates of the main elements at national level. The key components are: information on the age and gender structure of occupational employment; information on rates of outflows due to retirement (including early retirement); inter-occupational mobility; migration and/or other reasons for leaving the workforce.

The information on outflow rates can also be estimated using stocks of age-cohorts within occupations for several years. Using the year-to-year changes the outflow rates by occupation-age cohort can be estimated. However, these estimates may not allow for discrimination between the reasons for the outflow that leads to replacement demand. Given the data availability, this methodology is used for the purposes of the current forecast.

Age Structure: Data on age structure are required since many of the flows, especially retirements, mortality and occupational mobility, are age specific. Age structures vary significantly by occupation. For some groups, such as corporate managers and administrators, experience is a key requirement and this is associated with age. The proportion in the 45-59 year old category is therefore relatively high. In contrast, in many other occupations the age structures are much more heavily skewed towards younger age groups. In sales occupations, for example, the age structure is much more heavily weighted towards younger age groups. Differences in age structure across occupations influence replacement demand due to occupational mobility and retirement, which are age related. Even inter-occupational mobility is affected differently over occupations.

Retirement: Retirement rates vary by gender and by age and may differ for different occupational groups. But since sample numbers are often too small to allow for meaningful estimates methods to deal with these problems need to be adopted. Estimates can be based on data from the LFS, which show the percentage of those employed one year ago who have retired from employment, either temporarily or permanently. For males, the main outflows are associated with retirement per se. For females, in particular, there is significant, quite often temporary, outflow for younger age groups associated with family formation.

Mortality: Another potential outflow is due to mortality. While losses due to death are not great for individual age groups up to the age of 65, they can cumulate to produce significant losses over an extended period. However, the current model does

not explicitly incorporate differential mortality risks (not least because no significant or radical changes are expected in them). Rather the focus of the cohort component methodology is to identify overall outflows over cohorts, irrespective of the cause (sickness, death, family obligations).

Migration: Net migration can have an important effect on the in- or outflow of the labour market. One of the problems of migration is the lack of suitable data.

Occupational Mobility: Occupational mobility is an important source of replacement demand in some occupations although not for all. The full occupational mobility flow matrix indicates that some occupations such as managers tend to gain employment as people are promoted from other occupations. The cohort component approach does not differentiate the replacement demand which is due to occupational mobility. It only identifies net mobility.

The overall scale of change is obviously dependent upon the length of period considered, as well as the opening stocks and the age structure of the current workforce. Replacement demand is also dependent on the level of occupational aggregation. With lower levels of aggregation, the observed occupational mobility is lower. For most projections rates of outflow are assumed to be constant over time. The scale of structural or expansion demand (which in some cases may be negative) is usually modest compared to replacement needs, and in most cases the latter offsets any negative change.

Replacement demand is driven by the proportion of employees in an occupation that is likely to leave within the forecasting period. A higher share of those workers in the base period of a forecast will lead to a higher predicted replacement demand. Business cycles are also prone to shifts and outflows at some point in time. With respect to the timing of (early) retirement, in good economic times people are likely to stay on a little longer, hence the outflow rate will be somewhat lower. In contrast, in bad economic times, people that are likely to leave soon will have incentives to move out earlier.

The period of the economic downturn (global or sectoral) has an impact on the timing of the outflow that can lead to some short-term shifts in replacement demand. Companies try to accommodate the lower demand for workers by reducing flexible work (temporary agents and not core staff), but also by bringing forward outflows that are likely to occur in the near future (retiring rather than firing). In other words, early retirement schemes – official or not – are being used to reduce the workforce if possible. This implies that the outflow among the cohort of older workers, who are close to retirement, is temporarily higher, while the amount of outflow will be lower for some time after the crisis. This lowering effect is the simple result of the reduction in the population of workers that reach retirement age.

On the other end of the age distribution, the outflow of younger workers is also likely to be increased somewhat as they are more likely to have temporary contracts or may be the workers that are the easiest to lay-off. There can be several interrelated reasons for this, including common ‘last-in first-out’ rules which apply in many countries or sectors and legal rules which often stipulate compensation based on tenure and age, which encourages employers to focus on younger workers. Other economic arguments of accumulated human capital can also lead to this result.

While the outflow increases temporarily – this in the methodology of replacement demand means that the replacement demand increases as well – it is not likely that replacement demand in those economic circumstances will be filled in immediately. Some catch-up will rather take place after the economic recovery. The annual replacement rate is taken as an average over the entire forecasting period, which is not affected by such cyclical behaviour on the labour market. However, it is important to be aware of the implications of the crisis for in- and outflows of workers that might lead to a temporary deviation from the overall replacement rate.

6.2. Current specifications of the model

The methodology follows the approach used by ROA in its national forecasts (Cörvers et al., 2008), adapted for the data availability of the other European countries. It is based on the cohort-component analysis that uses the Eurostat LFS for all countries, while disaggregating education into several ISCED categories (for replacement demand by education), and ISCO categories (allowing estimates of replacement demand by occupation).

There are three components to the model:

- (i) a forecast of demographic development within a country
- (ii) a forecast of (changes in) participation, preferably by gender and age groups
- (iii) an estimate of the outflow by occupation (education) category, gender and age group

Components (i) and (ii) are usually considered external to the replacement demand model. Current estimations are based on the baseline model of the Europop2008 forecast⁽³¹⁾, which was the most recent demographic forecast by Eurostat. Changes in participation use the same participation rate by country, age and gender as generated within the E3ME model. This insures consistency across the entire set of forecasts.

The basic steps use occupation (subindex *o*) as the relevant subcategory. However, one can interpret the methodology analogously if education is used instead. For the purposes of the Cedefop forecast, education is not estimated separately given the high level of aggregation on the education variable. Rather, the replacement demand by education is deduced from the occupational replacement demand. By using the occupational replacement demand and imposing the most recent distribution of education by occupation, we are able to present the most likely replacement demand using the current demand for education levels within an occupational class.

Table 9 gives a schematic input-output table of the labour force/population in a country (see also Willems and de Grip, 1993). The first rectangle gives the movements within the labour market. The second, bigger rectangle encompasses movements out of the labour market, while the third rectangle also considers changes in the population. Adding rows (for time *t*) or columns (for time *t-n*) of these flows gives the total population within an occupation.

⁽³¹⁾ In the Cedefop forecasting work we do intend to use as actual data as possible. For the forecast which will be published in 2012 Europop 2010 will be used with the highest probability.

Table 9: Schematic of replacement demand

Outflows Inflows	Occupation 1	Occupation 2	Unemployed	Outside the labour force	Outflow population	Total
Occupation 1	A	B	C	D		$W_{1,t-n}$
Occupation 2	E					$W_{1,t-n}$
Unemployed	F					
Outside the labour force	G					
Inflow population						
Total	$W_{1,t}$	$W_{1,t}$				

Source: Willems and de Grip (1993)

Several flows are indicated in the table with capital letters. A denotes the workers that work in occupation 1 at time $t-n$ and continue to do so in period t . B denote the workers that move from occupation 1 to occupation 2 in the observed time. E denotes the opposite movement from 2 to 1. Thus, B and E denote the job-to-job mobility. C and D denote movements out of the labour market from holders of occupation 1. Corresponding inflows into occupation 1 are F and G in the schema.

The first step in modelling future replacement demand per occupational class is a description of the inflow and outflow patterns by occupational class in a historical period. Because there is no appropriate data for mobility flows on the labour market, stock data are used. With the so-called cohort components method, cohort-change rates based on the number of persons of the same birth cohort who were employed at two different time periods can be calculated (see Shryock and Siegel, 1980). These cohort-change rates can be rewritten as average annual net inflow or outflow percentages (flow rates for males and females are differentiated):

$$\dot{F}_{o,a}^{t-1} = \frac{k W_{o,a+1}^t - k W_{o,a}^{t-1}}{k W_{o,a}^{t-1}} \quad (16)$$

Where $\dot{F}_{o,a}^{t-1}$ is the annual net inflow or outflow ratio of workers in occupational class o of age group a (with class width k) at time $t-1$ during the period $(t-1,t)$; $\square W_{o,a}^t$ is the number of people working in occupational class o of age group a (with class width k) at time t . The time lags are used to describe how particular cohort is moving within occupation. $F_{o,a}^{t-1} > 0$, there is a net inflow for a certain age group from an occupational class, and if $F_{o,a}^{t-1} < 0$ there is a net outflow.

The second step in modelling is to translate these inflow- and outflow-percentages into the replacement demand by occupational class. As stated above, for occupational classes with an increase in employment in the period $(t-1,t)$, replacement demand is equal to total net outflow in this period. However, for occupational classes which faced a decrease in employment, not all vacancies due to the outflow of workers will have been filled. Therefore, replacement demand for these occupational classes equals the number of vacancies that is likely to be actually refilled, that is, the total inflow of

workers into the occupational class. In this way, the more or less 'structural' replacement demand is derived. This methodology measures only the net flow to or from an occupational class. This means that replacement demand satisfied by re-entering workers of the same age cohort is not measured. So replacement demand is actually measured only for newcomers into the labour market.

A model is then estimated in which the net inflow or outflow ratios are explained on the basis of the average inflow or outflow from the total working population, on the one hand, and the occupation-specific deviations per age-gender group, on the other. This approach guarantees that the sum of the net flows among the occupations corresponds to the total inflow or outflow.

Written mathematically:

$$\dot{F}_o = \dot{F} + \sum_k \beta_{ok} D_x \quad (17)$$

Where:

\dot{F}_o is the vector of net inflow of outflow ratios for occupation o , with observations for gender, age group and year; \dot{F} is the vector of net inflow - outflow ratios for the total working population; D_x is the matrix with dummy variables where elements are equal to 1 for cohort x and 0 elsewhere; and β_{ok} represents random parameters.

The third step is to project the historically measured net replacement demand rates per age-gender group for a particular occupational class onto the age-gender structure of the workers at the beginning of the forecasting period. The outflow coefficient is then combined with changes in the participation rates and applied to the population of workers within an age cohort. An increase of participation rates implies less replacement demand. Higher participation rates of workers manifest themselves in this model by lower outflow rates. Given that we estimate on historic outflow rates, the estimated coefficient of outflow will be too high for the future. The expected increase in the participation rate is included by correcting the outflow coefficient for these changes in participation rate.

Finally, a projection is made based on the estimated coefficient combined with participation rate changes applied to the age-gender structure of the occupation as predicted by demographic and participation forecasts. To model the demographic composition of an occupation and its dynamic changes, we project uniform changes of one age cohort in the next cohort over the total projected time-horizon.

Replacement demand due to other reasons is the remainder of the estimated replacement demand net of the retirement group. It comprises the occupational mobility, migration, early retirement, and movements out of the labour force for other reasons. This result is therefore driven by all elements of replacement demand, population, participation, and the gender-age specific outflow coefficient.

In the forecasting results we distinguish between the two components of replacement demand: retirement and other reasons. While the first figure gives the components by country totals, the second calculates the European totals by occupation group. It can be seen that retirement accounts for less than half of the replacement demand. However, this does not imply that retirement is not one of the most important reasons for replacement demand, as it can also be manifested in some countries as early

retirement schemes, or other permanent outflows from the labour force (e.g. unemployment of older workers), which diminishes the population of active older workers before they reach the official retirement age.

An important aspect that influences replacement demand is the participation rate of cohorts by gender. For example, an increase of participation of women around the time that their children reach schooling age (usually in the cohorts of 30-34 and 35-39) will offset other elements of replacement demand. This is a change that has happened or is happening in many countries of the European Union. Female labour participation is increasing, especially around the age groups that they were formerly retreating from the labour market.

Some Nordic countries, but also the Netherlands, with high replacement demand forecasts have already achieved a high level of participation of women across all age cohorts. They cannot gain as much from increasing participation as can the countries that are starting from a low level of participation for cohorts of middle aged women.

6.3. Testing the alternative approaches

The current design of replacement demand modelling in the form of cohort component method is considered as rather robust and stable. On the other hand the cohort component approach has been criticised in volatile environments, in which e.g. large in- or outflows due to migration take place. This critique has been voiced among others by Fox and Comerford (2008).

It is truth that using cohort component method we are facing two main difficulties: (1) data used does not allow us to observe the full population, but rather a sample of the population; and (2) we do not observe birth cohorts, but rather identify them through age cohorts. Depending on the data set we can distinguish between one year brackets in age, or only five year groups. This last aspect can be important for the derivation of the outflow estimate and it's precision.

6.3.1. Panel data

The potential availability of panel data makes it worthwhile to investigate their use in the context of replacement demand. In this section we distinguish between short, rotating-panels as they are included in several national labour force surveys, and longer panels that are usually household-based. The theoretical advantage of the panel is that the same person can be observed several times. This allows for a true measure of flows if the population is representative with respect to their occupation change behaviour. Panels are, however, costly to collect and even more difficult to maintain. Such panel, however, might be biased with regard to flow measures, if there is an attrition bias related to flow measures.

The rotating panel is a new element added to many national labour force surveys. It follows up on the labour force survey with the same respondent (several times) with a subset of questions. Changes in employment and education status can then be used to evaluate the dynamics of those items.

This should allow estimation of the probability of changes in (ISCO) employment and (ISCED) education for a given age and gender group. The short time duration does

not, however, allow to elaborate panel-estimation techniques. It is also potentially more difficult to identify changes, given that changes might also lead to increases in non-response. For example, a (respondent) worker migrating to another country will be missing in a follow-up. He leaves however an open position, which we would like to measure within the context of replacement demand. Therefore, a careful evaluation of how missing information within the panels is filled in should be included in the analysis. This might differ by country, resulting in different degrees of accuracy and also outcomes.

Below the example of the Netherlands is adopted in order to investigate how such a rotating panel set-up could be used with the replacement demand.

In order to examine the usefulness of short panels as an alternative to the cohort component methodology, it is insightful to compare results of flow estimates based on the two different methodologies while using the same type of data. We use in the following the Dutch LFS which includes a short rotating panel. Each respondent is approached five times, on a quarterly basis. We use the first and last responses which are one year apart. On a 3 digit occupational level, we observe occupational changes.

Any change in occupation is considered an outflow from the occupation at t for the occupation at point t inflow for the new occupation, observed at $t+1$. Net flows are then the total flows within an age cohort, where we subtract the outflows from the inflows. The percentage flows are then the net flows relative to the total number of workers in the age cohort by gender of an occupation at point t .

Table 10: *Regression analysis of cohort component versus panel flow estimates*

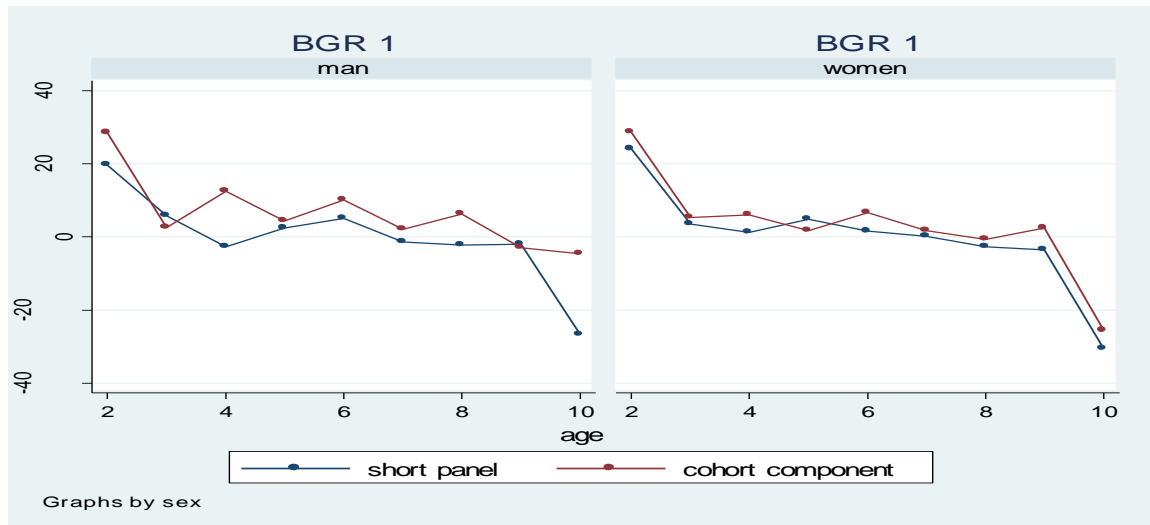
	% net flow cohort component			
	(1)	(2)	(3)	(4)
% net flow panel	0.667***	0.667***	0.648***	0.858***
	(0.147)	(0.147)	(0.143)	(0.000316)
gender		YES	YES	YES
size of occupation			YES	
Constant	Yes	Yes	Yes	Yes

Source: Dutch LFS, 2001-2007, pooled flow measures. Estimates are at the 3 digit occupation level by gender and age cohort. Estimation technique are OLS (1 – 3) and weighted OLS (4). *** significant at the 1% level.

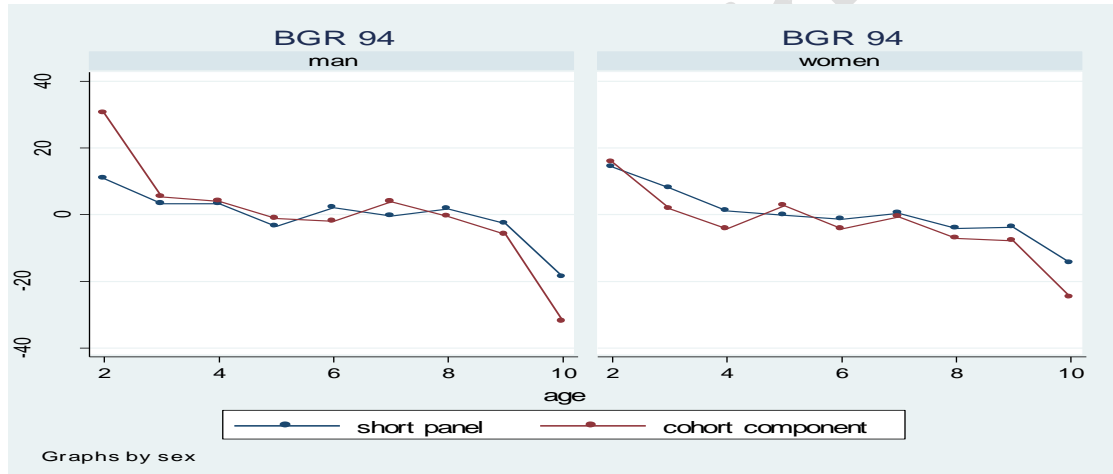
The percentage flows by occupation – age – gender are surprisingly similar. Regressing the net flow rates using panel estimates to those of a cohort component methodology shows a correlation that ranges between 0.648 and 0.858 (cf. Table 10). A similar conclusion can be drawn using the plots of flow rates by age cohort for several occupations. We show three occupations (3 digit occupation level), for the age groups in Figure 7.

