Department for Education

Working Futures 2017-2027: Long-run labour market and skills projections for the UK

Technical report on sources and methods

February 2020

Rob Wilson – Institute for Employment Research, University of Warwick

Mike May-Gillings, Shyamoli Patel and Ha Bui – Cambridge Econometrics

Preface and acknowledgements

The authors are grateful to the Department for Education for commissioning this research. Special thanks are due to Shivali Chotai, Patrick Vanderpant and Eleanor Adamiw from the Skills Policy Analysis team at the Department for Education.

This report has been a team effort, involving a large number of people. Mike May-Gillings, Shyamoli Patel and Ha Bui from Cambridge Econometrics, together with Luke Bosworth, Rosie Day, Peter Millar, David Owen and Sally-Anne Barnes from the Institute for Employment Research all made important contributions to the data analysis and processing. Derek Bosworth was responsible for developing key elements of the modelling the supply of qualified people. The responsibility for the views expressed and for any remaining errors lies with the authors.

Contents

List of figures

List of boxes

List of tables

1. Introduction

Working Futures 2017-2027 is the latest in a series of quantitative assessments of the employment prospects in the UK labour market over a 10-year horizon. It presents historical trends and future prospects by sector for the UK and its constituent nations and the English regions. The prime focus of Working Futures is on the demand for skills as measured by employment by occupation and qualification, although the supply side is also considered. Its prime objective is to provide useful labour market information that can help to inform policy development and strategy around skills, careers and employment, for both policy makers and a much wider audience. The results are intended to provide a sound statistical foundation for reflection and debate among all those with an interest in the demand for and supply of skills.

1.1. The new projections

This document provides a technical description of the sources and methods used to generate the sets of employment projections by industry and occupation presented in Working Futures 2017-2027.[1] These projections have been prepared by the Institute for Employment Research (IER) and Cambridge Econometrics (CE) on behalf of the Department for Education. They update those produced in 2016 on behalf of the UK Commission for Employment and Skills.[2]

This document explains the methodological approach employed to generate the detailed historical employment **Database**, as well as the models and procedures used to produce the projections.[3] This includes: information about the working assumptions adopted; the limitations of the estimates produced; and comparisons with official estimates.

The full results of the projections may be found in the following documents and files:

- The **Working Futures 2017-2027** report (henceforth referred to as the Main Report) for the whole of the UK. This summarises the main findings. It describes the key employment trends, and the implications for the next 10 years if they continue. It includes tables of data for selected years, together with a written commentary explaining and interpreting the forecasts. It covers the whole of the UK and the constituent countries which make it up.
- A spatial analysis, contained in Annex D to the main report, covering the four UK nations and nine English regions.

[1] Wilson *et al*. (2019) *Working Futures 2017-2027,* Department for Education.
[2] Wilson *et al*. (2016) *Working Futures 2014-2024,* UKCES and earlier sets of projections.
[3] The term ***Database*** has been used throughout this document to refer to the time series data on employment and output, cross classified by detailed sector (and in the case of employment by gender, status and occupation). It is indicated by the use of bold italicised script.

- The main Technical Report (this present document). A more detailed Qualifications Technical Report was produced in 2012 which described the models and methods used to develop the estimates of the demand for and supply of skills (as measured by qualifications) in more detail. Since the methodology remains basically unchanged this has not been updated.[4]
- Excel workbooks and the related User Guide and General Guidelines for using the workbooks. A comprehensive set of tabulations for the projections is provided in electronic format and supported by the User Guide, etc. All the detailed projections from Working Futures 2017-2027 are presented in the workbooks.

1.2. Structure of this document

The remainder of the present document is structured as follows:

- Section 2 outlines, in general terms, the models used to develop the employment scenario.
- Section 3 describes, in more detail, the methods used to model the UK economy, including detailed sectoral prospects.
- Section 4 deals with the modelling of employment in smaller geographical areas within the UK.
- Section 5 covers Labour Supply.
- Section 6 presents the categories and classifications used for defining industries and sectors, including those used for reporting.
- Section 7 covers the treatment of employment by gender and status.
- Section 8 deals with occupational employment structure, including development of views about the likely nature of projected structural changes and new results developed at a 4-digit level of detail.
- Section 9 deals with the methods used to generate replacement demands for occupations (covering losses due to retirements, etc.).
- Section 10 describes the main employment and Output **Database**, including how these have been developed.
- Section 11 describes, in more general terms, the data sources and methods used to produce the historical **Database**.
- Section 12 describes the detailed estimates prepared for Local Enterprise Partnership (LEP) areas. These provide the most detailed information available from the projections.

[4] Bosworth and Wilson (2012).

- Section 13 covers issues relating to statistical precision and the robustness of the estimates.
- Section 14 presents some warnings about confidentiality and statistical reliability when accessing the more detailed data.
- Section 15 covers the methods used to deal with the demand for and supply of skills as measured by the highest qualifications held.
- Section 16 covers general caveats on the employment estimates produced, including issues related to comparison with official estimates.[5]

The various sections of this report are designed to be read independently. They have therefore been written so that they can stand alone, with only limited cross-referencing. Inevitably this leads to a certain level of duplication and repetition. The authors hope that the benefits outlined above will outweigh any disadvantages that the latter may bring.

[5] Comparisons with previous *Working Futures* projections are in Annex B of the Main report.

2. The Models used

2.1. The need for a macroeconomic model

Best practice worldwide suggests that labour market projections should be firmly grounded on an understanding of how the economy as a whole is changing. Changes in employment structure are intimately tied up with the development of the economy more generally. This has been operationalised in the form of the regional Multi-sectoral Dynamic Model of the UK economy (MDM-E3) developed by Cambridge Econometrics (CE). Details of MDM-E3 and its relationship with other model components are given in Figure 2.1.

Figure 2.1 summarises the models used by CE/IER for employment forecasting. MDM-E3 is described in more detail in Section 3. It has a Keynesian structure incorporating an input-output system and concentrates on the determination of changes in the real sector of the economy. Each region is modelled separately, with (for many variables) regional results being scaled to UK results. The level of disaggregation of commodities and industries is considerable by the standards of other models of the UK economy: at the UK level 87 sectors are distinguished, and disaggregation at the regional level is 46 sectors. Primarily because of the degree of disaggregation, the model is a large one and comprises over 5,000 behavioural and technical relationships (excluding accounting identities). Its main components are equations explaining consumption, investment, employment, exports, imports, and prices. At its heart is an input-output matrix, which deals with the flows of goods and services between industries and determines total industrial outputs. These equations are all solved together so that the final results are consistent with the various identities required by the national accounts.

In MDM-E3 there are currently 87 main employing activities distinguished at the UK level (and 46 for the regions), defined using the Standard Industrial Classification 2007 (SIC2007). These categories are based on the limitations of available data.

At its greatest level of sector disaggregation, Working Futures 2017-2027 presents results for 75 sectors defined by SIC2007. Using methods described below, the UK 87 sectors from MDM-E3 have been aggregated to the 75 sectors, and the model's regional results (by 46 sectors) are disaggregated up to the level of the 75 sectors.

2.2. The employment output relationship

A key relationship is that between industry employment and output. Employment is treated as a demand for labour, derived from the demand for goods and services. UK employment equations are estimated, relating industrial (headcount) employment in each industry to its gross output and the relative wage costs as measured by industry wages relative to industry prices. In the vast majority of cases the results suggest that

an 'error correction' formulation can be applied, so this model was imposed in all industries. In this form, the residuals from the first stage 'co-integrating regression', (which represents the long-run relationship between employment and its determinants) are used in a 'second stage' dynamic specification, which incorporates various lagged terms to reflect adjustment lags.[6] The inclusion of the residuals from the 'first stage' ensures that the long-run solution, given by the co-integrating regression, is imposed. To complement the employment equations, a set of hours equations by industry have also been estimated, which relate average weekly hours worked by industry to normal hours and capacity utilisation.

2.3. Other model components

The links between the main macroeconomic model and the other forecasting models are illustrated in Figure 2.1. The macroeconomic model is, generally speaking, based upon quite sophisticated econometric analysis of long time series data sets. The links between the main macroeconomic model and the other forecasting models are illustrated in the figure. The macroeconomic model is, generally speaking, based upon quite sophisticated econometric analysis of long time series data sets.[7] It is characterised by many feedbacks from one set of equations to another. By contrast, the other sub-models relating to occupational employment and replacement demands are based on much more limited data and do not feed back into the main macroeconomic model. These include the models used to develop projections of occupational structure and qualifications. The projections involve further procedures, which allow for even greater detail, including:

- Extension from regional 46 industries to 75 industries (defined in SIC2007), with the UK results aggregated from 87 to 75 industries;
- Development of results for detailed geographical areas, including the countries of the UK and English Regions.
- Extension to the 4-digit level of SOC2010 for occupations.
- These are extensions are described in greater detail in the following sections.

[6] For an example see: Briscoe, G., and Wilson, R. A. (1991). Explanations of the Demand for Labour in the United Kingdom Engineering Sector. *Applied Economics* 23, pp.913-26.
[7] The equations use a slightly different time frame for different variables. Most equations use data back to 1979, but some are based on earlier or more recent data than that.

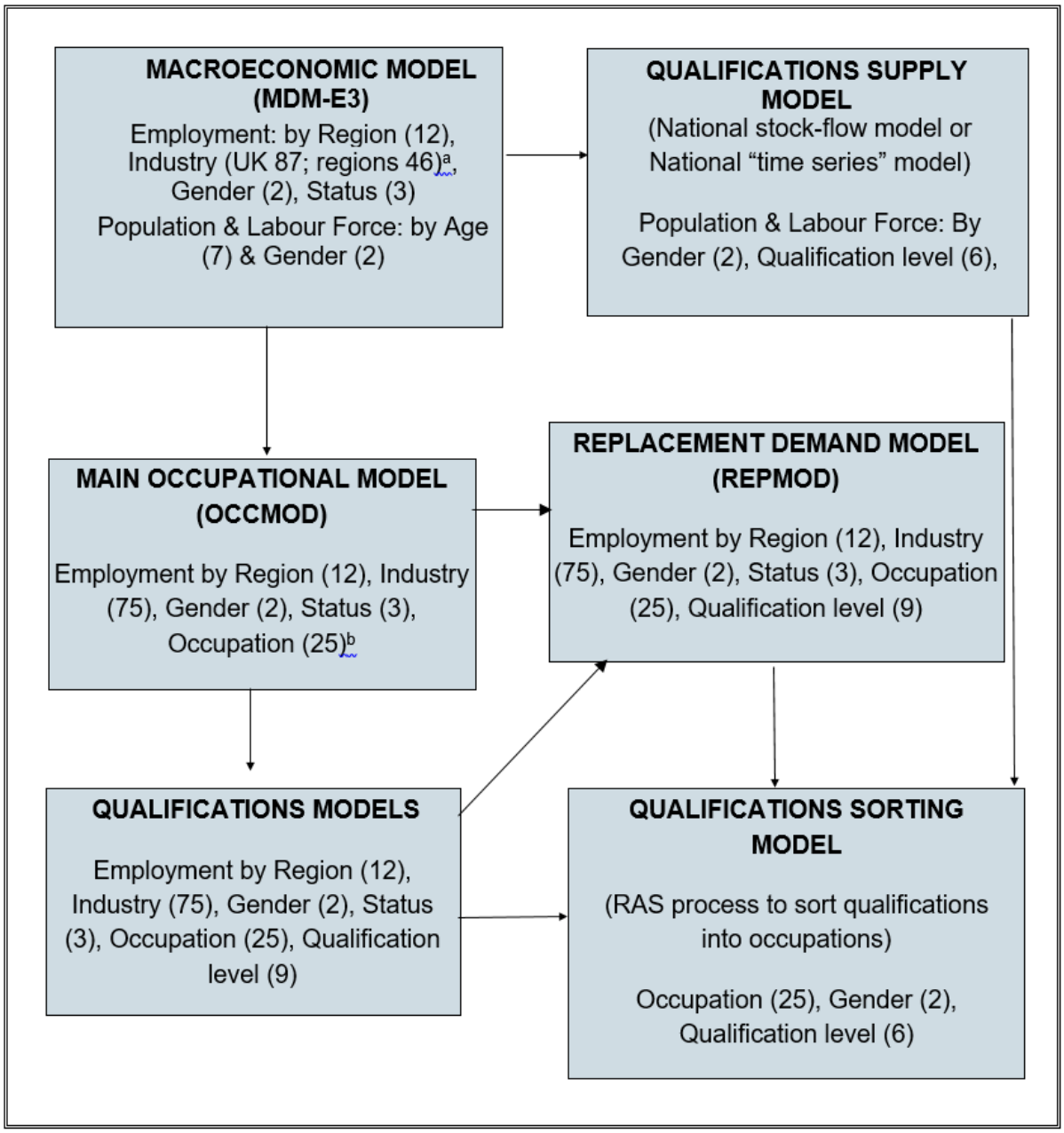

Figure 2.1: The Working Futures models and modules

Notes:

(a) These are extended to cover 75 industries defined in SIC2007, as described in Sections 3 and 4.

(b) These are extended to cover 369 4-digit SOC2010 categories as described in Section 8.

3. Modelling the UK economy

3.1. Introduction

As outlined in Section 2, the macroeconomic model used to develop the underlying scenario for the employment projections is based on a detailed analysis of economic and other behavioural relationships, statistically estimated using robust econometric methods. The model offers a combination of great detail, and a high level of sophistication. The use of a fully-specified, formal macroeconomic regional multi-sectoral model provides a number of advantages over more ad hoc extrapolation methods. These include enforcement of logical and accounting constraints, and emphasis on making explicit the underlying assumptions built into the projections. The importance of using such methods, and further information about the approach, are set out in Barker and Peterson (1987)[8] and Wilson (1994)[9].

The forecasts for Working Futures 2017-2027 were prepared using the latest version of the Cambridge Econometrics Multi-sectoral Dynamic Model (MDM-E3 Revision 13406 which is based on SIC2007. National Accounts data (with chained volume measures, with reference year 2016), along with a consistent input-output table and classification converters, have been incorporated into this revision of MDM-E3. All the main equation sets in the model, including the regional equations, were re-estimated on the latest data using a standard co-integrating technique. The estimation and model solution procedures were programmed in a common framework, with software facilities incorporated for checking the results and identifying errors.

Finally, the results of the model were translated into 75 industries defined in SIC2007 divisions for presentational purposes.

3.2. The latest version of MDM-E3

MDM-E3 continues to benefit from a substantial programme of sectoral modelling development work. This programme of work aims to improve all of CE's sectoral-regional E3 models (the global model E3ME and the UK model MDM-E3) and to implement changes required to make the models consistent with the most recent data and methods. CE's E3 models provide a framework for generating forecasts and alternative scenarios, analysing changes in economic structure and assessing energy-environment-economy (E3) issues and other policies.

[8] Barker, T., and Peterson, W. (1987). (eds.) *The Cambridge Multi-sectoral Dynamic Model of the British Economy*. Cambridge University Press: Cambridge.
[9] Wilson, R, A. (1994). 'Modelling and Forecasting the Structure of Employment in the United Kingdom', in H. Heijke (ed.) *Labour Market Forecasts by Occupation and Education*. Massachusetts: Kluwer Academic, pp.9-35.

The number of industries in MDM-E3 has been chosen to give a balanced representation of the structure of the economy. As that structure changes over time, the model is reviewed and revised accordingly. The industry classification comprises 87 at the UK level and 46 for the regions. These are further aggregated or disaggregated outside MDM-E3 to obtain the 75 industry breakdown used in Working Futures.

The MDM-E3 database incorporates the latest chained volume measure (CVM) data (see section 3.4) and the latest input-output estimates, with industrial disaggregation defined using the SIC2007.

3.3. Impact of European System of National and Regional Accounts 2010

The MDM-E3 database is constructed using the Office for National Statistics (ONS) National Accounts, Regional Accounts and other key ONS statistics. The statistics conform (since 2014) to the European System of National and Regional Accounts (ESA 2010), with a methodology consistent with the System of National Accounts 2008 (SNA 2008). The main changes compared with the preceding ESA95) include: the reclassification of research and development (R&D) from intermediate purchases to investment (and other changes to the treatment of investment); and a different treatment of private pension schemes. These changes impact the level of Gross Domestic Product (GDP) and since the ONS has revised historical data to be consistent, the impact on output growth is minimal.

3.4. Incorporating National Accounts data in CVM form

The 2003 National Accounts saw the introduction of 'annual chain-linking', a method for constructing aggregate CVM of economic growth which better reflect the changing structure of industry and patterns of expenditure. The latest version of MDM-E3 incorporates CVM data from the National Accounts 2018.

Using the 'annual chain-linking' method, the detailed estimates for growth for different industries are summed using information for the price structure updated every year to give each industry the most relevant weight which can be estimated. CVM indices are referenced to the most recent year for which a price structure is available; later years are compiled in the same way as constant-price data (using fixed weights from the most recent year for which a price structure is available).

The move to annual chain-linking has produced some loss of additivity in the components of aggregate totals in the years prior to the reference year. For example, if Gross Value Added (GVA) for each industry is summed through simple addition the total across the industries will not correspond to the CVM estimate of total GVA. A

more complex method of weighting the series together is required to correct for this discrepancy.

3.5. Constructing a time series of input-output tables

Input-output supply and use tables (SUTS) provide a framework to make consistent estimates of economic activity by amalgamating all the available information on inputs, outputs, GVA, income and expenditure. For a given year, the input-output framework breaks the economy down to display transactions of all goods and services between industries and final consumers (e.g. households, government) in the UK. Since 1992, ONS has used the input-output process to set a single estimate of annual GDP and ONS has published the detailed analyses in the SUTS.