Figure 7: Flow rates for selected occupations, cohort component versus short panel, 2001-2007, Netherlands

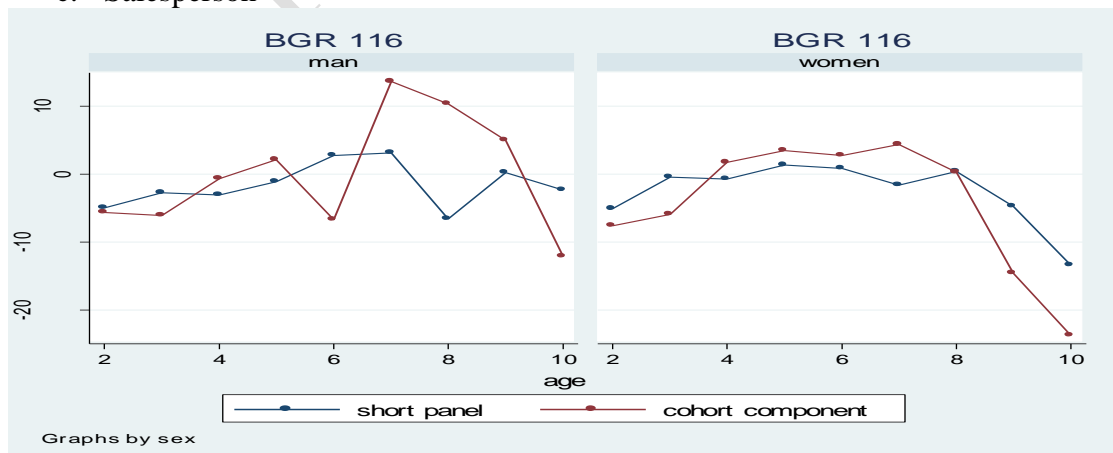
a. School teacher



b. Lower administrative worker



c. Salesperson



Source: Dutch LFS, 2001-2007, pooled estimates.

Long panels are usually more accurate as they enable to following up on workers that do not respond ⁽³²⁾. It is also easier to identify individual labour market behaviour, as well as the changes that appear in over it's life-cycle and career. However, not all countries have (publicly available) panels which span a longer time period and have sufficient amount of respondents to allow for a more detailed analysis of the behaviour.

Long panels have limited population which is problematic. For each of the occupation categories the outflow by ten age categories, identified separately for males and females, is identified. This leads to small cell sizes which influence the outflow figures. Given that the population does not rotate as in the rotating (short) panel of the labour force survey, it is also less likely that all occupations are covered consistently. While we attempted to calculate outflow rates for Germany and the United Kingdom, it became obvious that the cell size is too small to provide sensible estimates on ISCO 2 digit level. For example, using the last ten years of the BHPS (1998-2008), and aggregating across gender and ages, yields outflow percentages by occupation between 0% and 2.9% annually, with an average of 0.26%. Worse still, these flows are on an occupation level heavily influenced by the cell size (the number of people observed in the occupation), in such a way that both the lowest and the highest flow figures are coming from the occupations with the least observed respondents.

6.3.2. Retrospective questions

In the retrospective question, workers are asked retrospectively whether the current (t) labour market status is the same as the one they had at some previous time (t-1). In detailed questionnaires this can entail changes in employment status, occupation, employer, industry, but also education level and direction.

A problem of this approach is retrospective bias and item non-response. Recall bias is shown to affect non-salient changes in the answers of respondents. Changes that are not seen as being very important are forgotten during the time that the respondent answers the questionnaire. It is likely that the recall bias affects those issues that are salient less than those that are less salient. In other words, movements into or out of employment are probably not forgotten, whereas changes of position, upgrading of degrees, or maybe even changes in companies might be forgotten.

A more subtle problem is the problem that respondents cannot easily judge timing of events in retrospective questions. If the question is not properly anchored, the respondent might attribute different times to changes in his work, this recall bias, however, can go either way.

Both issues can lead to a bias in the answer to the retrospective question. Whereas the recall bias can be signed, i.e. giving the direction and the order in which it affects the underlying question, the second bias cannot. We can therefore assume that the errors are random.

⁽³²⁾ As the long term trends can be used for smoothing eventual non- responses.

6.3.3. Administrative data

Administrative data has two advantages: First, they usually encompass the entire population. Second, it does not rely on surveys that would have to deal with non-response, question wording, and other such problems. Therefore, it is usually assumed that administrative data contain little or no error⁽³³⁾. Administrative data has been made available to the research community in several countries (cf. Lazear & Shaw, 2009). The data varies, however, in terms of the underlying data source and the purpose for which the data was originally collected. Nevertheless, they do have the possibility to be linked with other data. Several aspects make the general use of administrative data cumbersome:

- data sets are generally big;
- access to the data is usually very restrictive;
- documentation of the data is often limited.

The treatment of administrative data can be done in an analogous way to the long-term panels. The advantage is that there is usually less attrition. However, given that access to administrative data is restrictive, and often only available within national borders, we refrained from continuing and including exemplary flow rates.

6.3.4. Conclusions from testing the alternatives

The alternative approaches and datasets described above can be used in forecasts at national level but their usability for Cedefop forecast is limited due to the lack of necessary data for the whole of Europe.

There could be a way if the European LFS would systematically ask the retrospective question in all countries. Given that a similar question on the sector of employment in the previous year exists, it seems rather straightforward to include a similar question on the occupation. Ideally, also the practice of including short, rotating panel set-ups for the national LFS could be applied for the whole of Europe. As the case of the Netherlands show, this would provide a more stable estimate of net flows and also allow further investigation into the causes of the flows.

Another option would be to allow national experts to supply unconventional flow data using one of the alternative methodologies that can improve the flow measure. Good and consistent data-sets available at the national level could potentially significantly improve the quality of the replacement demand forecast for Europe.

⁽³³⁾ The degree to which there are no or few errors in the data depends, however, on the purpose for which the administrative data are collected. For example, the data of the Netherlands are based on Dutch tax data. It only contains data on legal salary payments, including all errors made by companies in calculating them. Given that the tax authorities have every incentive to control those, it is likely that the data is at least more accurate than those contained in surveys. They would be, however, less accurate for the purpose of assessing money paid for (illegal) work.

7. Reconciling skills supply and demand

Economic theory as well as economic reality shows that coexistence of unemployment and unfilled vacancies is a natural and simultaneous feature of the labour market. Even in full employment it is difficult to reduce the number of unfilled vacancies to zero due to the search costs and asymmetries in the labour market. This is especially the case when the imbalances within particular occupations are caused by a lack of appropriate skilled labour force which is usually solved by retraining and/or reallocating workers. One of the aims of the process of anticipating changing skill demand and supply is to uncover potential imbalances in such a way that adequate preventive measures can be taken.

Knowing more about potential skill imbalances in the labour market is very important for policy. The projections of the skills supply and demand can throw light on possible future developments in European labour markets, highlighting potential education mismatches and helping to inform decisions on investment in skills, especially formal qualifications, made by individuals, organisations and policy-makers.

Comparing current demand and supply projections is however problematic for both practical and theoretical reasons. Unless the two sets of results are based on common data and are carried out simultaneously, they cannot be directly compared. In reality there are large numbers of adjustment mechanisms that operate in the labour market to reconcile imbalances that may arise. In the short term, these include adjustments in wages and different kinds of mobility, as well as changes in the ways employers utilize the skills that are available. In the longer term both supply and demand will adjust to reflect the signals and incentives that arise due to these forces.

Generally, employers will not cease their operations if they cannot find the ideal mix of skills. They will operate with what is available. Conversely, if the educational system delivers too many people with particular levels of formal qualification this does not necessarily imply that these people will remain unemployed. Rather they tend to find jobs that make less direct use of their qualifications, since their education and training still often puts them at an advantage in the labour market compared to those with lower level qualifications. The labour market operates as a kind of sorting mechanism that allocates people to jobs, based on the limited information available to both sides (employers as well as actual and potential employees).

In principle, these mechanisms can be modelled and incorporated into a forecasting tool. In practice, this demands very detailed and rich data that are, at present, not available at a pan-European level. In the present results a more limited reconciliation is used to recognise the key features of the labour market interaction. The projected numbers on the supply side are taken as given for this purpose. This reflects the fact that the total numbers available by qualification level are largely predetermined by demography and educational and training decisions already made. The much better qualified new entrants coming into the labour market, replacing much less well qualified older people, imply that substantial improvements in average qualification levels are inevitable in the short to medium term.

This section describes Cedefop solutions to the above-mentioned problem. The main data and methodological limitations of reconciling labour supply and demand with respect to qualifications, including the use of labour market accounts residuals are

presented in the first part of this section. The second section focuses on the approach used by Cedefop to provide reconciliation of skills supply and demand. The construction of possible indicators for better understanding and interpretation of the imbalances is described in the final part of this section. More details can be found in Kriechel and Wilson (2010, 2011b)

7.1. Measuring imbalances

As discussed in previous section, within the current Cedefop framework the focus is on employment in sectors, occupations and by qualifications; labour supply by qualification, age and gender; and unemployment distinguished by qualification category. Vacancies are not used as there are no detailed and comprehensive ⁽³⁴⁾ measures available at a pan-European level ⁽³⁵⁾.

When comparing estimates of demand and supply of labour (and skills) it is important to recognise significant problems that arise due to different measurements applied in different sources. This section focuses on differences in the historical estimates of the labour force, employment and unemployment used in the Cedefop framework.

The population data used in E3ME are constrained to match the official Eurostat numbers and projections. The labour supply numbers in E3ME are therefore not LFS benchmarked as such, although they use LFS activity rates. They rely on Eurostat demographic data to produce the overall numbers and LFS activity rates by age and gender.

Labour demand is measured as employment. Obviously this is not strictly correct. Observed employment is the consequence of both demand and supply factors, nevertheless it is common practice in work of this kind to refer to employment as de facto 'demand'. Overall employment levels from E3ME by sector are translated into implications for occupations by the EDMOD module, as described in Section 5. This is based on a detailed analysis of occupational employment patterns within sectors. This module also produces initial (unconstrained) estimates of employment by qualification (again based on an analysis of changes in employment patterns within occupation and sectors).

In order to focus on imbalances by skill (as measured by qualification) these initial estimates of employment by qualifications are constrained to match 'supply in employment'. This is a measure of the number of people by highest qualification held who are economically active and in employment. This is on an LFS/Eurostat demographic accounts basis. It is then scaled to match the E3ME National Accounts based estimate of employment. Therefore dealing with the so called 'labour market accounts residuals' (LMAR). This final set of employment estimates by qualification matches the total employment in E3ME on a NA basis and is known as 'constrained demand'.

⁽³⁴⁾ The Vacancy monitor used by DG EMPL does not provide data of sufficient quality to be used in the modelling framework.

⁽³⁵⁾ Although Cedefop is exploring the possibility of collecting such data via a new Employer survey.

As noted above, the labour market accounts residual (LMAR) in E3ME is the difference between Employment (workplace jobs, national accounts) $E(j)$, and Employment (head counts, LFS based, residents) $E(r)$.

$$LMAR = E(j) - E(r) \quad (18)$$

The person/jobs distinction is not entirely clear cut. The LMAR arises for a range of reasons of which occupation is just one (double jobbing). Other factors include: commuting (flows across national borders); and statistical discrepancies between NA and LFS based estimates. NA employment appears to generally refer to persons rather than jobs (as in the LFS), meaning that most of the discrepancies arise from reasons other than double jobbing.

The LFS based estimate of employment ($E(r)$) is a count of people employed in a particular country. It is equal to the Labour Force (LF) less the number of people unemployed (U), both measured by head count.

$$E(r) = LF - U \quad (19)$$

Information on unemployment by qualification level is available from the LFS. This can be used in combination with the projected totals of unemployment from E3ME to generate projected levels of unemployment by qualification level, by making assumptions about maintenance of historical differentials in unemployment rates.

Equations 18 and 19 can be variously rearranged in order to derive indicators of interest from the model outputs:

$$E(j) = LMAR + (LF - U) \quad (20)$$

In E3ME the following slightly different terminology is used:

$$E(j) = EMP \quad (21)$$

'Unemployed' in E3ME is given by:

$$\text{'Unemployed'} = LF - E(j) = E(r) + U - (LMAR + E(r)) = U - LMAR \quad (22)$$

E3ME then generates a variable called 'U level' as follows:

$$\text{'U level'} = \text{'Unemployed'} + LMAR \quad (23)$$

This is equivalent to the normal ILO measure of unemployment.

Unemployment in all countries is calculated this way, except for Luxembourg, where the discrepancies were so large that it was not possible to model unemployment in a stable manner. The LMAR is calculated to match the last year of historical data, taken from DG Ecfm's AMECO database, which uses ILO-consistent definitions. In the modelling, the LMAR is calculated using a 'fixed share of employment', although in the workbooks it can appear to vary; this is because the unemployment rate in the workbooks is only calculated to one decimal place. 'U Level' can easily be calculated from 'U rate' by multiplying by the total labour force (LF).

However, as shown in equation (22) above, this will include the LMAR. The value of the LMAR will vary for those with high, medium and low qualifications. It is possible to assess this by going back to the raw LFS data and using the historical estimate of the unemployment rate for high, medium and low qualified people to generate a number for those unemployed in each category in the base year. This can then be compared with the difference between the ‘demand’ and ‘supply’ numbers in the base year. The difference is the LMAR for that qualification category. In principle, this can then be projected assuming (in the first instance) that it remains a constant proportion of the total LMAR (from E3ME) for all future years. In practice this has not been done. Instead an assumption is made about how unemployment is ‘shared out’ amongst high, medium and low qualification categories.

The E3ME data on total unemployment are used to provide overall constraints on the implied unemployment numbers by qualification (three broad levels: High (H), Medium or intermediate (M), and Low (or no) qualifications (L)) in the imbalances work. The latter are constrained to match the overall E3ME estimates of ‘U level’, making assumptions about how overall unemployment will be ‘shared’ between those with different levels of qualification, using LFS historical data and assumptions about how these patterns might change in the future. These assumptions are that previous differentials will be maintained but that the better qualified will take an increasing share of total unemployment in line with their increasing share of the workforce.

One measure of initial imbalance and mismatch by H, M & L qualification levels can be obtained by subtracting the unconstrained ‘demand’ estimates (employment estimates by qualification from the demand model, summed across all sectors and occupations) from the corresponding ‘supply’ estimates (the total labour force across all ages and genders).

Initial comparisons suggest that the independent projections of qualifications patterns for supply and demand exhibit significantly different trends, with the supply of those with high and intermediate level qualifications generally rising more rapidly than the demand.

The implied demand side employment rates by qualification category, when compared with the supply side activity rates, indicate some odd patterns, both across categories and over time. In principle, of course $e/r < a/r$. A final adjustment has been made to the employment by qualification estimates to take into account the LMAR.

7.2. Estimation of imbalances

The historical patterns of employment by qualification observed are the result of a combination of both supply and demand factors. Separating them is not straightforward. Recent trends have seen a sharp rise in the formal qualifications held by those in employment in most countries. There is some evidence that this reflects demand changes, with many jobs requiring more formal higher level qualifications than used to be the case. There are also indications that the returns to obtaining such qualifications have remained high (for a review see Wilson et al. (2007)). On the other hand it is clear that there have been major changes on the supply side, in part at least in response to government policies to increase participation in higher education. The latter has resulted in a big increase in the numbers of people entering the labour

market with high formal qualifications. The proportion of young people with higher formal qualifications is much higher than for older people. There is therefore a strong cohort effect. This has been reinforced to some extent by increasing qualification rates for older people as well (due to lifelong learning and ‘up-skilling’ effect). (See part of 3.4)

The observed patterns of employment (stocks of people in employment with formal qualifications) clearly reflect both demand and supply side influences. Certain indicators are more informative about one than the other. In particular, there are various measures of the flows of people through the education system which can be regarded as primarily supply side indicators (although even these reflect decisions that people are making about education based on their perceptions of the overall balance of supply and demand for different qualifications).

In principle, it is possible to develop quite sophisticated analyses of the numbers of qualified people at higher level, using information on the flows of people through the education system. The overall supply of people holding formal qualifications at higher level (ISCED 5 and 6) is relatively straightforward to conceptualise and model. However, there are considerable conceptual and practical difficulties in extending this to include lower level qualifications (ISCED 1-2). A particular difficulty is to conceptualise the idea of supply to cover specific dimensions such as occupation, sector and geographical area. This is because the educational systems in most countries are not completely hierarchical. These issues are discussed in turn.

Limitations by ISCED level: The first problem to be addressed in extending this type of model to cover the full range of qualifications is the much more limited information available on lower level qualifications (ISCED1-2). Ideally, stock-flow modelling requires a comprehensive set of demographic accounts showing how individuals progress throughout the educational system and the labour market over time. In practice such accounts do not exist, although there is a considerable amount of information on certain flows as exploited in the skills supply module described in Section 4 of this publication

Statistical agencies collect and publish a considerable amount of information on the higher education in particular. This can be used to develop estimates of the main flows involved and thereby develop stock-flow models of this process. In practice, this information is often disparate and far from comprehensive.