The information from the regular releases of SUTS are used in conjunction with the more detailed analytical tables (published for 2013 in March 2017) to construct the inputs that are required for the MDM-E3 model. A time series of input-output tables has been estimated from official data to provide the detail needed to model inter-industry purchases and sales. The work required to adjust the original ONS input-output supply and use tables (which are in purchasers' prices) mainly entails (1) the reallocation of the duties on alcohol, tobacco and petrol to final consumers and (2) the reallocation of distribution and other margins from the valuation of each commodity's demand to wholesale and retail distribution commodity output. Associated classification converters have been constructed using the available ONS data.

3.6. ONS gross output and value added data

The forecast also incorporates data from the ONS on gross output and value added. CVMs of value added by industry are constructed from ONS SIC2007 indices of output data (see section 3.3). Input-output balances provide data for gross output by SIC2007 in the reference year 2016. A time series for gross output has been constructed based upon updated gross output data in SUTs 2016, originally collected at the 105-industry level of detail, which have been aggregated to the MDM-E3 industry definitions. To extend the series further back from 1997 (for which SIC2007 data are not available) gross output data at the 123-industry level of detail corresponding to that of the 2005 input-output analytical tables (SIC2003) was aggregated and reclassified to the MDM-E3 industry definitions (see Table 3.1). These data have been updated in line with short-term indicators for more recent years.

3.7. Reconciling final demand time series with ONS National Accounts

MDM-E3 incorporates investment data by 88 investing sectors (corresponding to the 87 industry sectors, plus dwellings), based on the ONS's detailed data on investment by 82 industries and 44 products.

Household final consumption expenditure classified by 51 categories of purpose (which includes final consumption expenditure of non-profit institutions serving households) has been incorporated into MDM-E3, corresponding to the National Accounts. Historical data published in detail in the UK National Accounts and Consumer Trends are used to construct the data.

The latest data from the ONS for exports and imports have also been incorporated into this forecast. These use the detailed data from the SUTS available at 105 sector detail, which is mapped to the MDM-E3 87 industries. The time-series data for years after 1997 were reconciled at an aggregate level with data from the ONS's Blue Book and more recent press releases.

3.8. Intermediate demand

Intermediate demand is the monetary value of the goods and services used as inputs in production by other industries. The input-output coefficients derived from the input-output tables allow intermediate demand to be derived from each product given the final demand at the product level of disaggregation.

Table 3.1: Classification of Industries in MDM-E3 (SIC2007) - UK

MDM-E3 Industries	SIC2007 Division
UK87	
1. Crop and Animal Production, Hunting and related Service Activities	01
2. Forestry and Logging	02
3. Fishing	03
4. Coal	05
5. Oil	06.1
6. Gas	06.2
7. Other Mining and Quarrying	08
8. Mining Support Service Activities	09
9. Manufacture of Food	10
10. Manufacture of Drinks	11
11. Manufacture of Tobacco	12
12. Manufacture of Textiles	13
13. Manufacture of Wearing Apparel	14
14. Manufacture of Leather and Related Products	15
15. Manufacture of Wood and Wood Products, etc	16
16. Manufacture of Paper and Paper Products	17
17. Printing and reproduction of recorded media	18
18. Manufacture of Coke and Refined Petroleum Products	19
19. Manufacture of Chemicals	20
20. Manufacture of Pharmaceuticals	21
21. Manufacture of Rubber and Plastics Products	22
22. Manufacture of Other non-metallic mineral products	23
23. Manufacture of Basic Metals	24
24. Manufacture of Fabricated Metal Products	25
25. Manufacture of Computer, Electronic and Optical Products	26
26. Manufacture of Electrical Equipment	27
27. Manufacture of Machinery and Equipment N.E.C	28
28. Manufacture of Motor Vehicles	29
29. Manufacture of Other Transport Equipment	30
30. Furniture	31
31. Other Manufacturing NES	32
32. Repair and installation	33
33. Electricity supply	35.1
34. Gas, heat and cooling supply	35.2-35.3
35. Water supply	36
36. Sewerage	37
37. Waste disposal activities	38
38. Waste management activities	39
39. Construction of buildings	41
40. Civil engineering	42
41. Specialised construction activities	43
42. Wholesale and retail trade of motor vehicles	45
43. Wholesale trade	46
44. Retail trade	47

MDM-E3 Industries	SIC2007 Division
UK87	
45. Land transport	49
46. Water transport	50
47. Air transport	51
48. Warehousing/storage	52
49. Postal and courier services	53
50. Hotels and other accommodation	55
51. Catering	56
52. Publishing	58
53. Media	59
54. Broadcasting	60
55. Telecommunications	61
56. Computer services	62
57. Information services	63
58. Financial services	64
59. Insurance and pension funding (excl compulsory social security)	65
60. Other financial and insurance support services	66
61. Real Estate	68
62. Legal and accounting activities	69
63. Management consultancy and other professional outsourcing activities	70
64. Architectural and engineering activities	71
65. Scientific Research and Development	72
66. Advertising and market research	73
67. Other professional services	74
68. Veterinary activities	75
69. Rental and leasing activities	77
70. Employment activities	78
71. Travel agencies	79
72. Security and investigation activities	80
73. Services to buildings and landscape activities	81
74. Office administrative and business support activities	82
75. Public administration and Defence	84
76. Education	85
77. Human health activities	86
78. Residential care activities	87
79. Social work activities without accommodation	88
80. Creative, arts and entertainment activities	90
81. Library, archives, museums and other cultural activities	91
82. Gambling and betting services	92
83. Sport and recreational activities	93
84. Activities of membership organisations	94
85. Repair of computers and personal household goods	95
86. Other personal service activities NES	96,97
87. Unallocated	

3.9. Detailed employment data consistent with BRES

Detailed UK Employment data by gender and status were derived from ONS Labour Market Statistics, which provides quarterly employees (1992Q4-2018Q1) by gender and status, and self-employment data (1996Q1-2018Q1), by gender, for 82 sectors based on an aggregation of 2-digit SIC2007.

The results were then converted to CE's MDM87 classification by splitting some of the 82 sectors further using a converter derived from the share of the more detailed sectors in the full 2-digit sector, using employment data from the Business Register and Employment Survey (BRES).

The quarterly data was then converted to an annual basis by taking the Q2 (June) observation for each year. This annual series was then extrapolated back to 1971 using growth rates from CE's own, consistent, earlier historical dataset, which is based on previously published ONS data.

3.10. Analysing and forecasting changes in economic structure

The economic model is designed to analyse and forecast changes in economic structure. To do this, it disaggregates industries, commodities and household and government expenditures, as well as foreign trade and investment. MDM-E3 disaggregates all of the main variables that are treated as aggregates in most macroeconomic models. The detailed variables are linked together in an accounting framework based on the United Nations System of National Accounts. This framework ensures consistency and correct accounting balances in the model's projections and forecasts.

The model is a combination of orthodox time-series econometric relationships and cross-section input-output relationships. Although it forms aggregate demand in a Keynesian manner, with a consumption function and investment equations, it also includes equations for average earnings by industry. Other aspects of the supply side come in through the export and import equations, in which capacity utilisation affects trade performance, as well as a set of employment equations which allow relative wage rates and interest rates to affect employment and therefore industry-level productivity growth.

The main exogenous variables of the model are as follows:

- world growth in GDP;
- world inflation in GDP deflators and in prices of traded goods such as crude oil;

- UK and regional population, labour force and natural resources (the main natural resources being coal, oil and natural gas);
- current and capital spending of the UK government;
- UK tax rates and allowances;
- the sterling-dollar and other exchange rates;
- UK and US interest rates.

3.11. Adjustments made to MDM-E3

The main adjustments made to the model in order to produce a forecast were as follows:

- Recent data on outcomes and short-term industrial forecasts for 2018 are included directly in the model solution with multiplicative errors between model calculations and actual values being estimated.
- Time trends are not included in the long-term component of the equations unless based on theoretical grounds. Constants are included in the dynamic components of the equations, so that the forecast will settle down to a steady growth path, unless there are long-term effects, such as the effect of accumulated investment.
- Cyclical variables were phased out by holding the variables constant at 'normal' values after the first year or so of the forecast.
- Special assumptions are made for forecasts of investment in the coal, oil & gas, electricity, gas and water industries, and public sector investment.

The multiplicative errors from the co-integrating equations and most of the other estimated residuals in the model are held constant at values for the last year for which data or short-term forecasts and estimates were available, unless they are changed to allow the model to incorporate expert views or updated forecasts.