In the case of lower level qualifications, while there is an enormous amount of detailed information available on the acquisition of qualifications, there is much less information on what prior qualifications these individuals may have possessed. This makes it difficult, if not impossible, to develop stock-flow models analogous to those constructed for higher levels (as for example in Wilson and Bosworth (2006) for the UK).

Highest versus all qualifications held: The discussion so far has focussed on highest qualifications held. As individuals acquire ISCED level 4, 5 and 6 qualifications, it is almost inevitable that the proportions with ISCED levels 1-3 as their highest qualification will fall. This can mean that, despite increases in those acquiring ISCED level 1-3 qualifications, the numbers and proportions of people possessing these as their highest qualification may actually decline.

Problems in conceptualising supply into occupations or sectors: Most occupations are undertaken by people with a range of formal qualifications. This is partly a function of age, with older workers generally relying more upon experience than formal qualifications. However, even allowing for the age factor, there are enormous differences. This makes defining the supply of people into an occupation almost impossible. It is possible to identify some key elements, focussing on the flows of people through the education and training system, but boundaries are too blurred and transitory to enable robust quantitative modelling.

Much the same is true for the concept of supply of labour to a sector. This will depend upon the occupational mix of the sector and its geographical location. For some occupations the labour market may be worldwide. This is increasingly true of many high level managerial and professional groups. Ever increasing ease of transport now means that it is also a feature of the labour markets for many lower-level occupations (for example, construction and agricultural workers, as well as nurses). While these issues may be addressed within individual sectors it is very difficult to develop a general approach that can cover all these aspects consistently for the whole economy.

There may be some over or under-qualification and this pressure varies between occupations and sectors. The following elements are important here:

- (i) the demand for qualifications model, which delivers overall numbers of people in employment, qualified at three broad ISCED levels;
- (ii) the stock of labour supply;
- (iii) the sorting model (SORT algorithm described in the Annex IV), which sorts people according to the qualifications held into occupations to make the results from (i) and (ii) consistent.

The SORT algorithm reconciles the two sets of estimates of demand for and supply of qualifications. This final element compares the supply numbers with the demand ones and re-computes the employment patterns to bring the two into agreement (making certain assumptions about unemployment). Effectively it acts as a sorting mechanism that raises or lowers qualification shares within occupations until demand and supply numbers match. This does not imply that demand and supply are equal however, since some people may be over or under-qualified for the jobs they are employed to do.

The Sort algorithm used in BALMOD ⁽³⁶⁾ provides a simpler approach to reconciling the demand and supply results in aggregate, given the data available for all countries. Its outcome is that for individual occupations or sectors the patterns of qualifications as revealed by the original unconstrained demand projections and the constrained ones will show how any surpluses or shortages affect the qualification mix. If supply is growing faster than demand for particular levels of qualifications then the constrained qualification mix will be ‘richer’ than the unconstrained ⁽³⁷⁾ one (and conversely).

⁽³⁶⁾ Module BALMOD of the Cedefop conceptual modelling framework (see Figure 1 in Introduction) is designed to bring together the demand and supply estimates to tackle this issues. Demand is projected by sector, occupation, and qualification level (highest qualification held), whereas the supply focuses on qualification, by gender and age.

⁽³⁷⁾ Reminder: as the unconstrained demand we understand the demand initially produced by the model and as the constrained demand we understand the one adjusted to fit the supply as described above.

Comparison of the constrained and unconstrained results provides a useful indicator of supply-demand pressures for different occupational and sectoral groups.

The concept of supply of qualifications at a spatial level is somewhat more manageable than that for occupations or sectors. It is relatively straightforward to develop quantitative estimates and projections of population and the labour force for each country. In principle, this can be extended to cover formal qualifications held. However, the data available at pan-European level are generally less robust than at a national level. Moreover the issues of commuting and migration flows become significant. While it is possible, in principle, to envisage the development of customised qualification supply models for each individual country this would require considerable resources and time.

The present modelling is therefore limited to a much more simplified level than the more detailed and sophisticated stock-flow analysis applied in some individual member states (e.g. UK, Wilson and Bosworth (2006)).

7.3. Indicators of imbalances

In addition to the reconciled demand and supply estimates indicators of imbalances were also developed to help to understand how imbalances evolve, to identify emerging trends and to allow for comparison across countries. These indexes provide a comprehensive picture on possible imbalances and mismatches in the labour market. We distinguish between indicators that are derived from the raw supply-demand comparisons, and those that are derived after we have reconciled supply and demand. These indicators are currently in the stage of preliminary results and being tested for their robustness.

7.3.1. Unemployment as a general indicator

The first set of indicators is based on the supply and demand forecast from the separate modules. These indicators are indicative of overall imbalances in supply and demand, i.e. an over- or undersupply, be it by education or in total. Furthermore, we use the extrapolated unemployment rates by education level, both as an indicator of the allocative process but also of imbalances that are not directly identified within the model.

The main relation of labour supply and demand is that supply should be equal to the sum of fulfilled demand and unemployment. As described in previous sections, unemployment is derived within the model. The unemployment rate by education level can be seen as an indicator of matching efficiency. Overall high levels of unemployment imply that the supply cannot be properly matched to demand. This can have two reasons: (1) there is too much supply relative to demand; (2) the supply does not fulfil the requirements for the demand. The first point is straightforward, as it is a simple imbalance of total oversupply. The second one captures elements of the efficiency of the labour market in matching and generating the supply of skills that the economy actually needs. For example, there can be a high overall unemployment rate if the labour market demands only high educated, while the supply consists mainly of low and intermediate educated people. If firms do not adjust their production technology to substitute low and intermediate educated individuals for high educated

ones, hence change their demand, it will lead to unemployment among the low and intermediate educated, while there are at the same time shortages for the high educated. Within education levels there can also be mismatch if the field of education within a level does not match supply and demand. For example, if the supply is mainly within the field of health, while the demand is mainly in the field of technical studies, it is likely that there is at least temporary unemployment. This last aspect of field mismatch is not currently modelled in the supply and demand forecasts. If, however, this is a structural problem within the economy, this will show up in higher unemployment (and vacancy) rates.

7.3.2. Difficulty to hire indicator

This indicator should identify the difficulties an organisation is likely to have if it needs to hire a worker for a specific occupation. The indicator (ITKB) summarises the supply-demand relationships of all education types that can be employed for each level of education. This is weighted by the likelihood that an occupation is filled with a certain type of education. The weighting is based on observed (base year) shares of the occupation-education matrix. The number of people working with a specific background (education) in an occupation thus determines these weights.

$$p_i = \max\left(1, \frac{\text{demand}}{\text{supply}}\right)$$

$$ITKB = \frac{\sum_i p_i x_{ij,t-1}}{\sum_i x_{ij,t-1}} \quad 0 \leq ITKB \leq 1 \quad (24)$$

Where $x_{ij,t-1}$ is the total amount of people in occupation j with education type i in the base year ($t-1$). The indicator gives the relative degree to which difficulties can be expected in meeting the occupation in demand. Note that the share p_i is the same for all occupations, as it simply denotes the relative demand to supply of an education type. The implicit assumption is that all shortages in education types will be felt in the same way by all occupations, but weighted to the importance of that education type for the respective occupation. A value of 1 indicates that there are no shortages expected, whereas a (theoretical) 0 would indicate that no demand could be fulfilled. The indicator is rank-ordered and the quintiles determine the relative level of difficulty to fill a vacancy of that occupation.

7.3.3. Occupation level indicators based on RAS outcomes

7.3.3.1. Indicator of change (IC)

The indicator of change measures the adjustment that is needed to unconstrained demand (Du) in order to reach the level of constraint demand (Dc). High levels of the indicator of change indicate significant adjustment processes necessary and higher potential for imbalance. The indicator is calculated for each occupation j across all education types i .

$$IC_j = \frac{\sum_i |D_{c,i} - D_{u,i}|}{\sum_i D_{c,i}} \quad (25)$$

The indicator shows the level of change that is necessary relative to the path that the occupation is taking in the projection years. Higher values indicate a higher level of constraint, and more adjustment to the current path of employment.

7.3.3.2. *Measure of change (MC)*

A similar indicator is the measure of change. It calculates the distance between constraint demand (D_c) at the year of the forecast (e.g. 2020) and the base year counts (D_1) (e.g. 2010). In other words, it gives the adjustment that is necessary from base year to the forecast.

$$MC_j = \frac{\sum_i |D_{c,i} - D_{1,i}|}{\sum_i D_{1,i}} \quad (26)$$

Higher values indicate higher level of adjustment relative to the current (base year) state of the labour market and indicate higher potential for imbalance.

8. Quantitative evaluation of the skills supply and demand forecast

The main motivation for evaluating Cedefop's forecast was to examine its consistency, robustness and usability. The rationale for such work has been hotly debated from the very beginning, with many critics arguing that such exercises are neither useful nor necessary. Such criticisms have been rejected by those involved (and others). Some of these rebuttals are technical, but many arguments are along the lines that such critics are missing the point and often end up attacking a 'strawman'. The aim of this section is not to directly extend that particular debate, although it is concerned with certain key issues that have been fought over by employment forecasters and their critics. These include the question of how to better evaluate employment forecasts.

In some respect the evaluation could be regarded as premature. The main work has only just begun and insufficient time has elapsed to properly assess projections which still focus upon the period yet to come. However, it is important to set in place systems to assess the work and to learn lessons from this in order to improve future projections. The process of evaluation is also not solely a quantitative technocratic one, but also entails a more qualitative element focussed upon the use that is being made of the projections and their value (or otherwise) to users. The approach set out here attempts to encompass both quantitative and qualitative assessments, from both an internal and external perspective (the latter drawing heavily upon the Skillsnet network of individual country experts (ICEs), who have provided critical support from the start of the process).

Before focussing upon the specific quantitative and qualitative assessments of the results produced to date it is important to deal with a number of general issues about what it means to talk about forecast accuracy in the context of the social sciences. It is argued there that such a concept may be a chimera and that the focus of attention should not be on some non-operational ideal measure of forecasting precision. Instead, a more general emphasis should be given on the usefulness and value of the projections.

As becomes clear from the discussion below, a key aspect of the quantitative evaluation is the accuracy of the macroeconomic model, which underlies the employment projections (as is the case for nearly all exercises of this nature worldwide). This section is based on background paper of Wilson and Pollitt (2011). The first part of this section is focused on the general ideas underlying the labour market forecast evaluation. The second part describes the focus and objectives of this exercise. The third section will discuss the overview of projection errors. The final part presents results of the quantitative evaluation. The results of particular indicators (economic development, supply and demand) will also be presented.

8.1. Considerations in evaluating labour market forecasts

Labour market forecasting should be regarded as part of a continuous process rather than a one-off exercise. As such, the projections and the models used to produce them

are continually being assessed and modified in the light of new information. Nevertheless, it is useful for users of the results to have some idea about the accuracy, reliability and robustness of the forecasts.

Assessing the accuracy of relatively simple equations and systems is a well established branch of econometrics. Such analysis is often undertaken as a partial contribution to evaluating the overall accuracy of sets of employment projections (see for example Wilson (1980)). However it is quite a large step from straightforward academic exercise to assessing the accuracy of more complex systems which typically lie at the heart of most detailed employment projections. These are generally dependent upon models involving literally thousands of independent (often inter-related) equations.

The most obvious method for assessing the accuracy or reliability of a forecasting system is to consider how well forecasts made in the past matched up to reality. However this fails to recognise two key points. First, a fundamental problem in all social science forecasting is that forecasts are generally intended to influence behaviour and change outcomes from what might otherwise have been expected. The second one is based on an almost philosophical question about what is meant by 'reality'?

The first point means that evaluation of accuracy is not a simple task. The situation is not one where the results of a simple scientific experiment can be accurately measured, given fixed and known conditions. Such considerations call into question the validity of asking about how accurate the projections are at all. A more relevant question to ask is whether or not the forecast was useful.

This can be illustrated by a very simple example. Consider a forecaster, taking a stroll by the seaside, who observes a blind person walking towards a cliff edge. The forecaster might conclude that, on the basis of observed behaviour, assuming the blind person does not change this pattern of behaviour, then he/she will topple over the edge. If the forecaster shares this forecast with the blind person, who as a consequence changes direction and avoids disaster, the forecast would turn out to be 100% inaccurate. However, it would not have been useless. Indeed, assuming that the blind person was not bent on suicide, it would have been very valuable.

Of course, the consequences of most social science forecasting are not a matter of life and death. Nevertheless, they are frequently concerned with highlighting possible problems and alerting policy makers and individual labour market participants about the consequences of current patterns of behaviour and policy.

The second point raises concerns about data quality and what 'reality' means. All too often in the social sciences analysts are faced by the problem of working on shifting sands. Official estimates of fundamental economic and labour market indicators can often change very dramatically from one vintage to the next, changing perceptions of historical reality. Such shifts in understanding about the current position and what recent trends have been can clearly make the task of predicting the future very uncertain. It is essential that such factors are taken into account in trying to assess the accuracy and reliability of any projections. This is a particular concern in the pan-European projections which are based on less sound statistical foundations than many national ones.

8.2. Focus and objectives of the evaluation

The models used for developing occupational projections are generally very large and complex, often appearing to the un-initiated as black boxes which produce results which are not easily traced back to small set of simple assumptions or axioms. One of the aims of the present study is to make the employment projections produced as part of the Cedefop work more accessible and transparent. A second aim is to provide some useful information about the value, reliability and accuracy of such projections.

The demand for labour depends on many factors, including the state of the macro-economy, the scale of capital investment and on its allocation between industries, the pace of technical change, changing patterns of tastes as real incomes rise, as well as government policy. These factors are often interconnected. Developments in one industry (the introduction of IT in the service sector, for example) affect the demand for labour in other industries (in this case, by raising the demand for the output of those industries that produce computers and related equipment). The multi-sectoral macroeconomic models used by most employment forecasters to produce their projections attempt to incorporate all these factors in a set of consistent and interlinked forecasts for labour demand, covering the whole economy.

The main focus of the present evaluation was on the occupational employment dimension. However, in order to address this issue it was also necessary to consider the various factors which drive the occupational projections. These include the multi-sectoral macroeconomic model outcomes and, in particular, the industrial employment forecasts which drive the occupational employment projections. In each case, the outcome may be different from the projections for a number of reasons. It is important, therefore, to have a clear understanding of how the occupational projections have been derived.

The main and most obvious aim of this evaluation was to assess the scale of forecast errors in the key variables of interest. A secondary and equally important objective is to attempt to explain these, so as to inform users of the projections about the sensitivities of the results to different factors and to give them some feel for the range of possible future forecast errors.

However, given the present state of economic knowledge, it is clear that any attempt at disaggregated medium-term economic forecasting will result in mixed success. Whatever measure of accuracy is chosen, the forecasts for some variables are likely to turn out to be more accurate than others. Forecasters should be wary therefore of implying undue precision to their results. Rather they should emphasise their value as an attempt to work out the possible implications of a set of explicit assumptions about the future which users may find helpful.

8.3. Overview of projection errors

Given the way that employment projections are usually produced and the concepts and issues raised above, it is clear that there are a number of factors which contribute to the errors observed in occupational projections. The ideal taxonomy of these errors is in Annex V.

The first of the set of causes of errors is that primary data used at the time of the forecast are likely to have been in error and may have been revised subsequently - such errors will clearly affect the forecasts. Error in the measurement of the dependent variable is obviously crucial. There are many examples of major revisions to employment estimates. These affect all dimensions (industry, gender and occupation). Errors in the endogenous drivers of the dependent variables are likely. For example, in the case of employment, variables such as economic output or wages will affect the projection of that variable. Errors in the assumptions about exogenous variables underlying the forecast may have been incorrect too. These may be technical assumptions such as extrapolated shares in the occupational model or policy assumptions in the macroeconomic model.

Errors may also arise because of forecaster's errors. Errors of judgement by the forecasters about exogenous variables; errors of specification relating to various aspects of model specification (the models may themselves be miss-specified and inaccurately represent the way that the economy and labour market behaves). This is reflected in the various parameters of the model. In addition, there may be further errors of judgements made by the forecasters in modifying the model's output. Econometric and other forecasting models are rarely used without some intervention by the operator to deal with perceived problems.

The various factors set out above are often inter-related. Errors in data may cause model misspecification or the need for operator judgement. Nevertheless the above taxonomy provides a means of explaining how observed outcomes may differ from projected ones.

Because the occupational analysis is towards the end of a sequence of steps, involving development of a macroeconomic scenario and sectoral prospects, the occupational projections will depend on the accuracy of a whole series of prior models and assumptions. These are represented by the rows of the table in Annex V. They can be divided into three main categories:

- macroeconomic/scale effects concerned with the overall level of employment;
- sectoral effects, dependent on the factors influencing the broad industrial employment structure of the economy;
- occupational effects, primarily driven by technological and organisational change.

Although the main focus of attention here is the bottom right hand corner of the table (total errors in the occupational projections), this depends directly on all the cells to the left and above, any one of which may contribute to the final error. Generally, the overall error in the bottom right hand cell could be broken down into component parts from all the other cells. In fact, the main interest is not in the causes of the errors in the rows above, but their total scale. Therefore the focus here is on the right hand side column and the bottom row only. In other words, the concern is not so much about what the source of the macroeconomic or sectoral structure errors might be, but mainly on identifying their average level.

A variety of summary statistics can be generated, which throw light on the accuracy of the projections. A very simple indicator of accuracy is a comparison of the predicted and observed direction of change. This can be produced for both industries and

occupations. Some care in interpretation is needed in cases where little change is occurring and so the results may simply reflect sampling errors in the data.

Another useful summary statistic is the absolute (i.e. discounting sign) error in percentage per annum growth rates (ppagr) ⁽³⁸⁾. It is the difference between the observed ppagr and the projected one. To set this figure into context it can be compared to the observed typical values for ppagr (again ignoring the sign). Note, however, that this ratio can take extreme values when the actual change is close to zero.

Shares of employment measures the projected share compared to the observed share. A particular issue here is that, as outlined in the discussion above, historical revisions can affect the starting point quite significantly. It is also helpful, therefore, to consider a second measure, which nets out any errors in the base year share due to later data revisions.

Finally, it is possible to focus on errors in the projected level of employment. The absolute (i.e. discounting sign) percentage errors can be computed by comparing the projected and observed levels and expressing these as percentages (ignoring sign differences). Again, corrections to the base year data need to be taken into account.

It is clear that the errors in the occupational projections are linked to those at the industry level. The complexity of this relationship makes it hard to construct simple descriptive statistics, since this requires detailed information about the occupational mix within industries. Nevertheless, some patterns may emerge. For example, faster than average loss of jobs in sectors such as mining and manufacturing may be an important factor in the underestimation of the job losses amongst certain skilled and other manual occupations (given their high concentration in these sectors). Similarly the underestimation of the employment increases in some service industries can be a major factor in the underestimation of job increases amongst particular occupations (e.g. managers or caring personal service occupations).

8.4. Evaluation results

The analysis has been carried out by reviewing the forecasts published in the first two pilot projects, Cedefop (2008) and Cedefop (2009), and comparing these to actual outcomes and to current projections (which are based on more recent data) ⁽³⁹⁾.

The primary evaluation analyses were focused on Europe as a whole, rather than individual countries, although there is some discussion of the situation in the larger Member States. It should be noted that when the original demand-side projections were formed in 2007, Bulgaria and Romania were not yet covered by Cedefop

⁽³⁸⁾ It is important to focus on absolute errors, since otherwise the pluses and minuses tend to cancel out margins of error for aggregates are, as a consequence generally less than those for more disaggregated categories.

⁽³⁹⁾ The focus was to examine results coming out from E3ME model (see Section 3).

forecasts ⁽⁴⁰⁾, and so the EU25 is used as an EU total and EU10 as a total for the Member States that joined the EU in 2004.

The projections of labour demand (employment) come from external projections of economic output (by sector) and productivity. The performance of the output forecasts therefore has a crucial bearing on the performance of the employment forecasts. First, comparisons are made between the projections for growth in economic output and the actual outcomes. This is followed by a brief section on the other explanatory factors for employment demand and a comparison of output and employment projections by sector.

8.4.1. Output

The original source for future output growth used in the 2007 baseline projections was the EC's Energy and Transport: Trends to 2030 (2007 update) report, which the current version of E3ME uses as its baseline. The values shown in subsequent tables (especially for the 2006-08 period) are produced by Cambridge Econometrics, but using the EC publication as a reference starting point and are broadly consistent at the macro level.

The figures in Table 13 clearly show that the 2007 projections overestimated growth for the period 2006-08. For example, growth for the EU25 was forecast to average 2.7% p.a. but growth was actually 0.8pp lower, at 1.9%. The relatively low rate of growth over the period is largely attributable to the effects of the financial and economic crisis and falling growth rates in the second half of 2008, which were not anticipated in the 2007-based baseline ⁽⁴¹⁾.

Similarly, the 2007-based forecasts for output growth over 2006-15 were also much stronger than the current projections. Although the long-term post-recession trend rate of growth is largely unchanged, average annual growth over the period after the recession in 2009 (2010-15) is around 2.1%. The revised figures include reduced output in 2008-09, lowering the average growth over the period. Output growth is currently expected to be around 1 percentage point lower each year over the period than in the 2007-based forecasts, with Spain being the worst affected country.

⁽⁴⁰⁾ Romania and Bulgaria have joined the EU in 2006 and so due to temporary lack of consistency and unavailability of data they were included in the Cedefop's forecast in 2009. Results were published in Cedefop (2010).

⁽⁴¹⁾ Although published in 2007, work to define the context of the baseline probably started earlier, with data only available to 2006.

Table 11: Predicted output growth in 2007 compared to actual outcomes and current projections

	Average annual gross output growth, 2006-08		Average annual gross output growth, 2006-15	
	Expected then	Actual**	Expected then	Expected now
EU25*	2.7	1.9	2.7	1.7
EU15	2.5	1.8	2.6	1.6
EU10*	5.2	5.1	5.0	3.8
Germany	2.7	2.2	2.4	1.1
France	2.7	1.5	2.8	1.7
UK	2.5	1.6	2.6	2.0
Italy	1.2	0.4	1.7	1.4
Spain	3.5	2.5	4.2	2.0

* Bulgaria and Romania were yet to be included in E3ME at this stage.

** The measure of output is gross, as this is the determining factor in E3ME's equations. However, data availability is better for net output (GVA) in recent years so this is used for 2006-08 actual data. The difference between the two measures in terms of growth rates is small.

Source: Wilson , Pollitt (2011)

8.4.2. Value added

This analysis focuses on the forecasts for 16 broad sectors (built up from more disaggregated sectoral forecasts). The sectoral breakdown is important for the analysis as the model's projections for aggregate employment demand are obtained by summing the sectoral results (i.e. a 'bottom-up' approach).

Similarly to Table 11, Table 12 presents the 2007-based forecasts together with the most recent data and projections (for EU25).

Output in agriculture and mining was expected to be weak over the period 2006-08, while output in these sectors over the medium-term period 2006-15 was expected to be weaker still, or even to decline. Output growth in agriculture was in fact 1 percentage point (pp) weaker than expected for the period 2006-08, while growth in mining and quarrying output was much higher, partly owing to high commodity prices and strong growth in coal and oil and gas output in 2008. The current expectations for 2006-15 are broadly similar to the 2007 projections, although growth is projected to be weaker in agriculture, while a smaller decline in mining and quarrying is expected.

The 2007 projections for output in manufacturing were too optimistic overall, for both time periods. Output in food, drink and tobacco was particularly weak in 2008, bringing the average annual growth rate for the period 2006-08 down (large falls were experienced in Finland (-5.9%), Estonia (-6.4%) and Slovenia (-11.6%)). The broad 'rest of manufacturing' sector (mainly basic industries) also saw particularly weak growth over the period 2006-08, contrary to what was expected in 2007. It is now apparent that these sectors were particularly affected by the recession and reduction in world trade. The more high-skilled engineering sectors were less affected, at least up to 2008. Manufacturing output expectations for the period 2006-2015 are now

between 0.6 and 1.8pp lower than the previous forecast, mainly due to declines in output in 2009 due to the global recession, and weak growth expected in 2010 and 2011.

Table 12: Sectoral projections of economic output, EU25

	Average annual output growth, 2006-08		Average annual output growth 2006-15	
	Expected then	Actual	Expected then	Expected now
Primary sector & utilities				
Agriculture etc	1.6	0.6	1.4	0.9
Mining & quarrying	0.4	3.4	-1.1	-0.7
Electricity, gas & water	0.2	0.6	0.1	1.8
Manufacturing				
Food, drink & tobacco	3.6	0.4	3.7	1.9
Engineering	3.5	3.0	3.4	2.1
Rest of manufacturing	2.9	0.1	2.4	1.8
Construction	2.7	1.1	2.8	1.4
Distribution & transport				
Distribution and retailing	3.2	2.3	3.4	2.0
Hotels and catering	0.6	2.2	1.7	1.3
Transport & telecom.	1.3	3.0	1.5	1.4
Business & other services				
Banking & insurance	1.5	3.7	1.7	0.8
Other business services	3.8	3.5	4.1	2.1
Miscellaneous services	2.1	1.2	1.8	1.1
Non-marketed services				
Public admin and defence	2.2	1.9	2.4	1.4
Education	1.6	1.2	1.6	1.5
Health and social work	1.9	1.8	2.1	1.5
All industries	2.7	1.9	2.7	1.7

Source: Wilson and Pollitt (2011)

For the construction sector, expectations for both time periods were again optimistic compared with actual growth between 2006 and 2008 and the current projections for 2006-15, since it was not known at the time how severe the impact of the financial crisis on the sector would be. The expectations for growth over 2006-15 have been revised down and are now more in line with expectations of growth in the economy overall.

The short-term projections made in 2007 for the hotels and transport sectors were for quite weak growth, reflecting previous years' patterns in some larger member states. However, the outcome in both sectors was growth of 2-3% pa (falls in household

expenditure generally came later in the crisis). Output in distribution and retail was roughly 1pp pa less than expected.

Output growth projections for the distribution and transport sectors over 2006-15 have been revised down, reflecting the negative impact of the recession in 2009, and subsequent low growth rates in household expenditure during the recovery. Average growth for the distribution and transport sectors is expected to be broadly similar to the average EU25 output growth rate for the period.

The banking and insurance sector was hit particularly hard by the global downturn. It comes as no surprise then that medium-term growth expectations have been revised down since the projections made in 2007, from 1.7% pa to 0.8% pa. However, the short-term projections made in 2007 were in fact too pessimistic, as 2006-08 largely represented the final months of booming output before the crisis hit. High growth was observed in the sector in 2007, and growth was particularly strong in eastern and southern European member states, such as the Czech Republic, Estonia and Spain; many of which are the countries that were later to be affected most by the crisis.

The other business services sector was also a major casualty of the financial and economic crisis. The short-term projections made in 2007 for average growth were very similar to the actual growth rates over the period 2006-08. However, average annual growth for 2006-15 has been revised down by 2pp. Countries such as Germany, Spain and France are forecast to see particularly low growth, bringing the EU25 average down. Furthermore, negative growth in 2009 and low growth during the 2010/11 recovery contribute heavily to the overall low average over the period.

The previous short-term projections for output in miscellaneous services and the public sector were not far off the actual outcomes. However, output growth is now expected to be slower over the period 2006-15, particularly in the public admin and defence sector, in which public spending cuts will have an adverse effect on output growth.

Important factors which may affect rates of employment growth are wage rates and working hours. In the original 2007-based projections it was assumed that, within each sector, nominal wage rates would grow in line with nominal productivity and average working hours would remain unchanged.

It turned out that both these factors help mitigated the effects of the economic and financial crisis, although mainly in the period after 2006-08. For example, many companies chose to cut working hours rather than reduce headcount employment and there were stories of voluntary pay cuts being taken with the same effect. In many ways this was a new phenomenon, which reduced the negative impacts of the recession, but could also be expected to reduce the speed of recovery in employment (as wage rates and working hours would be expected to rebound when growth returns). This is to be considered in the 2011 projections, when more information about trends in recovery should be available.

Finally it must be noted that the population projections that were used changed between the 2007 and 2010 forecasts; although this primarily affects labour supply, this is expected to be translated into changes in demand through adjustments in long-term wage rates.

Also relevant to the long-term trends in employment is the rate of technological development. In the E3ME model, this is represented by accumulated capital and R&D spending, with the baseline showing an extrapolation of previous trends. The impacts of technology on sectoral employment may be either positive or negative, as machinery may be labour-saving, but may also require skilled operators or designers.

The impact of the crisis on technological development remains unclear; credit restrictions may have affected innovation at start-up firms but low rates of return on financial assets may have stimulated private investment.

More time is required for data to become available with which to carry out an assessment of the predicted trends for technological development.

Table 13: Sectoral projections of employment growth, EU25

	Average annual growth, 2006-08		Average annual growth, 2006-15	
	Expected then	Actual	Expected then	Expected now
Primary sector & utilities				
Agriculture etc	-2.8	-0.6	-2.1	-1.8
Mining & quarrying	-3.2	0.4	-2.6	-2.2
Electricity, gas & water	-1.5	-0.4	-1.1	-1.0
Manufacturing				
Food, drink & tobacco	0.1	0.1	-0.2	-1.2
Engineering	0.5	1.3	0.0	-0.9
Rest of manufacturing	-0.3	-0.1	-0.3	-0.9
Construction	1.1	1.8	0.6	-0.7
Distribution & transport				
Distribution and retailing	0.5	2.0	0.6	0.4
Hotels and catering	1.8	2.1	1.8	0.9
Transport & telecom.	-0.1	1.3	0.0	0.2
Business & other services				
Banking & insurance	-0.1	0.8	0.0	-0.5
Other business services	2.7	4.2	2.9	1.6
Miscellaneous services	1.5	1.3	1.6	0.7
Non-marketed services				
Public admin and defence	0.2	0.1	0.2	-0.1
Education	0.8	0.9	0.9	0.4
Health and social work	0.8	1.7	0.8	0.9
All industries	0.7	1.5	0.7	0.2

Source: Wilson and Pollitt (2011)

The 2007-based forecasts predicted that employment growth would average 0.7% pa over 2006-08 and that productivity would grow by around 2% pa. However, the crisis

meant that this two-year period was anything but standard, incorporating the first part of the recession, when output began to fall, but before job cuts were made. Consequently the annual increase in productivity appears low, at less than 0.5% pa, and increases in employment were higher than forecast. The links between the output and employment projections are discussed further below.

The differences between the 2007-based forecasts for employment growth over 2006-08 and the outturns are greatest for the primary and utility sectors, in which employment did not decline by as much as was expected. Employment in mining and quarrying in fact increased on average each year by a small 0.4%, partly driven by high commodity prices. The short-term projections for the manufacturing sectors were quite close to the actual outcome, with the biggest difference in the engineering sector, where growth was particularly strong in Estonia, Hungary and Poland. Construction employment also grew by more than was expected.

For the distribution and transport sectors the actual average annual growth rate over the period 2006-08 was higher than projected in 2007. For all of these sectors high employment increases were mainly driven by higher than expected employment growth in central and eastern European countries. For example, employment in distribution and retailing increased by 8.0% pa in Lithuania, whereas the 2007 projections had only predicted a 3.8% pa increase. Other EU15 member states also saw large increases in employment in some of these sectors, such as the hotels and catering sector in Ireland, and the transport and telecommunications sector in Spain.

The short-term annual employment growth projections made for business services were also lower than the actual outcome, by around 1-1.5 pp. Nevertheless, the projections had correctly predicted that this sector would see the strongest employment growth over the period. The short-term predictions made for employment in miscellaneous services and the public sectors were broadly similar to the actual outcomes, although lower for health and social work.

As for the medium-term projections, the current expectations for the period 2006-15 have not changed a great deal for the primary and utility sectors, transport and telecommunications and the health and social work sector, compared to the projections made in 2007 (although the most recent projections anticipated public spending cuts, in most cases they were too early to incorporate specific packages).

However, annual employment growth in all other sectors is now projected to be lower than previously thought, by between 0.2 and 1.3pp. Overall, this translates into average annual employment growth of 0.2% over the period, compared to the more positive 0.7% growth in the 2007-based forecast. The differences reflect the downturn in 2009-10, expected impacts on government balances and the revised demographic projections.

8.4.3. Differences between output and employment projections

The aim of this evaluation exercise is to identify where discrepancies between predicted and actual outcomes occurred. So far the focus has been on projections of output, which were an input to the forecast, and the results for employment. However, of most interest is the process of going from output to employment, which is the focus of this section. Table 14 presents a clearer picture of the differences in the projections

made in 2007 and the actual short-term outcomes and current medium-term projections. Differences are shown for six broad sectors.

The most obvious point to note from Table 14 is that output growth proved to be weaker than forecast whereas the growth in employment proved to be stronger than forecast. This outcome can be explained by the short two-year period used and the position it had in the economic cycle; by the end of 2008 economies were contracting but, as changes in employment tend to lag changes in output, at this point there were no notable impacts on employment. Hence the implied error in productivity (1.6% annual growth) is due to short-term reductions in aggregate demand.

It is difficult to make much inference at sectoral level. The sectors with the largest under-estimates of employment were also those that showed economic growth over 2006-08 and the sectors that were hit hardest by the crisis (manufacturing and construction) are the ones with the largest differences. There is some correlation between the output and employment errors.

It is easier to show a pattern between the 2007 and 2010 medium-term projections. In general, half of the reduction in the rates of output growth forecast translates into reduction in employment meaning that, in effect, the loss of output is split 50/50 between loss of productivity (i.e. wages) and loss of employment levels by 2015. The sectors with significant variation from this central trend are mainly those which have seen the largest changes in employment, notably construction and some manufacturing sectors. The public sectors are the least elastic in this respect, with lower levels of output translating less into lower levels of employment.

Table 14: Differences between output and employment projections (percentage points)

	Difference in 2006-08 actual outcome to projections		Difference in sets of 2006-15 projections	
	Output	Employment	Output	Employment
Primary sector & Utilities	0.2	2.3	0.7	0.3
Manufacturing	-1.8	0.4	-1.1	-0.8
Construction	-1.6	0.7	-1.4	-1.3
Distribution & Transport	0.3	1.2	-0.8	-0.2
Business & Other Services	0.4	0.9	-1.6	-1.0
Non-Marketed Services	-0.2	0.4	-0.6	-0.2
All Industries	-0.8	0.8	-1.0	-0.5

Source: Wilson and Pollitt (2011)

8.4.4. Supply of labour

In this section the projections for growth in the EU27 labour force and participation rates that were made in 2008 are compared with the most recent ones made in 2010. A comparison of population projections is not shown, since these have not changed (they did, however, change between the 2007 demand and 2008 supply forecasts).

As there is only one year of difference between the two forecasts, it is not really possible to compare the predictions to actual outcomes, so this section focuses upon the medium-term forecast.

Compared to employment demand, the effects of the financial and economic crisis are less important to the forecasts of supply (i.e. demand falls by more than supply so unemployment increases) but there are impacts, for example from:

- lower output growth and wage rates mean people may be less inclined to seek work
- higher unemployment causes some people to withdraw from the labour market

There is one other important factor, changes in migration patterns, that has not been taken into account as this is implicitly included in the exogenous population projections and so is outside the scope of our assessment.

Table 15 shows the differences between the predictions for participation rates in 2020 and for the growth in the labour force by 2020 compared to 2008. It should be noted that a large part of the differences in results is due to the extra year of data being available for the later forecast; the differences in some age groups were quite large, possibly indicating a response to the crisis but also possibly variation within the LFS data.

The similarity between the two forecasts for 2020 is also a reflection of the methodology that was used to produce them. The 2009 forecast and 2010 update essentially uses the 2008 projections as a starting point, plus an additional year of data and a representation of the recession. However, as recovery is well under way by 2020, the main differences are due to the additional year of data. While this means that there is a degree of consistency between the two forecasts, it cannot be said that one is a confirmation of the other, and further assessment should be made further down the line.