3.12. The treatment of Brexit

The Working Futures projections are grounded in a forecast of the future macroeconomic and labour market context. When developing the UK forecast in MDM-E3, certain assumptions were made about Brexit:

- there is no "cliff-edge" / "no-deal" moment, (i.e. the UK agrees some form of transitional deal with the EU);
- the bespoke arrangement with the EU involves:
  - the UK securing an ability to reduce EU migration;

- the UK remains in the single market for goods but not services (so there is no financial services passporting); and
- there are likely to be some continued payments for continued access to EU markets and reflecting ongoing commitments previously entered into.

3.13. The reliability of the forecast

The reliability of the forecast partly reflects the reliability of the data. In recent years, the implementation of ESA2010 has been an important driver of improvements to the National Accounts. Resources have been invested in the production of annual input-output supply and use tables and these tables, and the associated analyses, are now incorporated in the annual estimates of the National Accounts published in the Blue Book.

The measurement of economic growth has been improved by the introduction of chain-linked estimates of GVA and its components since the 2003 National Accounts. These changes have improved the international comparability of UK data and reduced the size of revisions that occur when data are rebased to a new reference year.

The forecast should be seen as providing a reasonably consistent, comprehensive and sustainable view of the development of the economy which is built up from projections of individual industries. Part of the plausibility comes from the fact that strong trends over history, such as the extraordinary growth in household expenditure in the run-up to the 2008 recession, have not been thought to be sustainable because of their implications for the balance of payments and for inflation. Assumptions are made in the projections about changes in policy or behaviour, which produce changes in such trends and credible outcomes for both the macro economy and the individual industries.

The forecasts for individual industries are much less certain than those for the aggregates. Some indication of the errors involved is given by the residuals. These are the industrial counterparts to the ONS's residual errors for the whole economy, published in the Blue Book.

3.14. Aggregating the UK output (GVA) and employment data to 75 SIC2007 sectors

The correspondence between the 87 industries and the detailed 75 industries for Working Futures 2017-2027 are shown in Table 4.1 below. The UK-level results for output (GVA) and employment by these 75 industries were created by aggregating the 87 industries on this basis.

4. Modelling the spatial dimension

4.1. Modelling individual countries and regions within the UK

A distinctive feature of the forecasts for the individual countries and English regions within the UK is that they are based on a fully specified and coherent model, MDM-E3, of the constituent economies (henceforth referred to here as “regions”).

The model has a clear economic structure allowing incorporation of incomplete and partial data, but at the same time validating the model's projections against the available data for employment and output. The regional specification of MDM-E3 is a development of the original Cambridge Multi-sectoral Dynamic Model of the UK economy. Accounts of the model are provided in Barker and Peterson (1987)[10] (version 6) and Barker et al. (2001)[11]. The current MDM-E3 incorporates a time-series regional specification distinguishing, inter alia, 46 industries and 51 categories of household expenditure. The constituent countries of the UK and the English regions are treated as one of several classifications in the model, with several commodity, industry and employment variables regionalised according to the availability of data. The current version of the model has been re-estimated on the December 2017 release of Regional Accounts data, which were adjusted to be consistent with the latest National Accounts (chained volume measures with reference year 2016) using a consistent input-output table and classification converters.

4.2. Development of a UK Regional Econometric Model

To develop a model that embodies for all of the regions an accounting structure (including input-output coefficients) to parallel that of the UK would inevitably entail a substantial exercise in data construction and imputation.[12] Instead, the approach taken in MDM-E3 is to make best use of the regional data available to support detailed modelling of the key variables of interest – output, labour demand and labour supply. The approach has been to build up a regional econometric model and database, as an integral part of the MDM-E3 model. The model has a clear economic structure, uses incomplete and partial data, and applies econometric techniques to those variables for which the data is judged sufficiently robust to support econometric estimation. The forecasts and projections for the recent past are calibrated so as to reproduce the

[10] Barker, T., and Peterson, W. (1987). (eds.) *The Cambridge Multi-sectoral Dynamic Model of the British Economy*. Cambridge University Press: Cambridge.

[11] Barker, T., Fingleton, B., Homenidou, K., and Lewney, R. (2001). The Regional Cambridge Multi-sectoral Dynamic Model of the UK Economy, pp. 79-96 in G. Clarke and M Madden (eds.). *Regional Science in Business*, Springer-Verlag, Heidelberg.

[12] Previous versions of MDM-E3 included a fuller accounting treatment for the regions, but the advantages that this provided were not considered sufficient to outweigh the limitations of the data and associated efforts to maintain that treatment.

available data for employment and output. A sensible direction of economic causation for employment is an inherent feature of the model.

An important guiding principle is that that the regional variables and data are consistent with the UK variables and data. At the regional level, a less detailed (46) industry classification (See Table 4.1) has been adopted for the industry variables (such as GVA and employment) in the regionalised MDM-E3 because the available regional data are not sufficient to disaggregate to 87 industries (as in the UK analysis).

4.3. Problems with regional data

In developing a regional model for the UK, the data problems have been tackled as follows.

Where the data are of suspect quality, three checks have been done. First, all sources have been used to cross-check data where possible. Second, the UK totals have been used to control the regional data in as much detail as possible. And third, the views of regional experts are sought.

MDM-E3 Industries	SIC2007 Division	MDM-E3
REG46		**UK87**
1. Agriculture , forestry & fishing	01-03	1-3
2. Mining & quarrying	05-09	4-8
3. Food, drink & tobacco	10-12	9-11
4. Textiles etc	13-15	12-14
5. Wood & paper	16-17	15-16
6. Printing & recording	18	17
7. Coke & petroleum	19	18
8. Chemicals	20	19
9. Pharmaceuticals	21	20
10. Non-metallic mineral products	22-23	21-22
11. Metals & metal products	24-25	23-24
12. Electronics	26	25
13. Electrical equipment	27	26
14. Machinery	28	27
15. Motor vehicles	29	28
16. Other transport equipment	30	29
17. Other manufacturing & repair	31-33	30-32
18. Electricity & gas	35	33-34
19. Water, sewerage & waste	36-39	35-38
20. Construction	41-43	39-41
21. Motor vehicles trade	45	42
22. Wholesale trade	46	43
23. Retail trade	47	44
24. Land transport	49	45
25. Water transport	50	46
26. Air transport	51	47
27. Warehousing & postal	52-53	48-49
28. Accommodation	55	50
29. Food & beverage services	56	51
30. Media	58-60	52-54
31. IT services	61-63	55-57
32. Financial & insurance	64-66	58-60
33. Real estate	68	61
34. Legal & accounting	69	62
35. Head offices & management consultancies	70	63
36. Architectural & engineering services	71	64
37. Other professional services	72-75	65-68
38. Business support services	77-82	69-74
39. Public Administration & Defence	84	75
40. Education	85	76
41. Health	86	77
42. Residential & social	87-88	78-79
43. Arts	90-91	80-81
44. Recreational services	92-93	82-83
45. Other services	94-96	84-86
46. Unallocated	HMF	87

Table 4.1: Classification of Industries in MDM-E3 (SIC2007) – Regions

The methods adopted have been applied systematically for all the regions of England, and this provides a further check in the case of Scotland, Wales and Northern Ireland, where more detailed data are available.

4.4. Processing the regional output data

The model and forecast are based on the latest National Accounts (chained volume measures with reference year 2016) and a consistent input-output table. The ONS publishes annually a series of Regional Accounts consistent with the UK National Accounts. Regional Accounts data published in December 2017 (last year of data is 2016), adjusted to be consistent with the 2018 National Accounts have been incorporated in the forecasts.

Data for nominal GVA, household expenditure and household incomes are included for the English regions, Wales, Scotland and Northern Ireland. ONS Regional Accounts data (from 1997 onwards) by industry (31) and region were used where there was a direct mapping available. For those sectors where only aggregated totals were available from Regional Accounts (e.g. manufacturing), more detailed data (based on Annual Business Survey (ABS)) was used to disaggregate the Regional Accounts totals, to give the full MDM-E3 regional 46 industry breakdown. For years prior to 1997, growth rates from previous Working Futures estimates were used. Current price data at the 46 industry level were deflated using the corresponding national deflators.

4.5. Data for regional employment

The source for regional employment data is also the ONS. Data for the total of employees in employment, self-employment and HM Forces come from the ONS quarterly Workforce Jobs series, from which the June (Q2) count seasonally unadjusted data are used. This provides data for employee jobs and self-employment jobs, by 19 sectors and gender/ status. These are further disaggregated to the 46 sectors of MDM-E3, using data from BRES and the Annual Business Inquiry (ABI). Data for Northern Ireland is not available from BRES/ABI, and so the 19-sector data was dis-aggregated using ratios for Great Britain.

4.6. Data for unemployment

Two measures of unemployment are used in MDM-E3. The first is claimant count unemployment, defined by the annual average, seasonally adjusted, of benefit claimants aged 18 and over. The second is the, wider, International Labour Organisation (ILO) measure, which is obtained from the Labour Force Survey (LFS).