Table 15: *Labour force and participation rate projections, EU27*

	Participation rate projections		Labour force projections	
	2020 participation rates expected in 2008	2020 participation rates expected in 2010	2008-20 growth expected then	2008-20 growth expected now
Male 15-19	0.23	0.22	-18.4	-22.0
Male 20-24	0.69	0.65	-12.1	-14.3
Male 25-29	0.89	0.87	-6.0	-6.6
Male 30-39	0.95	0.93	-2.4	-2.9
Male 40-49	0.94	0.93	-2.2	-2.5
Male 50-54	0.87	0.88	10.7	12.2
Male 55-59	0.72	0.76	14.8	19.7
Male 60-64	0.42	0.45	31.2	31.1
Male 65+	0.08	0.08	47.9	34.8
Female 15-19	0.21	0.20	-13.4	-19.7
Female 20-24	0.57	0.56	-13.3	-14.3

Female 25-29	0.80	0.79	-3.7	-3.4
Female 30-39	0.79	0.80	-2.9	-1.3
Female 40-49	0.81	0.82	-1.2	-1.1
Female 50-54	0.72	0.74	10.6	12.1
Female 55-59	0.56	0.59	21.9	24.8
Female 60-64	0.24	0.25	32.8	29.2
Female 65+	0.03	0.03	36.3	18.9
Total	0.56	0.56	1.1	1.3

Source: Wilson and Pollitt (2011)

This section has attempted to identify and isolate differences between predicted and actual (and revised predicted) outcomes for employment. The differences have been split into those in inputs (mainly economic projections and demographics) and those in processes within the E3ME model.

In summary, it is difficult to draw many firm conclusions from the evaluation so far. This is partly because only a short period has passed since the original projections were made, and partly because this period was dominated by the economic and financial crisis, which was not included in the baseline economic (and therefore employment) projections used in 2007. It should also be noted that the level of uncertainty is still rather high as different paths to recovery are considered and concerns remain over levels of consumer and government debt in certain parts of Europe. At the moment, several conclusions can be drawn, though, which are outlined below:

- although this means that the conclusions at this stage are rather vague and tend to focus on inputs used rather than the means with which the projections are used, there are some important messages to be nonetheless drawn.
- the medium-term projections must take into account short-term fluctuations, as showed in the period 2006-08. In particular, dynamic factors, with employment often lagging output, should be considered.
- revisions to data can have a substantial effect on the projections, even if other factors remain unchanged; using the most recent data is important.
- government policy, which is treated as exogenous in the modelling, plays an important role, particularly in periods where ‘business-as-usual’ cannot be assumed. Most obviously affected are high-employment sectors such as health and education, but there are other less obvious examples, such as the motor vehicles sector that benefited from car scrappage schemes in Europe.

8.4.5. Evaluating the occupational employment projections

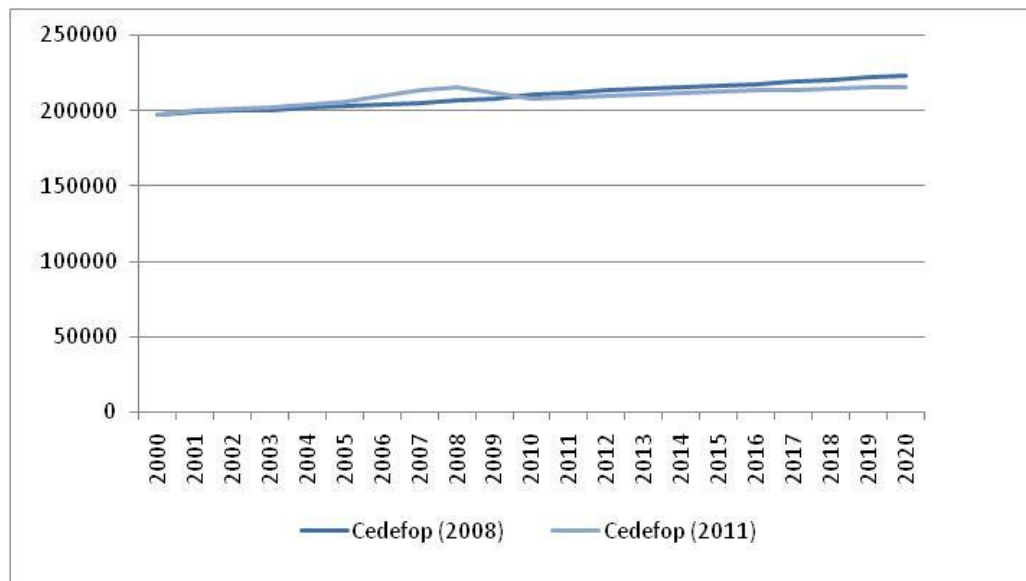
This section moves on to consider the implications for the demand for skills, focussing on occupational employment projections, based on the sectoral projections produced using E3ME.

The emphasis is on the results over a 5-10 year forecasting horizon. Because of the focus on medium term forecasts, at the time of writing (2010) the pilot projections being assessed are still focused on what is still the future (2015).

The assessment begins with a qualitative review of the projections, comparing the predictions with the outcomes, as reported in subsequent reports.

Figure 8 illustrates a number of the issues raised in the earlier discussion quite neatly. It compares the latest ‘quick update’ (used in Cedefop 2011) results with those from the pilot demand projections conducted in 2007 and published in Cedefop (2008).

Figure 8: Comparison of aggregate employment trends

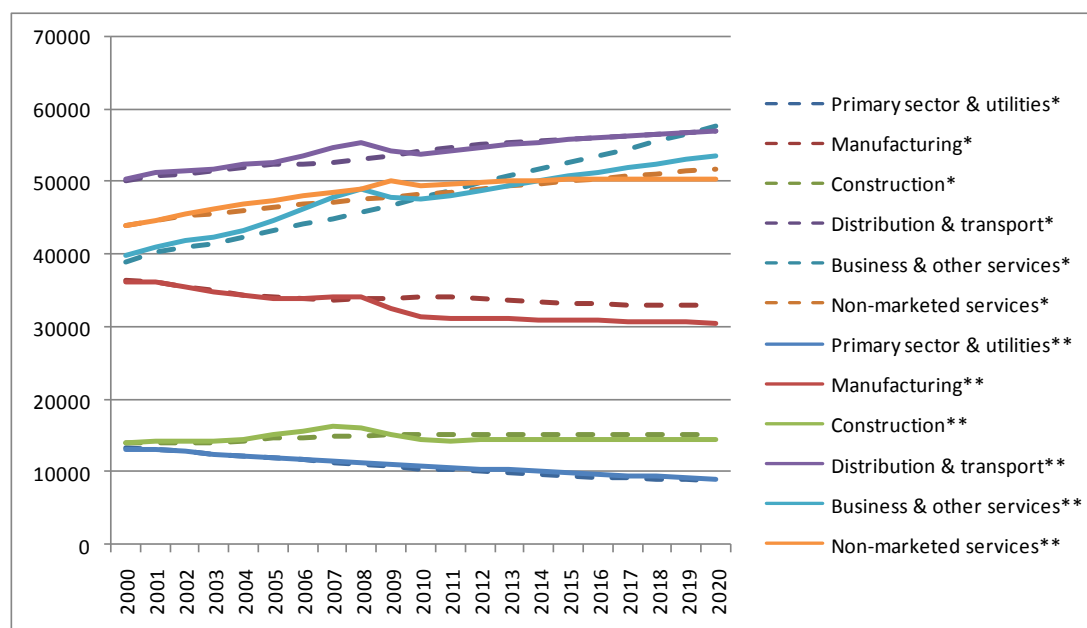


Source: Wilson and Pollitt 2011

The results show that historical data revisions dominate the differences up to 2008, while the financial crisis and subsequent worldwide recession explain the main differences in the post-2008 period. Although few financial commentators predicted the financial crash, this kind of ‘singularity’ is almost impossible to build into conventional economic/labour market assessments and the events of 2008 were not predicted by any mainstream forecasters.

The important question is how much does this matter in terms of the general messages emerging from the Cedefop projections. The next figures suggest that it is not as important as might first be thought. Although it is clear that the Cedefop projections based around the E3ME macroeconomic model were not able to predict the crisis, many of the patterns in terms of industrial and occupational employment that it provided remain surprisingly robust.

Figure 9: Comparison of aggregate employment trends by sector (thousands of jobs EU27+)



Note: ; * Cedefop (2008)l ** Cedefop (2011)

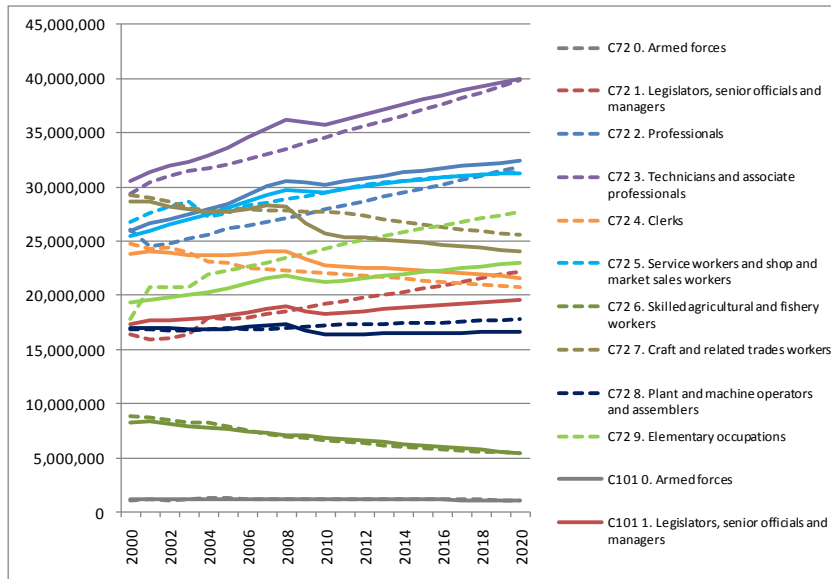
Source: Wilson and Pollitt 2011

Figure 9 illustrates the time series profiles for employment by sector in the two sets of projections (Cedefop 2008 and fast update 2011). Although the impact of the crisis and recession is immediately apparent again in most of the sectoral profiles, it is also clear that the relative sizes and underlying trends in the two sets of projections are very similar.

This is probably even more the case if a comparison is made in terms of occupational or qualification trends as shown in Figures 10 and 11. While there are obvious differences between the two sets of projections, these are again dominated by historical data revisions and the impact of the crisis.

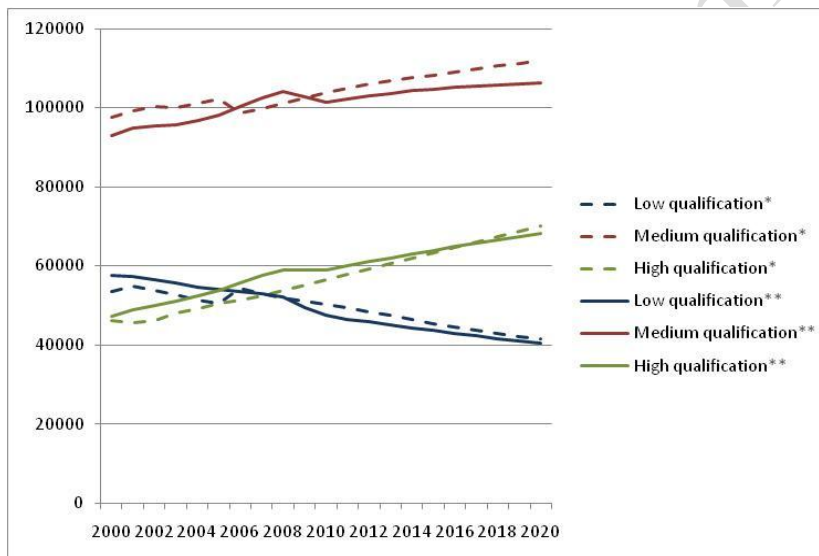
The broad patterns in the historical data and in the projections remain very similar in the two sets of projections. This is even more true if the focus is on replacement needs and total requirements as opposed to net change (so called expansion demands), as the latter are highly dependent on the level of employment as opposed to the change over time.

Figure 10: Comparison of aggregate employment trends by occupation



Source: Wilson and Pollitt (2011)

Figure 11: Comparison of aggregate employment trends by qualification



Source: Wilson and Pollitt (2011)

9. Qualitative evaluation

The quantitative evaluation of the forecast accuracy was accompanied by the qualitative survey on the usage of the skill forecasts and related analyses. The main purpose of such evaluation was to obtain information on the meaningfulness of the forecasting efforts as well as to steer the project to the direction of better satisfying the needs of different stakeholders. The aim was not only to gather information on the general satisfaction with presentation of the results and documents but also to examine the assessment of quality and further use. Furthermore we have examined the perceived quality of the forecast and explored future directions.

This section is based on the background paper by Kriechel and Wilson (2011a). In the first section the survey methodology is introduced, including the main idea of the evaluation process. The second section presents results on the general content and usage of the skills forecast. The third section assesses the quality of the forecast. The final section describes the gathering of ideas for further development of the survey.

9.1. Methodology

An internet based survey containing 16 questions (see Annex IV) was used and respondents could answer these questions in less than ten minutes. The respondents received an invitation email and an endorsement email from Cedefop. All respondents that did not answer within ten days received a reminder email.

Ideally, the population of respondents would consist of all users of the skills forecast. As there is no close monitoring of the user base, though, we approximated the population by inviting all country experts participating in workshops on skill forecasting organised by Cedefop and all other experts who requested access to the detailed country results. In addition participants of the AGORA 2009 and AGORA 2010 conferences were also invited to participate. We expected that members of these groups should have, at least through their participation, some knowledge on the skill forecasting methodology and outcomes as they were key topics in the workshops and conferences. The survey was conducted by ROA based on the contact list provided by Cedefop. After eliminating multiple addresses of persons that participated in several events, we were left with a base population of 255 persons. All persons received an invitation letter from Cedefop, followed by an invitation mail that provided a link to the net questionnaire. There were 102 respondents, yielding a raw response rate of 40% (102/255) ⁽⁴²⁾.

Table 16 summarizes the information sources of the respondents. More than 90% of the respondents have received at least the synthesis report on the project, while about three quarters of the respondents replied that they have received the background technical report and the briefing notes.

⁽⁴²⁾ It should be noted though, that a significant amount of respondents could not be reached as their e-mail was no longer valid.

Table 16: Information sources of respondents

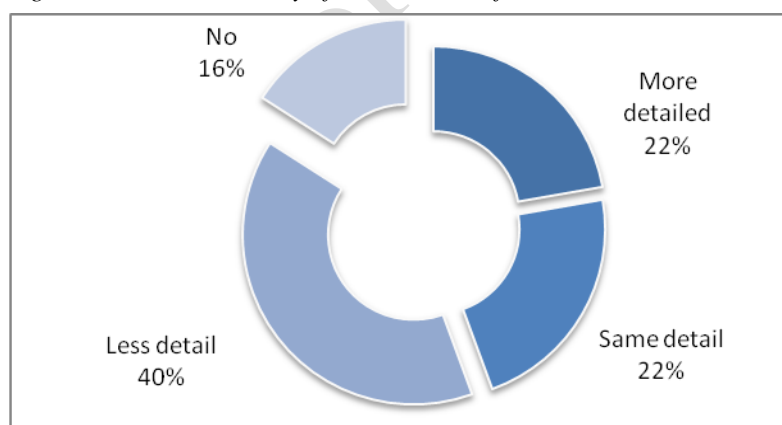
	Not received / Don't know this.	Received, but haven't read it.	Received, but found it not interesting.	Received, and found it somewhat interesting	Received, and found it very interesting
Briefing Notes	23.08	6.15	3.08	29.23	38.46
(Synthesis) Reports	10.77		7.69	23.08	58.46
Background technical report	27.69	9.23	1.54	32.31	29.23
Observations	65				

Source: Online survey, ROA, 2010

As expected, the most important information source was the synthesis report. All respondents that reported to having received it have also read it and found it interesting. The background technical report was relatively more often not read. This could be due to the technical nature of the report, which appeals only to readers that try to understand the underlying mechanisms of the modelling framework. An interesting question is whether readers that were not entirely content with the background technical report, i.e. found it 'somewhat interesting', would like to have more technical detail or whether they found the reports too complicated. However, we did not investigate this issue within the survey, so that we cannot make a distinction here.

As Figure 12 shows, the European skills forecasting provides policy makers and experts in the fields either with an additional skills forecast on a comparable (22%) or inferior level of detail (22%), but for other countries the EU skills forecast is the only one (16% of the cases) or a more detailed skills forecasting model (40%) than what is nationally available.

Figure 12: Availability of national skills forecast



Source: Online survey, ROA, 2010

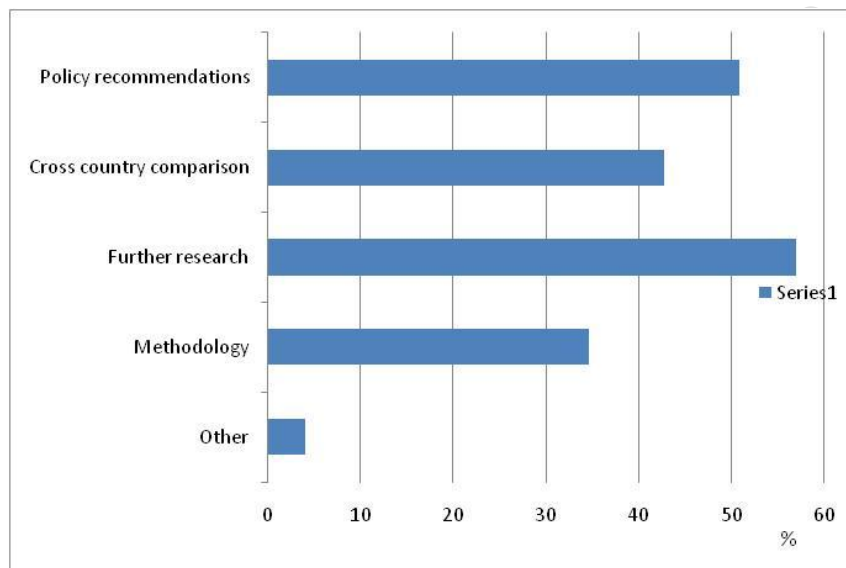
Most respondents of our population were, as expected, involved in some form of skills forecasting. Inevitably, some respondents of the survey were country experts that are part of the consortium developing and making the forecast.

9.2. Contents and usage of skills forecasting results

The projects' aim is to develop and publish regular medium-term skill forecasts at a Pan-European level. Next to the development of a European skill forecast, it should also provide individual country forecasts using a consistent and comparable methodology such that country results can be compared across Europe. The expertise built up and shared with country experts could provide a foundation for the development or improvements of national skill forecasts.

In the question regarding the main use of the Cedefop skill forecast to the respondent, it was our aim to elicit in which way the project helps the users. The first two aspects in Figure 13, namely policy recommendation (51%) and cross country comparison (43%), are part of the main goals of the project, which is to provide skills forecast for policy recommendation, both on EU and national comparative level. 57% of the respondents also replied that the project forms an important source for further research, while 35% reported the use of methodological aspects of the project.

Figure 13: Main use of forecasting projects result



Source: Online survey, ROA, 2010

The results of the skills forecast are presented in Excel workbooks. The workbooks provide detailed results on all aspects of the model, next to the underlying data that has been fed into the forecasting model. It provides a convenient way to the user to generate tables and figures to the user's specification. In addition, the workbook allows some changes in the underlying data and assumptions of the model. The effects of these changes applied by the users are then calculated within the workbook. This allows for some user modification as well as an interactive analysis by the user.

Table 17 summarizes the respondents' evaluation of the two elements of the workbook: the ability to change underlying data and the availability of detailed (underlying) data for the user. Especially the availability of the detailed data seems to be important to the respondents. 52% reported this to be very important and an additional 39% as important. Being able to change the underlying data or assumptions of the model is also appreciated: almost 20% find this very important and an additional 48% find it important. Thus, the availability of the detailed data seems to be

the more important aspect that almost all users want to have, while a smaller group actively use the possibility to change underlying data. The detailed workbooks were evaluated as important, and given the policy recommendation and additional research that has been undertaken on a national level based on the outcomes and data of the skill forecasting project, a continuation of providing detailed data to national experts seems sensible.

Table 17: Workbook usability

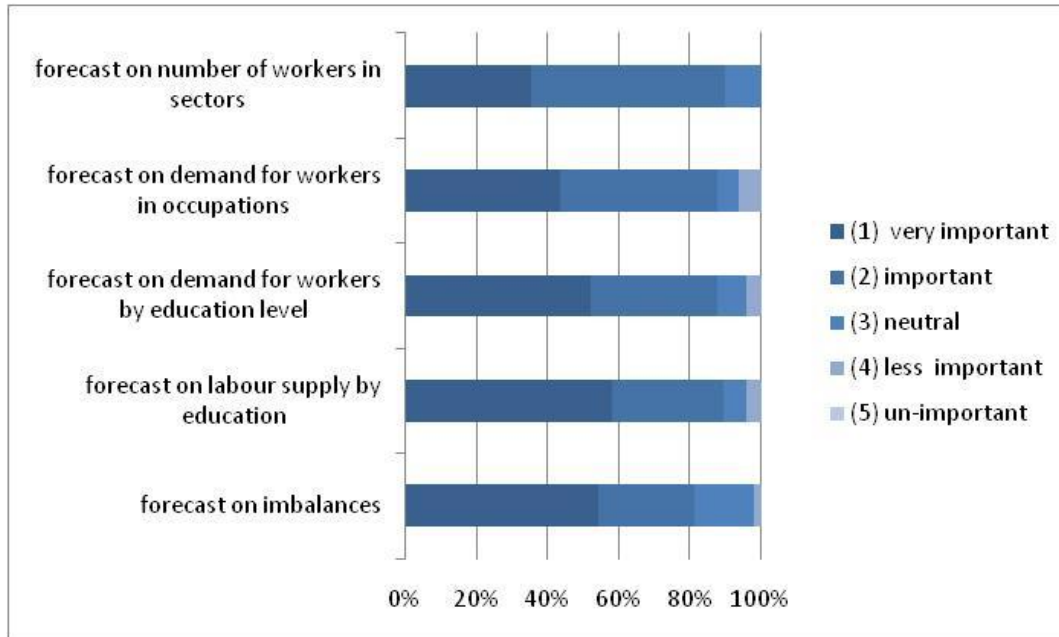
	Able to change underlying data	Detailed data in workbooks
(1) very important	19.57	52.17
(2) important	47.83	39.13
(3) neutral	21.74	4.35
(4) less important	2.17	4.35
(5) not important	8.7	0.00
Observations	46	

Source: Online survey, ROA, 2010

The importance of the forecasting elements is reported in Figure 13. A distinction is made between the forecast on the number of workers in sectors, on the demand for workers by occupation, on the demand for workers by education level, on the supply by education level, and on the imbalances resulting from supply and demand forecasts.

Figure 14 shows that all aspects are considered important or very important by most respondents. No aspect has less than 80% of respondents reporting less than important. Ordering the results by the ‘very important’ elements, yields the following order: most important is the forecast on supply by education (58%), the imbalance forecast (54%), followed by the forecast on demand by education level (52%) and by occupation (44%), with the forecast on the number of workers in a sector (35%) coming in last. However, this picture changes if one combines the ‘very important’ and ‘important’ responses. Then the forecast on the number of workers in sectors comes out on top, together with the forecast on labour supply by education (both 90%).

Figure 14: Importance of forecasting elements

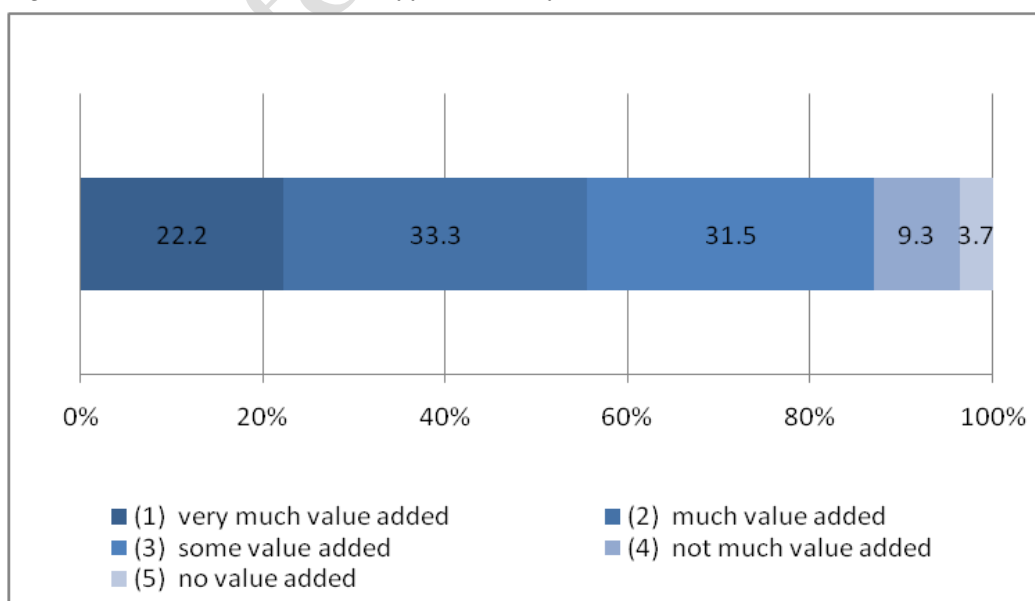


Source: Online survey, ROA, 2010

9.3. Qualitative evaluation of results

How successful was the project so far in generating usable and plausible results on national and cross country level? The overall evaluation of the forecast, as given in Figure 14, shows that the respondents see sufficient value added by the project. 22% think that very much value is added, followed by 33% that see much value added and another 32% that see some value added. Only 13% of the respondents see not much or no value added by the forecast.

Figure 15: Overall evaluation of forecast(% of total)



Source: Online survey, ROA, 2010

We also asked respondents to evaluate the results of the individual elements relative to national results if they existed, or their expectations on results if no national results existed. The plausibility of the results is evaluated favourably on all aspects of the model: demand by sector, demand by occupation, replacement demand, demand by qualification and supply of skills. While there are slight variations in the mean outcome of these five aspects none are statistically significant. The confidence band, which shows the area that mean plus or minus one standard deviation encompasses, gives some reassurance that the respondents evaluate the forecasting outcomes as plausible. This is confirmed in Table 18, which summarizes the results from a question on the overall evaluation of the forecast plausibility including all elements. More than half of the respondents report that the results are either close to national forecasts, or are in the same direction.

It is, however, also important to note that about one third of the respondents report partial contradictions of the outcomes with national outcomes. This is to be expected. The data and methodology used is geared towards a unified framework for all countries. Especially in countries that have national forecasting models, it is likely that these are more optimized to the national data and include much more knowledge on national institutions and other elements influencing projection outcomes. Within this project, we attempt to find those contradicting outcomes by discussing results with country experts and asking for their opinion on the plausibility of the results already during the forecasting process.

Table 18: Overall evaluation of forecast plausibility

	%
Don't know	10.9
Very close to national forecast / expectations	6.5
Same direction of outcomes	50.0
Partially contradicting outcomes	30.4
Contradicts national forecasts / expectations	2.2
Observations	46

Source: Online survey, ROA, 2010

The overall evaluation of the importance of the project, and the plausibility is thus quite favourable. However, we should not rest on the merits of these results, but rather look into improving the current model, and, whenever possible, include and solve the contradicting outcomes between national and the EU forecast.

9.4. Further development

The project has developed a well functioning model of skills forecasting. While there are many aspects that can be improved or extended, it is also important to note that given the results from the previous section we have achieved already an important building block of the project. The model provides forecasts that country experts evaluate as plausible and largely in line with national forecasts or expectations. Further development should go into scenario development, both on country or sector scale. These could be included in the presentation of the findings, e.g. by allowing the

user to change some key assumptions in the workbooks. The wish for more detailed skills forecasting will depend on the data availability.

Table 19 summarizes the outcome of the question on suggested directions for further development. Scenarios both on the country level (50.9%) and on the sector level (54.5%) score high on the respondents' wish list. In addition, more detailed skills and competence forecasts are wished for (54.5%). Expanding the forecast by including fields of study might already be a step into that direction. It is, however, important to stress that more detailed forecasts hinge upon the availability of reliable data.

Table 19: Suggested directions of further development

Direction of further development	
Policy simulation	41.8%
Technological / organizational changes simulations	29.1%
Individual country scenarios	50.9%
Individual sector scenarios	54.5%
More detailed skills / competences forecast	50.9%
Other	3.6%
Observations	55

Source: Online survey, ROA, 2010

The survey revealed that the EU-wide skill forecasting project provides many countries with skill forecasting information which was not previously available. The forecasts are used for policy recommendations, to compare developments in different countries, and to provide the basis for further research on skill demand and supply. The results of the skill forecast are seen by the national experts as plausible if compared to national forecasts or national expectations on future developments. Almost 60% of the respondents report that the overall results are close to national forecasts or expectations, whereas one third report (partial) contradictions between the forecast and national sources.

10. Summary and conclusions

10.1. Summary

The EU and individual Member States labour markets are undergoing structural changes. The shifts towards more service oriented and knowledge based economy are changing the structure of labour demand, mainly in terms of qualifications required. Ageing calls for increase of efficiency of labour force use. Austerity measures will decrease public investment in general not excluding education. Europe can not afford to waste labour force potential in unemployment and needs to ensure efficient use of public investments into education. Anticipation of skills supply and demand can provide crucial information on long-term trends and thus support decision-making.

Cedefop's skills supply and demand forecast is the only European level exercise based on comparable data. It relies on up-to-date and sophisticated methods and is being constantly developed with the help of key European research institutes.

Anticipation of future skills needs and supply is also taking place in Member States. Cedefop does not intend to compete with or replace efforts made at national level. With this publication, Cedefop intends to present a general overview of the methodology and to inspire those dealing with the forecasting exercises or trying to find relevant background to start own forecasts.

Consistent and comparable data base is a key prerequisite for obtaining trustful models and results. For this purpose several data sources needed to be adopted: it is necessary to link labour force survey data, which provides the desegregations by occupations and qualifications, and national accounts data providing complete estimates of sectoral employment consistent with sectoral value added and other macroeconomic indicators.

Cedefop methodology (Figure 1) is based on econometric modelling with certain elements of input-output techniques. The general framework is built on a modular approach which allows for independent development, fine tuning and extending of particular parts over the time. The core element is multisectoral macroeconomic model which produces labour demand data by sector (E3ME). Its augmented version also produces labour market participation rates for labour supply data. The labour demand by sector is further processed in modules of labour (expansion) demand by occupations and qualification. This forecast also uses replacement demand module to produce forecast of those leaving the occupation for different reasons (retirement, mobility etc). By combining expansion and replacement demand, the future total job openings can be calculated. Stock and flow modules are producing results for labour supply by qualification. A combined stock-flow model would be ideal but is not currently feasible given the lack of data. As labour supply and demand are mutually interrelated, the algorithms to calculate imbalances are not straightforward. Cedefop developed a module on imbalances to deal with this issue.

As said above, in Cedefop's forecast the E3ME provides the links between the labour market and the wider economy. The module is made up of four sets of equations: employment demand, average wages, average hours worked and participation rates.

E3ME that provides a coherent European perspective allows for the production of different projection scenarios of labour supply and demand.

The supply of skills module is based on demographic forecast and assumptions for individuals to acquire certain level of qualification. Ageing, which is generally spread over European labour markets, will result in decline of younger cohorts in the population and in the labour force. The turn down of youth in the labour force is expected also because younger people are staying longer in education than in the past. At the same time, older people are nowadays usually staying longer in employment due to legislative shifts of retirement ages. Based on such assumptions the stock of qualifications can be relatively easily derived. It is more complicated to follow the flows between different age categories and age groups important for more plastic view of the structure of labour supply. A stock–flow model would be ideal for forecasting supply of skills. Producing such a model for the qualification mix of individuals across Member States appears feasible, but is not without problems. The EU LFS data are now available over a sufficient time period to construct pseudo cohort information that allows modelling the transition from school to work. But when modelling qualification levels, stock-flow modelling has to deal with the issue of transitions between educational pathways. It has been demonstrated that while primarily concentrated amongst younger individuals, those still cut across a significant age range of at least 16 to 30 years. There are several other minor issues in the modelling process that can be dealt with in a fairly straightforward manner. These include the absence of information on qualification for those above retirement age and not in employment, as well as the possible lower bounds for proportions of the population with low qualifications. Other more demanding issues relate to modelling explicitly the effects of emigration and immigration on the qualification mix in different countries. Nevertheless, the present exploration demonstrates that appropriate data to undertake such modelling at a pan-European level are not available.

Changes in level of employment (expansion demand) disaggregated by occupation resp. qualification is calculated in two modules (EDMOD resp. QUALMOD). The projections of employment are derived by mapping projected shares of occupations and qualifications to sectoral employment projections obtained from E3ME. These results incorporate the latest data and as far as possible take into account latest global developments. In the recent years, Cedefop explored greater level of details in various data sets , including trials to implement more detailed level of educational attainment and attempts to incorporate fields of study. Given the exploratory nature of the most recent work, not all of the issues and problems have been resolved yet. Although present results are encouraging, the approach has to date not offered a viable alternative to the simpler methods for developing projections of changing skill demand patterns based on extrapolative techniques. Conceptual underpinnings of a ‘behavioural’ theory of labour demand, including occupations and education levels already exist. This theory has its roots in production and cost functions, which have been adapted to estimate employer demand for labour. Subsequent work has been carried out in extending Cedefop framework to look at skill-biased technological change (SBTC). The possibility to simultaneously join estimates of all 81 education / occupation categories was examined. The initial exploration of the data suggests that interesting patterns emerge but it is still premature to draw conclusions about the success of further work in this area. However, it is convincing that such work would

move the understanding of recent and current labour demands and employment significantly forward.

Replacement demand is an important component of the overall labour demand. This component of labour demand is representing demand which is due to people leaving the occupations for different reasons and who need to be replaced. The cohort component method is used to produce net flows from the labour market. The tests of alternative approaches for net flows by occupation estimates can be, however, used only at national level due to the current lack of necessary data sets at European level. We could observe on an example for one country that the flow estimates from panel versus cohort-component approach are quite similar, which leads to conclusion that the cohort component method currently used in Cedefop's forecast is a good substitute to a methodologically superior panel based approach if the underlying causes of replacement needs do not need to be identified.

Comparing labour demand and supply to derive potential imbalances is not straightforward. In Cedefop skills forecast supply and demand are calculated separately using comparable data and assumptions. In presenting the implications for imbalances it is essential to emphasise that both the trends in supply (towards a more highly educated workforce) and the trends in demand (towards greater use of such people in employment) are hard to predict precisely. They are also interrelated (supply can to some extent help to generate its own demand, and demand can also generate supply to some degree) but the models are not able to capture these interactions. Several indicators are currently being developed to better link occupational demand to educational supply. Both the indicator based on education shares in occupation and the RAS based indicator of constraint and measure of change are pointing towards the same direction: lower level occupations will face more adjustment needs, and potentially more difficulties in hiring workers. The indicators of imbalances would benefit greatly if a distinction by field of study could be made in education supply.