4.7. Gross value added (GVA) forecasts

The forecasts for GVA in the regions and nations of the UK are produced using equations estimated for each industry and region. The equations estimate the relationship between growth in GVA in a sector in the region and growth in that same sector in the UK as a whole. These same relationships are assumed to hold into the future. Thus, if GVA growth in a particular industry and region outperformed GVA growth in the same industry in the UK as a whole, it is assumed to do so in the future, and vice versa. The forecasts produced from these equations are then scaled to ensure they match the forecasts for the UK as a whole, on an industry-by-industry basis.

4.8. Employment forecasts

Employment is treated as a demand for labour, derived from the demand for goods and services. UK employment equations were estimated, relating industrial (headcount) employment in each industry to its gross output, wage rates and other drivers. Long-run cointegrating relationships were identified and estimated and dynamic error-correction equations estimated to allow for short-run effects. In general the equations were well determined and the parameters were of the expected sign and magnitude.

To determine employment by region, for each industry in the region, employment is set to grow at an assumed rate of productivity incorporated exogenously in the model. These productivity assumptions are derived from historical trends in regional productivity growth (by industry). The regional employment, by industry, is then scaled to match the UK employment.

In MDM-E3, labour supply is determined bottom-up with the UK results obtained by the summation of results from a set of equations specified by region, age band and gender (see Chapter 5).

4.9. Average wage rate forecasts

In general, wage rates in the UK are formed as the outcome of a bargaining process between employers, sometimes organised into employer organisations, and employees, sometimes organised into trade unions. The government affects the process as a major employer and as a source of legislation affecting all aspects of the process: the legal standing of the parties; the taxes imposed at various stages in the earning and spending of wages; the provision of benefits to the unemployed and the non-employed; and the direct legislation of permitted or recommended wage rates via income policies or minimum wages. In MDM-E3, average wages by industry are

determined at the UK level by industrial productivity, national price inflation, unemployment rates and benefit rates.

Productivity also has a positive relationship with wages: if employees in an industry are able to increase value added by increasing output for the same input then they are able to command higher wage rates. The aggregate consumer price index is assumed to have a positive relationship with wages, such that an increase in prices should lead to an increase in wages. However, unemployment benefit has a positive relationship with wages, as the unemployment benefit rate will mean that workers will want to gain sufficiently more than the available benefit transfer to justify employment. In MDM-E3, again following the wage bargaining models, unemployment levels also have an impact on wages: if unemployment is high it follows that wages will be low as there is no incentive for employers to pay an individual more when there are a large number of unemployed willing to work for a lower salary.

The retention ratio term identifies the average real take-home pay for any given salary level. The purpose of this is to simulate the characteristic of individuals operating in a way to make sure that their net pay means they are equally well off following a change in tax. If income tax increases, the retention ratio falls and wages rise to (fully or partially) compensate for the higher tax rate.

For each region, average wages by industry are scaled to match the UK wages. Wage bills are calculated across region and industry by multiplying the average wage by the number of employees.

4.10. Household expenditure data and forecasts

Household expenditure is estimated at an aggregated level for each of the 12 UK regions covered in MDM-E3 and then further disaggregated to the 51 expenditure categories which relate to the COICOP (Classification of individual consumption by purpose) classification. At the aggregate level regional consumption in real terms is predominantly a function of regional real income. This relationship is constrained to reflect the idea that expenditure cannot outgrow income levels in the long term, although it is possible in the short term.

4.11. Population data and projections

The historical population data for the UK, regions and sub-regions are ONS mid-year estimates to 2017. The population projections for the UK are based on the ONS 2016-based national population projections, and are generated by applying the growth rates for 2018 onwards from those projections to the mid-year estimates for 2017, by age and gender. The projections for the regions and sub-regions are generated using a similar methodology, but using ONS 2016-based subnational population projections. These are scaled to the UK projections. It should be noted that all of the qualifications

data from the LFS are scaled with these population figures. The qualifications of the active population are also scaled to CE estimates of the active population by region and country. See also the discussion in Section 5.2 below.

4.12. Constructing regional employment data and forecasts for the detailed (75) SIC2007 industries

The starting point for the regional employment data by detailed 75 sectors for Working Futures was the 46 sector data (by gender and status) from MDM-E3, as described above. These data were further disaggregated using BRES and ABI data available for the full detail. Prior to 1998 (the first year of ABI data) the shares of each detailed industry in the more aggregate level available in the 46-sector data were held constant going backwards.

A series of iterative RAS[13] procedures were used to ensure that the final data set was consistent with all totals published by ONS including detailed data for the UK. Further details of the development of the employment database are given in Section 10.

Regional employment forecasts for the 75 sectors were obtained by using historical trends to obtain initial estimates. A RAS procedure was then used to ensure consistency with regional employment forecast from MDM-E3 (i.e. at 46 sector level) and forecasts by gender and status for the detailed 75 industries in the UK.

Regional employment forecasts for the 75 industries were created as follows:

- Total employees

The historical trends in proportions of the detailed industries in the corresponding MDM-E3 industries are extrapolated over the forecast period and applied to the model forecast to create initial estimates. The RAS procedure is then used to make sure that the results are consistent with the UK forecasts for total employees in employment.

- Self-employment by gender

The procedure here was similar to estimating total employees. Historical trends in proportions in self-employment by gender in the detailed industry relative to the corresponding MDM-E3 industry for each region were extrapolated over the forecast period to create initial estimates of male and female self-employment. These estimates were made consistent with the corresponding UK self-employment projections for the detailed sectors and the regional self-employment projections for the MDM-E3 sectors using the RAS procedure.

- Employees by gender and status

[13] RAS is an iterative procedure to ensure elements in an array match row and column totals. For further details see Section 11.

Initially trends in employees by type (gender/status) were created by using the proportions in total employees. These data together with detailed data by type from ABI and BRES for 2007-2017 were used to split MDM-E3 industries and make initial projections of employees in employment by type in the regions. Using the RAS procedure these initial estimates were made consistent with the UK forecasts by type by 75 industries and the regional projections by type for the MDM-E3 sectors.

4.13. Regional output data and projections for the detailed (75) SIC2007 industries

For output, initial estimates of relative productivity of the detailed sectors in the corresponding aggregate sectors were created using regional employment and GVA in current prices from the ABS). These productivity ratios were applied to the MDM-E3 industries (46) productivity from the model to create initial GVA estimates by detailed (75) SIC2007 industries.

The initial estimates of GVA were then made consistent with the UK results for the detailed industries and the output data and projections for the MDM-E3 industries in the regions. The resulting forecast for output series were checked to ensure that they were plausible compared with the trends in more aggregated historical data.

The procedure in detail is as follows:

- For industries where there is a one-to-one mapping from one of the 75 detailed industries to one of the MDM-E3 industries, GVA was set equal to the GVA from the MDM-E3 industry for both history and forecast.
- For the remaining sectors a relative productivity of the detailed industry in the corresponding MDM-E3 industry was estimated over 2008-2016 using GVA from the ABS and our results for regional employment.
- The relative productivity ratios, for a given region and sector, were applied to productivity in the parent sector, calculated using regional GVA and employment from MDM-E3, to create initial estimates of productivity. For years prior to 2008 the 2008 ratios were applied, while after 2016 the 2016 ratios were applied.
- These were then applied to the regional employment time series at the 75 industry level to yield an initial estimate of output.
- A RAS procedure was finally applied to create consistency of the estimates with GVA by detailed industry in the UK and regional GVA for the MDM-E3 industries.

Inherent in this method of generating regional GVA for the detailed industries is the assumption that the relationship that prevails in 2008 between productivity in a detailed sector and productivity in the corresponding MDM-E3 sector, in a given region, holds throughout the entire historical period, and the relationship that prevails

in 2016 between productivity in a detailed sector and productivity in the corresponding MDM-E3 sector, in a given region, holds throughout the entire forecast period. Further, in some cases the ABS offers insufficient coverage of regional GVA. In such cases the productivity ratio of the detailed industry was set to that of the lowest disaggregated sector available. Where the ABS provided a missing or negative value for a given sector and region, the productivity ratio was set to that of the UK for that sector. Additionally, for a very limited number of sectors, the ABS offers no GVA data at all. In these cases GVA was disaggregated using detailed regional employment.

4.14. Data and projections for local areas by 22 SIC2007 sectors

The projections for local areas (Local Enterprise Partnership (England) and Economic Areas (Wales), See Table 4.2), come from Cambridge Econometrics' Multi-Local Area Forecasting Model[14]. These are produced for the 46 industries of MDM-E3, and aggregated to the 22 sectors published in Working Futures 2017-2027.

CE have developed a **Database**, which includes employment data for local authority districts by 46 sectors, gender and type, and where estimates have been constrained to be consistent with corresponding data in the regions and the UK. The starting point for this process is the BRES/ABI employment data for the local authority districts for 46 sectors, but estimates are also made for self-employment (based on the Annual Population Survey (APS)) by gender, and the results made consistent with ONS regional and UK data. Available ONS GVA data (19 sectors) by NUTS 2 (Nomenclature of territorial units for statistics) level geographies are disaggregated to the MDM-E3 industries and used to calculate productivity, which is then applied to the employment data at district level to create a complete set of GVA data by the 46 MDM-E3 industries for local authority districts.