Finally, when improving forecast methods, it is important to look back and assess how accurate and useful past projections have been. The detailed analysis of errors in the projections suggests that the aggregate projections of changes in GDP and total employment in the initial pilot studies (2007-08) were overtaken by events as a results of the financial crisis. Cedefop occupational projections appear at least as accurate as the industry ones, which is somewhat surprising given the quality of the data. However, this is probably (in part at least) due to the relative stability of the occupational structure. As for the industry results, the projections generally mirror the observed directions and magnitudes of change. The levels are less accurately projected but this is linked to revisions of the base year figures and to the impact of the crisis. The direction of change appears to have been correctly forecasted by Cedefop.

To examine the accuracy and numerical quality of the forecast is an important issue. The research on usability and overall satisfaction of the results is not less important. A user survey revealed that Cedefop skill forecasts provide many countries with information which was not previously available. National experts use Cedefop forecasts mainly for policy recommendations, comparisons of developments in different countries, and further research on skill demand and supply. Moreover, the results are considered plausible if compared to national forecasts or national expectations on future developments.

10.2. Continuing dialogue and country expert input

Cedefop conceptual framework, related improvements and results have been developed by a team of experts from leading institutions in economic modelling, labour market analysis and skills anticipation. The uniqueness of Cedefop's approach implies that it is not possible to compare results nor methods to similar exercises.

Cedefop has put together a group of experts within its Skillsnet network to ensure the high standard and credibility of methods used and to validate the plausibility of provided results. These experts present whole spectrum of professionals starting from practitioners, VET providers through economists and labour market analysts up to statisticians and econometricians. Regular workshops, ad hoc discussion groups and informal communication provide also directions for further developments and improvements. Without the expert's inputs and quality checks it would have been difficult to achieve the same outcomes and integrity of the project.

Cedefop is really grateful for each input provided by experts. All other experts and stakeholders are invited to join and provide their own views and suggestions.

10.3. The way forward

Important developments were made since 2005, when the first discussions about forecasting skills supply and demand for the whole of Europe started. Several high level techniques were put together to provide a unique conceptual framework able to forecast skills needs by different sectors and occupations across EU Member States. Digging deep into various difficulties and issues opens ways for improvement and development. Several avenues were already explored with more or less satisfactory results - these were reviewed in this publication; many more are, however, still waiting for detailed exploration.

One of the important issues to be explored further is the treatment of both sides of the labour market in terms of qualifications. It is clear that there is a complex relation between supply of and demand for qualification which cannot be easily captured. Sets of indicators to indicate potential labour market imbalances were developed but more has to be done to test their robustness and reliability, with respect to data and from the point of view of their conceptual clarity. This is the focus of upcoming work which will provide a better view on different forms of skills mismatches and imbalances.

Bringing more qualitative dimension to the model itself and to the final interpretation of results. Qualitative inputs are also important in forming different policy scenarios. Extending the current general framework by some of the CGE techniques will be done to improve the understanding of trends in qualification needs under different considered (policy) scenarios (for example greening of economies, ageing, etc.).

Other methodological developments are awaiting better data. There is a common agreement that internal mobility as well as migration from and to third countries is affecting both supply and demand for skills. But available information and data about migration do not allow the incorporation of this phenomenon into the overall modelling framework. More disaggregated data on the skill profiles of occupations and sectors are being developed. But these are based on the O*Net which is reflecting

the US reality and not the European one. It is rather difficult then to build up consequent European forecast.

Finally, the skills forecast is not the one and only skills analysis activity of Cedefop. Other projects focus on different aspects of skills formation and use in relation to education and labour market. One of them investigates and analyses skill mismatch in Europe, including new empirical analysis on skills obsolescence based on a Cedefop pilot survey in 4 countries. Another provides evidence on sectoral skills and qualification requirements, and supports anticipation of skill need at European and international level by providing information on new and emerging skill needs in selected sectors. Cedefop also contributes to the current debate on the greening of the economy and related skill needs. The results are used for different analysis such as the polarization and ageing of occupations. Finally, work is in progress on an employers survey on changing skill needs. All these activities will form different building blocks to provide better understanding of skill needs and trends in Europe; also as a part of the flagship initiative of Europe 2020 'The agenda for new skills and jobs'.

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Not for dissemination

Annexes

Annex I: Acronyms and definitions

Institutions and organisations

CE	Cambridge Econometrics
Cedefop	European Centre for the Development of Vocational Training
EU	European Union
Eurostat	Statistical Office of the European Communities
IER	Institute for Employment Research
ILO	International Labour Organisation
OECD	Organisation for Economic Co-operation and Development
ROA	Research Centre for Education and the Labour Market, University of Maastricht
Skillsnet	Cedefop's network on early identification of skill needs
UOE	Unesco-OECD-Eurostat
Unesco	United Nations Educational, Scientific and Cultural Organisation
US	United States
WTO	World trade organisation

Others

AMECO	Annual macro-economic database of the European Commission's Directorate-General for Economic and Financial Affairs
BALMOD	Module to reconcile skill supply and demand projections
BRIC countries	Brazil, Russia, India and China
CGE	Computable general equilibrium
E3ME	Energy-environment-economy model of Europe (multi-sectoral macroeconomic model)
E3ME*	E3ME augmented to include detailed labour supply model
EDMOD	Module to produce occupational demand projections (expansion demands)
EU-27	The 27 EU Member States
EU-27 ⁺	The 27 EU Member States plus Norway and Switzerland
FlowMOD	Module of flows into and out from the education system
GDP	Gross domestic product
ISCED	International standard classification of education
ISCO	International standard classification of occupations
LFS	Labour force survey
LMII	Labour market information and intelligence
NA	National accounts
p.a.	Per annum
QMOD	Module to produce qualification projections
RDMOD	Module to produce projections of replacement demands
StockMOD	Module of numbers acquiring qualifications (stocks)
WTO	World trade organisation

Definitions of terms used

Conceptual framework	The general theoretical and methodological approach to modelling and projecting the demand for and supply of skills.
Employment	The number of people in work (headcount), national accounts definition, (or the number of jobs in some cases), Split by various dimensions, including sector, occupation, gender and highest qualification held.
Labour force	The number of people economically active (the sum over the various age ranges of the working age population * the relevant labour market participation rate) which includes employed and unemployed.
Population (15+)	Anyone of age 15 or over is classified as part of the population in the context of the model. People over 65 are included in this definition, as these age groups have participation rates greater than zero.
Working age population	Anyone of age 15-64 is classified as part of the working-age population.
Participation or activity rate	The percentage of the population that is either employed or unemployed (ILO definition of labour force). This is differentiated by gender and age group.
Qualifications	This term refers to the highest level of education/qualification held by the individual. The ISCED classification is used for this purpose. The most aggregate level distinguishes three main levels of education/qualification: high (ISCED 5-6), medium (ISCED 3-4, excluding 3c short) and low (ISCED 0-2, plus 3c short).
Demand	In the context of the model, labour demand is taken to be the same as employment levels (number of jobs available). It does not include (for example) unfilled vacancies.
Supply	In the context of the model, labour supply is taken to be the same as the labour force.

Annex II: Classifications and aggregations used in the modelling framework

Industries and sectors

Table I Aggregation of NACE Rev 1.1 two and three digit industries to 41 industries

41-industry [NACE]		NACE Rev 1.1 [NACE]
1	Agriculture, etc.[01-05]	Agriculture, hunting and related service activities [01]
		Forestry, logging and related service activities [02]
		Fishing, fish farming and related service activities [05]
2	Coal [10]	Mining of coal and lignite; extraction of peat [10]
3	Oil and gas, etc.[11, 12]	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying [11]
		Mining of uranium and thorium ores [12]
4	Other mining [13, 14]	Mining of metal ores [13]
		Other mining and quarrying [14]
5	Food, drink and tobacco [15, 16]	Manufacture of food products and beverages [15]
		Manufacture of tobacco products [16]
6	Textiles, clothing and leather [17-19]	Manufacture of textiles [17]
		Manufacture of wearing apparel; dressing and dyeing of fur [18]
		Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear [19]
7	Wood and paper [20, 21]	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials [20]
		Manufacture of pulp, paper and paper products [21]
8	Printing and publishing [22]	Publishing, printing and reproduction of recorded media [22]
9	Manufactured fuels [23]	Manufacture of coke, refined petroleum products and nuclear fuel [23]
10	Pharmaceuticals [24.4]	Manufacture of pharmaceuticals, medicinal chemicals and botanical products [24.4]
11	Chemicals nes [24(ex24.4)]	Manufacture of chemicals and chemical products (except pharmaceuticals, etc.) [24 (ex 24.4)]
12	Rubber and plastics [25]	Manufacture of rubber and plastic products [25]
13	Non-metallic mineral products [26]	Manufacture of other non-metallic mineral products [26]
14	Basic metals [27]	Manufacture of basic metals [27]
15	Metal goods [28]	Manufacture of fabricated metal products, except machinery and equipment [28]
16	Mechanical engineering [29]	Manufacture of machinery and equipment n.e.c. [29]
17	Electronics [30, 32]	Manufacture of office machinery and computers [30]
		Manufacture of radio, television and communication equipment and apparatus [32]
18	Electrical engineering and instruments [31,33]	Manufacture of electrical machinery and apparatus n.e.c. [31]
		Manufacture of medical, precision and optical instruments, watches and clocks [33]
19	Motor vehicles [34]	Manufacture of motor vehicles, trailers and semi-trailers [34]
20	Other transport equipment [35]	Manufacture of other transport equipment [35]
21	Manufacturing nes [36, 37]	Manufacture of furniture; manufacturing n.e.c. [36]
		Recycling [37]
22	Electricity [40.1, 40.3]	Electricity, steam and hot water supply [40.1, 40.3]
23	Gas supply [40.2]	Manufacture of gas; distribution of gaseous fuels through mains [40.2]

24	Water supply [41]	Collection, purification and distribution of water [41]
25	Construction [45]	Construction [45]
26	Distribution [50, 51]	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel [50] Wholesale trade and commission trade, except of motor vehicles and motorcycles [51]
27	Retailing [52]	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods [52]
28	Hotels and catering [55]	Hotels and restaurants [55]
29	Land transport, etc.[60, 63]	Land transport; transport via pipelines [60] Supporting and auxiliary transport activities; activities of travel agencies [63]
30	Water transport [61]	Water transport [61]
31	Air transport [62]	Air transport [62]
32	Communications [64]	Post and telecommunications [64]
33	Banking and finance [65, 67]	Financial intermediation, except insurance and pension funding [65] Activities auxiliary to financial intermediation [67]
34	Insurance [66]	Insurance and pension funding, except compulsory social security [66]
35	Computing services [72]	Computer and related activities [72]
36	Professional services [70, 71, 73, 74.1-74.4]	Real estate activities [70] Renting of machinery and equipment without operator and of personal and household goods [71] Research and development [73] Other business activities (professional services) [74.1-74.4]
37	Other Business services [74.5-74.8]	Other business activities (business services) [74.5-74.8]
38	Public administration and Defence [75]	Public administration and defence; compulsory social security [75]
39	Education [80]	Education [80]
40	Health and social work [85]	Health and social work [85]
41	Miscellaneous services [90-93, 95-97, 99]	Sewage and refuse disposal, sanitation and similar activities [90] Activities of membership organisations n.e.c. [91] Recreational, cultural and sporting activities [92] Other service activities [93] Activities of households as employers of domestic staff [95] Undifferentiated goods producing activities of private households for own use [96] Undifferentiated services producing activities of private households for own use [97] Extra-territorial organisations and bodies [99]

Source: http://forum.europa.eu.int/irc/dsis/employment/info/data/eu_lfs/Related_documents/Nace_Rev_1.1.htm

Table II Aggregation of 41-industry to 6-industry

6-industry [NACE]		41-industry [NACE]			
1	Primary sector and utilities [01-14, 40, 41]	1	Agriculture, etc.[01-05]		
		2	Coal [10]		
		3	Oil and gas, etc.[11, 12]		
		4	Other mining [13, 14]		
		22	Electricity [40.1, 40.3]		
		23	Gas supply [40.2]		
		24	Water supply [41]		
2	Manufacturing [15-37]	5	Food, drink and tobacco [15, 16]		
		6	Textiles, clothing and leather [17-19]		
		7	Wood and paper [20, 21]		
		8	Printing and publishing [22]		
		9	Manufactured fuels [23]		
		10	Pharmaceuticals [24.4]		
		11	Chemicals nes [24(ex24.4)]		
		12	Rubber and plastics [25]		
		13	Non-metallic mineral products [26]		
		14	Basic metals [27]		
		15	Metal goods [28]		
		16	Mechanical engineering [29]		
		17	Electronics [30, 32]		
		18	Electrical engineering and instruments [31, 33]		
19	Motor vehicles [34]				
20	Other transport equipment [35]				
21	Manufacturing nes [36, 37]				
3	Construction [45]	25	Construction [45]		
4	Distribution and transport [50-64]	26	Distribution [50, 51]		
		27	Retailing [52]		
		28	Hotels and catering [55]		
		29	Land transport, etc.[60, 63]		
		30	Water transport [61]		
		31	Air transport [62]		
		32	Communications [64]		
		5	Business and other services [65-74, 90-99]	33	Banking and finance [65, 67]
				34	Insurance [66]
				35	Computing services [72]
36	Professional services [70, 71, 73, 74.1-74.4]				
37	Other Business services [74.5-74.8]				
41	Miscellaneous services [90-93,95,99]				
6	Non-marketed services [75, 80, 85]	38	Public administration and defence [75]		
		39	Education [80]		
		40	Health and social work [85]		

Occupations

Table III ISCO

Major group 1: legislators, senior officials and managers	
11	Legislators and senior officials
12	Corporate managers
13	Managers of small enterprises
Major group 2: professionals	
21	Physical, mathematical and engineering science professionals
22	Life science and health professionals
23	Teaching professionals
24	Other professionals
Major group 3: technicians and associate professionals	
31	Physical and engineering science associate professionals
32	Life science and health associate professionals
33	Teaching associate professionals
34	Other associate professionals
Major group 4: clerks	
41	Office clerks
42	Customer services clerks
Major group 5: service workers and shop and market sales workers	
51	Personal and protective services workers
52	Models, salespersons and demonstrators
Major group 6: Skilled agricultural and fishery workers	
61	Skilled agricultural and fishery workers
Major group 7: craft and related trades workers	
71	Extraction and building trades workers
72	Metal, machinery and related trades workers
73	Precision, handicraft, craft printing and related trades workers
74	Other craft and related trades workers
Major group 8: plant and machine operators and assemblers	
81	Stationary plant and related operators
82	Machine operators and assemblers
83	Drivers and mobile plant operators
Major group 9: elementary occupations	
91	Sales and services elementary occupations
92	Agricultural, fishery and related labourers
93	Labourers in mining, construction, manufacturing and transport
Major group 0: armed forces	

Qualifications

Level of qualification	
Low	(Pre)primary and lower secondary (ISCED 0-2)
Medium	Upper and post-secondary (ISCED 3-4)
High	Tertiary (ISCED 5-6)

ISCED 0: pre-primary education

Programs at level 0, (pre-primary) defined as the initial stage of organised instruction are designed primarily to introduce young children to a school-type environment, i.e. to provide a bridge between the home and a school based atmosphere. Upon completion of these programs, children continue their education at level 1 (primary education).

ISCED 1: primary education or first stage of basic education

Programmes at level 1 are normally designed on a unit or project basis to give students a sound basic education in reading, writing and mathematics along with an elementary understanding of other subjects such as history, geography, natural science, social science, art and music. In some cases religious instruction is featured. The core at this level consists of education provided for children, the customary or legal age of entrance being not younger than five years or older than seven years. This level covers, in principle, six years of full-time schooling.

ISCED 2: lower secondary education or second stage of basic education

The contents of education at this stage are typically designed to complete the provision of basic education which began at ISCED level 1. In many, if not most countries, the educational aim is to lay the foundation for lifelong learning and human development. The programmes at this level are usually on a more subject oriented pattern using more specialised teachers and more often several teachers conducting classes in their field of specialisation. The full implementation of basic skills occurs at this level. The end of this level often coincides with the end of compulsory schooling where it exists.

ISCED 3: upper secondary education

This level of education typically begins at the end of full-time compulsory education for those countries that have a system of compulsory education. More specialisation may be observed at this level than at ISCED level 2 and often teachers need to be more qualified or specialised than for ISCED level 2. The entrance age to this level is typically 15 to 16 years. The educational programmes included at this level typically require the completion of some nine years of full-time education (since the beginning of level 1) for admission or a combination of education and vocational or technical experience.

- ISCED 3A: programmes designed to provide direct access to ISCED 5A;
- ISCED 3B: programmes designed to provide direct access to ISCED 5B;
- ISCED 3C: programmes not designed to lead to ISCED 5A or 5B.

ISCED 4: post-secondary non tertiary education

ISCED 4 captures programmes that straddle the boundary between upper secondary and post-secondary education from an international point of view, even though they might clearly be considered as upper secondary or post-secondary programmes in a national context. These programmes can, considering their content, not be regarded as tertiary programmes. They are often not significantly more advanced than programmes at ISCED 3 but they serve to broaden the knowledge of participants who have already completed a programme at level 3.

Typical examples are programmes designed to prepare students for studies at level 5 who, although having completed ISCED level 3, did not follow a curriculum which would allow entry to level 5, i.e. pre-degree foundation courses or short vocational programmes. Second cycle programmes can be included as well.

- ISCED 4A: see text for ISCED 3
- ISCED 4B: see text for ISCED 3
- ISCED 4C: see text for ISCED 3

ISCED 5: first stage of tertiary education (not leading directly to an advanced research qualification)

This level consists of tertiary programmes having an educational content more advanced than those offered at levels 3 and 4. Entry to these programmes normally requires the successful completion of ISCED level 3A or 3B or a similar qualification at ISCED level 4A. They do not lead to the award of an advanced research qualification (ISCED 6). These programmes must have a cumulative duration of at least two years.

ISCED 5A: programmes that are largely theoretically based and are intended to provide sufficient qualifications for gaining entry into advanced research programmes and professions with high skills requirements.

ISCED 5B: programmes that are practically oriented/ occupationally specific and are mainly designed for participants to acquire the practical skills and know-how needed for employment in a particular occupation or trade or class of occupations or trades, the successful completion of which usually provides the participants with a labour-market relevant qualification

ISCED 6: second stage of tertiary education (leading to an advanced research qualification)

This level is reserved for tertiary programmes which lead to the award of an advanced research qualification. The programmes are, therefore, devoted to advanced study and original research and not based on course-work only. They typically require the submission of a thesis or dissertation of publishable quality which is the product of original research and represents a significant contribution to knowledge. They prepare graduates for faculty posts in institutions offering ISCED 5A programmes, as well as research posts in government, industry, etc.

Documentation by EULFS: Levels of education and training ISCED 1997

http://circa.europa.eu/irc/dsis/employment/info/data/eu_lfs/Related_documents/ISCED_EN.htm

Table V - Division of education by fields of study

01	Agriculture and veterinary
02	Computer science
03	Engineering, manufacturing and construction
04	Foreign languages
05	General programmes
06	Health and welfare
07	Humanities, languages and arts
08	Life science (including Biology and Environmental science)
09	Mathematics and statistics
10	Physical science (including Physics, Chemistry and Earth science)
11	Services
12	Social sciences, business and law
13	Teacher training and education science
14	Computer use
15	Science, mathematics and computing

Annex III: Distribution of fields of study across the occupations

ISCO	Fields of study	Bulgaria	Czech Republic	Germany	Spain	Italy	United Kingdom	EU27
131	Agriculture and veterinary	3.7	5.6	2.0	0.7	1.7	2.9	3.1
	Computer science	0.4	0.3	0.3	1.0	0.8	1.1	0.7
	Engineering, manufacturing and construction	49.9	46.5	26.4	7.6	13.7	21.4	18.7
	Foreign languages	0.4	0.2	0.3	0.0	1.1	1.0	0.6
	General programmes	13.6	4.4	4.9	17.4	2.9	0.5	8.9
	Health and welfare	2.0	2.0	2.8	2.1	0.5	4.4	2.2
	Humanities, languages and arts	2.4	2.4	2.7	1.7	3.5	6.6	3.4
	Life science (including Biology and Environmental science)	0.1	0.5	0.2	0.2	0.3	1.6	0.4
	Mathematics and statistics	0.4	0.2	0.2	0.1	0.1	0.4	0.2
	Physical science (including Physics, Chemistry and Earth science)	0.6	1.0	0.6	0.7	0.1	1.9	0.7
	Services	5.0	9.6	9.8	1.9	3.1	8.1	5.5
	Social sciences, business and law	15.4	20.8	32.3	12.4	19.4	20.1	19.6
	Teacher training and education science	2.8	5.0	2.3	1.4	2.6	2.1	2.0
	Computer use	0.1	0.0	0.4	0.0	0.1	0.6	0.2
	Science, mathematics and computing	0.0	0.0	0.0	0.6	3.9	0.7	1.4
NA	3.2	1.5	14.7	52.1	46.4	26.5	32.3	
241	Agriculture and veterinary	0.9	2.8	1.0	0.3	0.8	0.4	1.3
	Computer science	1.1	0.5	1.8	0.4	0.9	1.9	1.5
	Engineering, manufacturing and construction	11.8	17.3	14.6	3.2	11.2	5.0	10.1
	Foreign languages	0.9	0.2	1.0	0.0	2.0	2.2	1.2
	General programmes	1.6	6.1	4.5	1.5	2.9	0.3	4.1
	Health and welfare	0.8	1.7	2.0	2.2	0.3	2.6	2.3
	Humanities, languages and arts	1.0	1.9	2.9	5.0	3.3	5.9	3.7
	Life science (including Biology and Environmental science)	0.4	0.2	0.7	0.9	0.5	1.6	0.9
	Mathematics and statistics	0.3	1.1	0.7	1.7	0.5	4.1	1.5
	Physical science (including Physics, Chemistry and Earth science)	0.8	1.8	2.2	1.0	0.7	3.3	1.5
	Services	1.4	3.1	2.2	2.5	0.7	1.5	2.3
	Social sciences, business and law	77.5	59.6	58.4	77.3	67.6	60.9	62.1
	Teacher training and education science	1.2	3.1	3.3	3.0	1.5	1.8	2.8
	Computer use	0.2	0.1	0.8	0.0	0.2	0.4	0.4
	Science, mathematics and computing	0.0	0.0	0.0	1.0	3.1	2.6	1.2
NA	0.1	0.3	3.7	0.2	3.8	5.4	3.1	
343	Agriculture and veterinary	1.7	5.5	0.6	0.4	0.8	1.0	1.4
	Computer science	0.6	0.1	0.4	1.8	1.3	1.7	0.9
	Engineering, manufacturing and construction	12.7	13.5	8.3	2.7	7.2	2.3	7.2
	Foreign languages	0.4	0.2	1.3	0.0	2.5	2.0	1.3
	General programmes	12.3	10.8	3.7	26.0	4.0	0.8	9.4
	Health and welfare	0.8	2.4	2.6	1.7	0.6	2.0	2.1
	Humanities, languages and arts	1.6	1.3	1.2	4.8	4.5	4.4	3.2
	Life science (including Biology and Environmental science)	0.5	0.2	0.1	0.4	0.2	1.2	0.3
	Mathematics and statistics	0.7	0.2	0.2	0.4	0.3	1.5	0.4
	Physical science (including Physics, Chemistry and Earth science)	0.4	0.7	0.3	0.6	0.2	1.9	0.5
	Services	2.7	4.3	3.5	1.3	1.9	2.3	3.0
	Social sciences, business and law	62.9	58.5	68.6	44.9	59.5	62.9	59.3
	Teacher training and education science	2.2	1.6	1.8	3.4	4.7	1.6	2.5
	Computer use	0.0	0.1	0.6	0.1	0.3	1.8	0.3
	Science, mathematics and computing	0.0	0.0	0.0	1.3	3.8	1.9	1.3
NA	0.5	0.6	6.7	10.3	8.0	10.7	7.0	
712	Agriculture and veterinary	3.0	1.5	0.9	0.4	1.3	0.7	1.4

	Computer science	0.2	0.0	0.1	0.6	0.3	0.7	0.3
	Engineering, manufacturing and construction	42.6	89.3	78.5	9.3	11.6	65.2	40.7
	Foreign languages	0.1	0.0	0.0	0.0	0.2	0.0	0.1
	General programmes	14.4	0.6	0.9	10.3	0.5	0.9	5.1
	Health and welfare	0.0	0.1	0.3	0.4	0.0	0.4	0.3
	Humanities, languages and arts	0.2	0.4	0.5	0.4	0.7	1.9	0.8
	Life science (including Biology and Environmental science)	0.2	0.0	0.0	0.1	0.0	0.3	0.1
	Mathematics and statistics	0.0	0.0	0.0	0.1	0.1	0.4	0.1
	Physical science (including Physics, Chemistry and Earth science)	0.0	0.1	0.1	0.3	0.1	0.4	0.2
	Services	2.1	2.2	1.1	0.3	1.0	1.5	1.7
	Social sciences, business and law	0.8	0.8	0.9	1.6	2.5	2.9	1.9
	Teacher training and education science	0.2	0.0	0.1	0.2	0.2	0.4	0.3
	Computer use	0.0	0.0	0.0	0.0	0.0	0.2	0.1
	Science, mathematics and computing	0.0	0.0	0.0	0.1	1.1	0.3	0.3
	NA	36.1	5.0	16.6	76.1	80.3	23.8	46.7
832	Agriculture and veterinary	4.3	5.6	4.6	0.5	1.8	1.9	3.3
	Computer science	0.1	0.0	0.2	0.5	0.6	1.1	0.3
	Engineering, manufacturing and construction	57.7	77.0	50.3	10.2	14.4	27.0	34.9
	Foreign languages	0.0	0.0	0.1	0.0	0.1	0.4	0.1
	General programmes	14.2	2.2	2.4	13.6	0.9	0.8	6.6
	Health and welfare	0.3	0.3	0.7	0.6	0.2	1.7	0.6
	Humanities, languages and arts	0.4	0.4	0.9	0.5	1.2	3.8	1.1
	Life science (including Biology and Environmental science)	0.1	0.0	0.2	0.0	0.0	0.7	0.1
	Mathematics and statistics	0.0	0.0	0.0	0.1	0.0	0.3	0.1
	Physical science (including Physics, Chemistry and Earth science)	0.1	0.3	0.2	0.5	0.1	0.6	0.3
	Services	6.9	5.2	13.1	0.6	1.4	12.2	7.5
	Social sciences, business and law	1.0	2.3	6.8	3.9	5.5	9.8	5.1
	Teacher training and education science	0.5	0.0	0.6	0.3	0.4	0.7	0.4
	Computer use	0.0	0.1	0.1	0.0	0.1	1.1	0.1
	Science, mathematics and computing	0.0	0.0	0.0	0.3	1.2	0.4	0.4
	NA	14.5	6.6	19.7	68.4	72.0	37.5	38.9

Annex IV: Summary of SORT algorithm functioning

The sorting algorithm at the heart of BALMOD is designed to reconcile the projections from the Stock model of supply (numbers available by the three qualification levels) with those from the demand for qualifications model (number of jobs requiring particular qualification levels). The former provides a view of supply side developments (the overall numbers of people who have acquired qualifications at the three different levels that are actively searching for work), while the latter is more concerned with changing demand for qualifications within occupations (the number of jobs available requiring particular levels of qualifications).

The module also has to deal with differences between the various estimates of employment used in E3ME (based on National Accounts and LFS data) and the so called Labour Market Accounts Residual (LMAR), which arises in part because of such discrepancies but which is also affected by other issues, including measurement error. The main employment measure used in E3ME is a National Accounts based one. This is referred to as unconstrained estimates of employment. All the estimates by sector and occupation are on this basis. A second measure, based on LFS information and Eurostat demographic data, is implicit in the modelling of labour supply. This is referred to as supply in employment. The two differ for a variety of reasons, encompassed under the heading of the LMAR. These include:

- double jobbing (some have more than one job);
- distinction between residence and workplace (many people do not live in the same country as they work, this is especially significant for some small countries such as Luxembourg);
- government training and related schemes (which may count as in the labour force but not as in employment);
- different definitions of unemployment (ILO versus measures of claimants to benefits);
- statistical errors (in measures of employment, unemployment and related indicators, including sampling and measurements errors);
- other differences due to use of different data sources; treatment of the armed forces and nationals working abroad.

The Sorting model uses an iterative RAS procedure to reconcile two sets of estimates of employment, changing the overall qualification shares from the demand for qualifications model (QUALMOD) to match those from the Stock model of supply (STOCKMOD). This is done while at the same time maintaining the patterns of occupational deployment, and ensuring a plausible pattern of unemployment rates for the different qualification categories. It therefore focuses upon which occupations the people with different qualifications end up in.

Overall unemployment levels are taken from E3ME. This is taken as exogenous for these purposes. The overall level of unemployment is shared out between qualification categories, based on an extrapolation of patterns from historical LFS data. In the current versions it is assumed that the relative rates of unemployment for the three broad qualification categories are maintained. Checks are made to see that this results in plausible unemployment levels for the three qualification categories. The implied

unemployment levels by qualification are then deducted from the overall supply numbers to get the numbers of people in employment by qualification level (Supply in employment). The sorting model then reconciles these estimates with the number of jobs available (unconstrained estimates). This is done by altering the shares of people with the three different qualification levels employed within each occupation, until the overall numbers match the numbers of people available.

The final results may show indications of over or under-qualification of people in different occupations, depending on the overall demand-supply balance.

The constraint (matching of numbers by the three qualifications levels) is imposed at the 2 digit occupational level. The key dimensions in the SORT routine are:

- occupation (27);
- qualification level (3);
- sector (41);

(Note: The results in a number of the summary tables in the Imbalances workbooks where this process is undertaken show outcomes for aggregate 1 digit occupational groups and 6 broad sectors only)

The Sorting model operates for each country separately. There are assumed to be no adjustments via cross border flows (migration or commuting).

There is then one final step, where the final outcomes from the sort routine are scaled to match the original E3ME employment totals, to deal with the LMAR discrepancy.

Annex V

Table 1: An ideal taxonomy of the main components of error in developing occupational projections

Variables	Data errors: (basic sources (indicators), classification changes: NACE, ISCO, ISCED, etc)			Forecaster's Errors		Total error
	Errors in data on dependent variables	Errors in data on endogenous variables	Errors in data on Exogenous assumptions	Judgements on Exogenous assumptions	Model error (parameters)	(ex post)
1. Macro-level/ Scale effects						
1a. Macro-economic	GDP	Prices, wages, components of aggregate demand	Public finances, World economy Exchange rate Demography	Changes in key indicators	Macro model parameters	GDP growth Productivity growth
1b. Total Employment	Total employment	GDP	aggregate labour productivity	Productivity adjustments	Macro model parameters	Total employment growth
2a. Detailed employment by sector	Sectoral employment	Output, wages	Sectoral productivity	Sectoral productivity trends	Econometric estimates	Sectoral employment growth
2b. Employment by type (gender, status)	Employment by type	N/a	Employment by Sector	Trends by type	Coefficients (shares)	Shares by type and gender
3. Occupation						
3a. Detailed employment by occupation	Occupational employment	N/a	Employment by Sector and by type	Trends by occupation	Coefficients (shares)	Shares by occupation

Annex IV: Questionnaire for evaluation ‘Future Skill Needs in Europe’

The following short questionnaire will deal with several aspects of the medium-term skill needs forecast from CEDEFOP. Please help us improve the forecast by giving us your opinion. The results will be presented and reported in aggregated form.

The results of the forecast were published in different formats. There were concise summaries of results in briefing notes, while the full results can be found in the (synthesis) reports. Background papers give some of the technical details underlying the forecast.

1) Which reports are you aware of and how useful were they?

	Not received / Don't know this.	Received, but haven't read it.	Received, but found it not interesting.	Received, and found it somewhat interesting	Received, and found it very interesting
Briefing Notes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(Synthesis) report	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Background technical reports	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

2) Are there national skills forecast in your own country?

- yes, more detailed
- yes, about the same level of detail
- yes, less detailed
- no (*skip to 'Information text'*)

3) What is the time frame of the skill forecast in your country?

- less than 2 years ahead
- 2-5 years
- 6-10 years
- more than 10 years

The following questions are about the CEDEFOP Skills Forecast to 2020.

4) Which part of the Skills Forecast have you been using?

(*tick all applicable*)

- general results / summary
- workbooks
- methodology reports / background reports
- none (*skip to 'Information text'*)

What did you use the forecast for?

- to make policy recommendations
- for cross country comparisons
- for further research
- methodology adoption and implementation

Please rate the following aspects of the model in terms of importance to you

	(1) Very important	(2) Important	(3) Neutral	(4) Less important	(5) Not important
forecast on number of workers in sectors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
forecast on demand for workers in occupations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
forecast on demand for workers by education level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
forecast on labour supply by education	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
forecast on imbalances	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please rate the outcomes of the Skillsnet forecast in terms of its plausibility for your country and for pan-European comparison:

How plausible are the outcomes of the **sectoral** level forecasts?

	(1) plausible	(2) partly plausible	(3) neutral	(4) partly implausible	(5) implausible
On a national level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On a pan-European level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How plausible are the outcomes of the **occupation projections** (expansion demands)?

	(1) plausible	(2) partly plausible	(3) neutral	(4) partly implausible	(5) implausible
On a national level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On a pan-European level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How plausible are the **replacement demand** projections?

	(1) plausible	(2) partly plausible	(3) neutral	(4) partly implausible	(5) implausible
On a national level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On a pan-European level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How plausible are the outcomes of the **demand for qualification** level?

	(1) plausible	(2) partly plausible	(3) neutral	(4) partly implausible	(5) implausible
On a national level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On a pan-European level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How plausible are the outcomes of the **supply forecast by qualification** level?

	(1) plausible	(2) partly plausible	(3) neutral	(4) partly implausible	(5) implausible
On a national level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On a pan-European level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How plausible are the outcomes of **the demand for qualification** level?

	(1) plausible	(2) partly plausible	(3) neutral	(4) partly implausible	(5) implausible
On a national level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
On a pan-European level	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Overall, how do the outcomes of the CEDEFOP forecast relate to national forecasts and/or national expectations for the future?

- Very close to national forecast / expectations
- Same direction of outcomes
- Partially contradicting outcomes
- Contradicts national forecasts / expectations
- Don't know

How important is the availability of more detailed results and underlying data in the form of workbooks to you?

(1) Very important	(2) important	(3) Neutral	(4) less important	(5) Not important
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

How important is it to allow the user to change underlying data / forecast assumptions in the workbook?

- | | | | | |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| (1) | (2) | (3) | (4) | (5) |
| Very
important | important | Neutral | less
important | Not
important |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

In which direction should the project be developed in the future?

(Please choose up to three categories)

- Policy simulations
- Technological / organizational changes
- simulations Individual country scenarios
- Individual sector scenarios More detailed
- skills / competences forecast
- Other (please specify):

How much value added is there by the Pan-European projections compared with similar efforts already available at a national level?

- | | | | | |
|--------------------------------|--------------------------|--------------------------|----------------------------|--------------------------|
| (1) | (2) | (3) | (4) | (5) |
| very
much
value
added | much
value
added | some
value
added | not much
value
added | no
value
added |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Thank you for participating in the survey.

If you have any questions or comments, please feel free to contact:

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Abstract

This publication provides an overview of the methodology which stands behind the Cedefop skills supply and demand forecast. The aim is to share the knowledge obtained when developing different systems, modules and models, and to support the results which already achieved significant interest. The structure and robustness of methods used increases the clarity and reliability of the results.

Cedefop forecast is not meant to replace the forecasting efforts performed in individual countries. However, sharing the knowledge and experience from European level can contribute to improvement of existing methods used at national level and help to solve issues they may currently tackle. At the same time it can inspire the start of new forecasting initiatives and initiate further discussion. The feedbacks obtained can contribute to improvement of Cedefop methods and make the European forecast even more precise and reliable.

Not for dissemination