The projections were obtained using a similar procedure to that adopted in CE/IER's Local Economy Forecasting Model (LEFM). This involves a process of establishing relationships between the local area data, disaggregated by industry, and the regional and UK equivalents. The projections for this project were based on a model that relates local area performance in an industry to performance in the same industry in the region or the UK over the recent past. This model is based on the methodology for producing multi-local area forecasts which is used for producing forecasts for a large number of areas.

Projections for output are based on employment by industry and productivity growth in the same industry in the corresponding region.

[14] In *Working Futures 2017-2027,* this more detailed analysis is done for just England and Wales.

4.15. Data and projections for local areas by occupation and qualification

The database is then extended to cover occupation and qualifications. This full **Database** is the foundation for the projections for the local areas specified in Working Futures.

Table 4.2: Sub-regional Geographies in Working Futures 2017-2027

Working Futures 2017-2027 Sub-regional Geography	Local authorities included
England: Local Enterprise Partnerships (LEPS)	
Black Country	Dudley, Sandwell, Walsall, Wolverhampton
Buckinghamshire Thames Valley	Buckinghamshire
Cheshire and Warrington	Cheshire East (unitary), Cheshire West and Chester (unitary), Warrington (unitary)
Coast to Capital	Brighton and Hove (unitary), East Sussex: Lewes, Croydon, Epsom and Ewell, Mole Valley, Reigate and Banstead, Tandridge, West Sussex
Cornwall and Isles of Scilly	Cornwall (unitary), Isles of Scilly
Coventry and Warwickshire	Warwickshire, Coventry
Cumbria	Cumbria
Derby, Derbyshire, Nottingham and Nottinghamshire	Derby, Derbyshire, Nottingham (unitary), Nottinghamshire
Dorset	Bournemouth (unitary), Dorset, Poole (unitary)
Enterprise M3	Basingstoke and Deane, East Hampshire, Hart, New Forest, Rushmoor, Test Valley, Winchester, Elmbridge, Guildford, Runnymede, Spelthorne, Surrey Heath, Waverley, Woking
Gloucestershire	Gloucestershire
Greater Birmingham and Solihull	Cannock Chase, East Staffordshire, Lichfield, Tamworth, Birmingham, Solihull, Bromsgrove, Redditch, Wyre Forest
Greater Cambridge and Greater Peterborough	Cambridgeshire, Uttlesford, North Hertfordshire, King's Lynn and West Norfolk, Forest Heath, St Edmundsbury, Peterborough (unitary), Rutland (unitary)
Greater Lincolnshire	Lincolnshire, North Lincolnshire (unitary), North East Lincolnshire (unitary)
Greater Manchester	Greater Manchester
Heart of the South West	Devon, Somerset
Hertfordshire	Hertfordshire
Humber	East Riding of Yorkshire (unitary), Kingston upon Hull (unitary), North East Lincolnshire (unitary), North Lincolnshire (unitary)
Lancashire	Lancashire, Blackburn with Darwen (unitary), Blackpool (unitary)
Leeds City Region	Barnsley, Craven, Harrogate, Selby, West Yorkshire, York (unitary)
Leicester and Leicestershire	Leicester (unitary), Leicestershire

Working Futures 2017-2027 Sub-regional Geography	Local authorities included
Liverpool City Region	Halton (unitary), Merseyside
London Enterprise Panel	Greater London
New Anglia	Norfolk, Suffolk
North Eastern	County Durham (unitary), Northumberland (unitary), Tyne and Wear
Northamptonshire	Northamptonshire
Oxfordshire	Oxfordshire
Sheffield City Region	Bolsover, Chesterfield, North East Derbyshire, Bassetlaw, South Yorkshire
Solent	East Hampshire, Eastleigh, Fareham, Gosport, Havant, New Forest, Test Valley, Winchester, Isle of Wight (unitary), Portsmouth (unitary), Southampton (unitary)
South East	East Sussex, Essex, Kent, Medway (unitary), Southend-on-Sea (unitary), Thurrock (unitary)
South East Midlands	Bedford (unitary), Aylesbury Vale, Central Bedfordshire (unitary), Luton (unitary), Milton Keynes (unitary), Corby, Daventry, Kettering, Northampton, South Northamptonshire, Cherwell
Stoke-on-Trent and Staffordshire	Staffordshire, Stoke-on-Trent (unitary)
Swindon and Wiltshire	Swindon (unitary), Wiltshire (unitary)
Tees Valley	Darlington (unitary), Hartlepool (unitary), Middlesbrough (unitary), Redcar and Cleveland (unitary), Stockton-on-Tees (unitary)
Thames Valley Berkshire	Bracknell Forest (unitary), Reading (unitary), Slough (unitary), West Berkshire (unitary), Windsor and Maidenhead (unitary), Wokingham (unitary)
The Marches	Herefordshire (unitary), Shropshire (unitary), Telford and Wrekin (unitary)
West of England	Bath and North East Somerset (unitary), Bristol (unitary), North Somerset (unitary), South Gloucestershire (unitary)
Worcestershire	Worcestershire
York North Yorkshire and East Riding	North Yorkshire, York (unitary), East Riding of Yorkshire (unitary)
Wales: Economic Areas	
North	Anglesey, Conwy, Denbighshire, Flintshire, Gwynedd, Wrexham
Mid	Ceredigion, Powys
South West	Carmarthenshire, Neath Port Talbot, Pembrokeshire, Swansea
South East	Bridgend, Blaenau Gwent, Caerphilly, Cardiff, Merthyr Tydfil, Monmouthshire, Newport, Rhondda, Cynon, Taff, Torfaen, Vale of Glamorgan

5. Labour supply

5.1. Introduction

This section describes the specification used in CE's Multi-Sectoral Dynamic Model of the UK economy (MDM-E3) to provide detailed projections of economic activity rates, labour supply and unemployment, for each of the Countries and Regions of the UK. The projections provide an aggregate analysis, focusing upon total labour supply by gender and age-band.

5.2. Specification of the regional model

The key stages to determine the labour supply indicators

A set of stochastic equations is used to forecast economic activity rates for the UK by age-band/gender in MDM-E3. The remainder of the model required to construct the projections of labour supply indicators consists of a number of accounting equations to derive labour supply and unemployment from the existing labour market and demographic projections in MDM-E3. Definitions for a number of employment and labour market indicators are listed in Box 5.1.

The key stages to determine the labour supply indicators can be summarised as follows:

- UK activity rates (by age-band/gender) are modelled as a function of unemployment and lagged activity rates;
- regional activity rates are projected forward using the growth in the equivalent UK age-band/gender group;
- the regional labour force is determined by activity rates multiplied by the population (by age-band/gender) - this is then scaled to UK labour force and the final regional activity rates are calculated;
- workplace based employment jobs is determined using the existing MDM-E3 equations (see Section 4);
- the LFS measure of employment (employed residents) is determined from workforce employment minus a labour market residual (note that one element of the residual is net commuting);
- some adjustments to the labour market residual are made in the projections to account for trend changes;
- regional LFS employment is taken away from regional labour force to determine regional unemployment (ILO).

As noted above, the difference between the LFS measure and the workforce measure of employment is accounted for in the labour market residual. As the LFS is a survey of private households, employment estimates reflect the area of residence of people with jobs. The surveys used to compile the workforce estimates of employment are surveys of employers, and so the figures at a regional level reflect the location of workplace and jobs, not the place of residence of the worker. One element of the labour market residual is therefore net commuting which results from people travelling from their place of residence, across regional boundaries to their place of work. Both the LFS and the workplace measures of employment are determined in the model and the labour market residual is calculated as the difference. Differences between the labour supply and labour demand pictures are taken up in the labour market accounts residuals, including net commuting across geographical boundaries and "double jobbing".

ONS projections of population by region, gender and age-band are taken as exogenous inputs to MDM-E3.

Box 5.1: Definitions of employment and related labour market indicators

Alternative definitions

There are various ways of looking at employment. For example, a distinction can be made between the number of people in employment (head count) and the number of jobs. These two concepts represent different things, as one person may hold more than one job. In addition, a further distinction can be made between area of residence and area of workplace.

Similarly there are various different definitions of unemployment, the labour force, workforce and population. In Working Futures 2017-2027 the following definitions are used:

Residence basis: measured at place of residence (as in the LFS).

Workplace basis: measured at place of work (as in the ABI) and BRES).

Workplace employment (number of jobs): these are typically estimated using surveys of employers, such as the ABI, focusing upon the numbers of jobs in their establishments. In this report references to employment relate to the number of jobs unless otherwise stated.

Employed residents (head count): the number of people in employment. These estimates are based primarily on data collected in household surveys, e.g. the LFS. People are classified according to their main job. Some have more than one job.

ILO unemployment: covers people who are out of work, want a job, have actively sought work in the previous four weeks and are available to start work within the next fortnight (or out of work and have accepted a job that they are waiting to start in the next fortnight).

Claimant unemployed: measures people claiming Jobseeker's Allowance benefits.

Workforce: the total number of workforce jobs, and is obtained by summing workplace employment (employee jobs and self-employment jobs), HM Forces, government-supported trainees and claimant unemployment.

Labour Force: employed residents plus ILO unemployment.

Labour market participation or **Economic activity rate**: the number of people who are in employment or (ILO) unemployed as a percentage of the total population aged 16 and over.

Labour Market Accounts Residual: workplace employment minus residence employment. The main cause of the residual at national level is "double jobbing". At a more disaggregated spatial level, net commuting across geographical boundaries is also very significant. The difference will also reflect data errors and other minor differences in data collection methods in the various sources.

Total population: the total number of people resident in an area (residence basis).

Population 16+: the total number of people aged 16 and above (residence basis).

Working-age population: the total number of people aged 16-64 (males) or 16-64 (females), (residence basis). The State Pension age of females will increase from 60 in 2011 to 65 in 2018. From 2018 the State Pension age for all (both males and females) will start to increase to reach 66 by 2020.

6. Detailed industry categories and choice of sectors for reporting

6.1. Background

The sectoral analysis derives directly from the regional Multi-sectoral Dynamic Model of the economy (MDM-E3) as described in Sections 3, 4 and 5. This extended version of MDM-E3 was used to generate estimates for output and productivity for the main industrial sectors and projections of total employment by industry at a regional level. The industries used for modelling are based on the 2007 Standard Industrial Classification (SIC2007). In all, 87 (UK) and 46 (regions) industries are distinguished in the standard version of MDM-E3, as set out in Tables 1 and 2. For reporting, however, these are translated to the 75 Working Futures industries (see Table 3), also defined on a SIC2007 basis.

The estimates and projections of employment produced are consistent with official data published by the ONS. Further details of general data sources are given in Section 11 below, while a full description of the employment Database is provided in Section 10.

6.2. Extension of the number of industries in the models

The standard version of MDM-E3 provides forecasts for 46 industries, covering the Regions of England, as well as Wales, Scotland and Northern Ireland. These were extended to form the basis for a disaggregated set of projections of sectors at the detailed SIC2007 Working Futures 2017-2027 industries. These detailed 75 industries are shown in Table 6.1. This was achieved using a sub-modelling approach, as described in Sections 3 and 4. The methodology ensures that the results of the sub-model of 75 industry outcomes are consistent, both with existing historical data and the forecast results for the regional 46 industries produced by the MDM-E3. Regional output series for 75 industries were created consistent with the UK data and using available information for the regions. Further details about how the historical **Database** was developed are provided in Section 10. The remainder of this section presents the various industrial and sectoral classifications used for reporting.

6.3. Choice of sectors for analysis and reporting

Given the large number of stakeholders with an interest in the findings from this project, a variety of outputs have been designed. The detail to be provided in the various reports reflects various considerations (including those outlined in Sections 12 and 13 below): confidentiality; statistical robustness and precision; and practical considerations, including transparency and digestibility.

Table 6.1: Detailed Industries used in Working Futures (SIC2007)

Ind 75	SIC2007 Section	SIC2007 Division	Industry full name	Ind22	Ind 6	MDM-E3	
1. Agriculture etc.	A	01-03	Agriculture, forestry and fishing	1	1	1-3	1
2. Coal, oil & gas, mining & related	B	05-09	Coal, oil and gas, other mining and quarrying	2	1	4-8	2
3. Food products	C	10	Food products	3	2	9	3 (part)
4. Beverages & tobacco		11-12	Beverages and tobacco products	3	2	10-11	3 (part)
5. Textiles		13	Textiles	5	2	12	4 (part)
6. Wearing apparel; leather etc.		14-15	Wearing apparel, leather and related products	5	2	13-14	4 (part)
7. Wood etc.		16	Wood and cork products	5	2	15	5 (part)
8. Paper etc.		17	Paper and paper products	5	2	16	5 (part)
9. Printing & recording		18	Printing and reproduction of recorded media	5	2	17	6
10. Coke & petroleum; chemicals etc.		19-20	Coke and refined petroleum products, chemicals and chemical products	5	2	18-19	7-8
11. Pharmaceuticals		21	Pharmaceutical products	5	2	20	9
12. Rubber & plastic		22	Rubber and plastic products	5	2	21	10 (part)
13. Other non-metallic		23	Other non-metallic mineral products	5	2	22	10 (part)
14. Basic metals		24	Basic metals	5	2	23	11 (part)
15. Metal products		25	Metal products except machinery and equipment	5	2	24	11 (part)
16. Computers, etc.		26	Computer, electronic and optical products	4	2	25	12
17. Electrical equipment		27	Electrical equipment	4	2	26	13
18. Machinery etc.		28	Machinery and equipment n.e.c.	4	2	27	14
19. Motor vehicles, etc.		29	Motor vehicles, trailers and semi-trailers	5	2	28	15
20. Other trans. Equipment		30	Other transport equipment	5	2	29	16
21. Furniture		31	Furniture	5	2	30	17 (part)
22. Other manufacturing		32	Other manufacturing	5	2	31	17 (part)
23. Repair & installation		33	Repair and installation of machinery and equipment	5	2	32	17 (part)
24. Electricity, gas, etc.	D	35	Electricity, gas, steam and air conditioning supply	6	1	33-34	18
25. Water	E	36	Water collection, treatment and supply,	7	1	35	19 (part)

Ind 75	SIC2007 Section	SIC2007 Division	Industry full name	Ind22	Ind 6	MDM-E3	
26. Sewerage		37	Sewerage	7	1	36	19 (part)
27. Waste management		38-39	Waste and waste management services	7	1	37-38	19 (part)
28. Construction	F	41	Construction of buildings	8	3	39	20 (part)
29. Civil engineering		42	Civil engineering	8	3	40	20 (part)
30. Specialised construction		43	Specialised construction activities	8	3	41	20 (part)
31. Motor vehicle trade	G	45	Wholesale and retail trade or motor vehicles and motorcycles	9	4	42	21
32. Wholesale trade		46	Wholesale trade	9	4	43	22
33. Retail trade		47	Retail trade	9	4	44	23
34. Land transport, etc.	H	49	Land transport and transport via pipelines	10	4	45	24
35. Water transport		50	Water transport	10	4	46	25
36. Air transport		51	Air transport	10	4	47	26
37. Warehousing, etc.		52	Warehousing and support activities for transportation	10	4	48	27 (part)
38. Postal & courier		53	Postal and courier services	10	4	49	27 (part)
39. Accommodation	I	55	Accommodation	11	4	50	28
40. Food & beverage services		56	Food and beverage service activities	11	4	51	29
41. Publishing activities	J	58	Publishing activities	12	5	52	30 (part)
42. Film & music		59	Motion picture, video and music publishing	12	5	53	30 (part)
43. Broadcasting		60	Programming and broadcasting activities	12	5	54	30 (part)
44. Telecommunications		61	Telecommunications	13	5	55	31 (part)
45. Computer programming etc.		62	Computer programming, consultancy and related activities	13	5	56	31 (part)
46. Information services		63	Information service activities	12	5	57	31 (part)
47. Financial services	K	64	Financial service activities	14	5	58	32 (part)
48. Insurance & pensions		65	Insurance and pension funding	14	5	59	32 (part)
49. Auxiliary financial services		66	Activities auxiliary to financial services and insurance	14	5	60	32 (part)
50. Real estate	L	68	Real estate activities	15	5	61	33
51. Legal & accounting	M	69	Legal and accounting activities	16	5	62	34

Ind 75	SIC2007 Section	SIC2007 Division	Industry full name	Ind22	Ind 6	MDM-E3	
52. Head offices, etc.		70	Activities of head offices; management consultancy activities	16	5	63	35
53. Architectural & related		71	Architectural and engineering activities	16	5	64	36
54. Scientific research		72	Scientific research and development	16	5	65	37 (part)
55. Advertising, etc.		73	Advertising and market research	16	5	66	37 (part)
56. Other professional		74	Other professional, scientific and technical activities	16	5	67	37 (part)
57. Veterinary		75	Veterinary activities	16	5	68	37 (part)
58. Rental & leasing	N	77	Rental and leasing activities	17	5	69	38 (part)
59. Employment activities		78	Employment activities	17	5	70	38 (part)
60. Travel, etc.		79	Travel agency and tour operator activities	17	5	71	38 (part)
61. Security, etc.		80	Security and investigation activities	17	5	72	38 (part)
62. Services to buildings		81	Services to buildings and landscape activities	17	5	73	38 (part)
63. Office admin		82	Office administrative; office support activities	17	6	74	38 (part)
64. Public admin. & defence	O	84	Public administration and defence, compulsory social security	18	6	75	39, 46*
65. Education	P	85	Education	19	6	76	40
66. Health	Q	86	Human health activities	20	6	77	41
67. Residential care		87	Residential care activities	20	6	78	42 (part)
68. Social work		88	Social work activities without accommodation	20	6	79	42 (part)
69. Arts & entertainment	R	90	Creative, arts and entertainment activities	21	6	80	43 (part)
70. Libraries, etc.		91	Library, archives, museums and other cultural activities	21	6	81	43 (part)
71. Gambling		92	Gambling and betting activities	21	6	82	44 (part)
72. Sport & recreation		93	Sport activities, amusement and recreational activities	21	6	83	44 (part)
73. Membership organisations	S	94	Activities of membership organisations	22	6	84	45 (part)
74. Repair of goods		95	Repair of computers and personal household goods	22	6	85	45 (part)
75. Other personal service		96	Other personal services activities	22	6	86	45 (part)

6.4. Reporting at national (UK) level

Working Futures 2017-2027 adopts 22 industry categories defined precisely in terms of the SIC2007, as shown in Tables 6.1 and 6.2. These categories were also used for the main UK and regional level reporting in previous Working Futures projections.

The 22-fold categorisation was suggested by UKCES for Working Futures 2014-2024; and continued here. A number of the categories used in Table 6.2 are very small in terms of total employment (notably mining & quarrying, electricity & gas and water and sewerage). These pose problems in terms of obtaining statistically reliable historical and projected employment data, especially when breaks are required by occupation.

The 22 industry level of detail shown in Table 6.2 is within the guidelines adopted by ONS for headline statistics on employment (i.e. total numbers of employees). Within the workbooks, even more detailed breaks within these categories are provided (e.g. by gender and status). In some cases (especially self-employment and some detailed occupational categories) this stretches the data well beyond the limits which ONS would normally regard as acceptable for statistical purposes and for publishing as authoritative estimates, with a "public" seal of approval.

As noted in Section 13, ONS recommend using minimum cell sizes of 10,000 (grossed up), when presenting data based on the LFS. Given that there are 25 occupations to be distinguished in each sector, this suggests a minimum size for an industry **at UK level** of at least 250,000. In a few case the data reported in the workbooks fall below this threshold. They are included in the absence of any better estimates but should be treated with caution. For further discussion on these issues see Sections 10-14 below.

6.5. Reporting at country and regional level

At country and regional level, the quarterly Workforce Jobs datasets include data for 81 sectors and gender/status for the UK, but only for 19 sectors (see Table 6.3) for the regions. The 22-fold disaggregation has also been adopted for reporting for the regions. However, care needs to be taken in interpreting detailed estimates and trends over time.

6.6. Headline reporting at national (UK) level

For summary/headline reporting, on grounds of brevity, a 6-fold sectoral categorisation is used. This is shown in Table 6.4. The purpose of the reporting at this level is to give an overview of the main developments rather than provide sectoral detail. This represents a practical compromise, which can be replicated across regions for comparability, without becoming too burdensome for the reader. Table 7 also shows the relationship of the six aggregate sectors with the other groupings used in this Working Futures project. These sectors are also used to compare results with previous projections.

Ind 22	SIC2007 Section	SIC2007 Division	Industry full name	Ind 75
1. Agriculture	A	01-03	Agriculture, forestry and fishing	1
2. Mining & quarrying	B	05-09	Mining and quarrying	2
Manufacturing	C	10-33	Manufacturing	3-23
3. Food drink & tobacco		10-12	Food, drink and tobacco	3,4
4. Engineering		26-28	Engineering	16-18
5. Rest of manufacturing		13-25,29-33	Rest of manufacturing	5-15,19-23
6. Electricity & gas	D	35	Electricity, gas, steam and air conditioning	24
7. Water & sewerage	E	36-39	Water supply, sewerage, waste management	25-27
8. Construction	F	41-43	Construction	28-30
9 Whole. & retail trade	G	45-47	Wholesale and retail trade; repair of motor vehicles etc.	31-33
10. Transport & storage	H	49-53	Transport and storage	34-38
11. Accommodation. & food	I	55-56	Accommodation and food activities	39-40
Information & communication	J	58-63	Information and communication	41-46
12. Media		58-60, 63	Media and communication	41-43
13. IT		61,62	Information technology	44-46
14. Finance & insurance	K	64-66	Financial and insurance activities	47-49
15. Real estate	L	68	Real estate activities	50
16. Professional services	M	69-75	Professional, scientific and technical activities	51-57
17. Support services	N	77-82	Administrative and support service activities	58-63
18. Public admin. & defence	O	84	Public administration and defence etc.	64
19. Education	P	85	Education	65
20. Health & social work	Q	86-88	Human health and social work	66-68
21. Arts & entertainment	R	90-93	Arts, entertainment and recreation; other services	69-72
22. Other services	S	94-96	Other service activities	73-75

Table 6.2: Industry Groups (SIC2007)

		SIC2007 Section
1	Agriculture, forestry & fishing	A
2	Mining & quarrying	B
3	Manufacturing	C
4	Electricity, gas, steam & air conditioning supply	D
5	Water supply, sewerage, waste & remediation activities	E
6	Construction	F
7	Wholesale & retail trade; repair of motor vehicles and motorcycles	G
8	Transport & storage	H
9	Accommodation & food service activities	I
10	Information & communication	J
11	Financial & insurance activities	K
12	Real estate activities	L
13	Professional scientific & technical activities	M
14	Administrative & support service activities	N
15	Public admin & defence; compulsory social security	O
16	Education	P
17	Human health & social work activities	Q
18	Arts, entertainment & recreation	R
19	Other service activities	S

Table 6.3: Industries for which ONS supply employment data by gender and status for Nations and Regions in the UK

Broad Sector	SIC2007 Section	SIC2007 Division	Industry full name	Ind 22	Ind 75
1. Primary sector and utilities	A B D E	01-03 05-09 35 36-39	Agriculture, forestry and fishing Mining and quarrying Electricity, gas, steam and air conditioning Water supply, sewerage, waste management	1,2,6,7	1,2,24-27
2. Manufacturing	C	10-33	Manufacturing	3-5	3-23
3. Construction	F	41-43	Construction	8	28-30
4. Trade, accommodation. & transport	G H I	45-47 49-53 55-56	Wholesale and retail trade; repair of motor vehicles Transport and storage Accommodation and food activities	9-11	31-40
5. Business & other services	J K L M N R S	58-63 64-66 68 69-75 77-82 90-93 94-96	Information and communication Financial and insurance activities Real estate activities Professional, scientific and technical activities Administrative and support service activities Arts, entertainment and recreation; other services Other service activities	12-17, 21-22	41-63,69-75
6. Non-marketed services	O P Q	84 85 86-88	Public administration and defence etc. Education Human health and social work	18-20	64-68

Table 6.4: Broad Sectors (SIC2007)

7. Modelling gender and status

7.1. Historical estimates

Most official data on employment include breaks by gender. Employment status is more problematic. ONS estimates, based on the BRES, include a distinction between full and part-time status for employees. However, the published information, including such breaks, is much more limited than for all employees. Self-employment estimates are available from the LFS and the Census of Population. The former is the main source of time series information, although the latter is crucial for benchmarking. Given the much smaller numbers involved compared to employees, together with the much smaller sample size of the LFS compared with the BRES/ABI there are real problems in trying to obtain comprehensive and consistent estimates across all the dimensions needed. Details of how this was done, the limitations of the estimates, and restrictions on publication, are dealt with in Sections 10-14.

7.2. Method of projection of gender and status shares

As described in Section 2, forecasts of total employment by (MDM-E3 87) industry were produced for the UK using econometric equations and disaggregated to regions (by 46 industries) using logical forecasting rules. Changes of employment by gender and status were projected by extrapolating recent trends. First, at the UK 87 industry level, the trend change over the last whole economic cycle (1997-2007) studied by HM Treasury[15] in the shares of employment by gender and status was calculated. For some of the individual 87 industries the volatility of data resulted in infeasible trends; in these cases trends were used from the corresponding broad sector, e.g. trends for the transport, storage & communication sector used for the water transport industry. These trend changes were then applied to current shares to generate projections of shares of employment by gender and status. The projected shares were then applied to the forecasts of total employment to calculate levels of employment by gender and status, by 87 industries in the UK. For the regions, by 46 industries, the trend changes in the shares of employment by gender and status are assumed to follow those at the UK level.

Employment forecasts by type (gender/status) for the 75 Working Futures sectors were formed by:

- Using historical trends in proportions (using a functional form which reduces the rate of decline as the proportion approaches zero, or the rate of increase as the proportion approaches 1). This relationship was used to make initial estimates of employment by type over the forecast period.

[15] http://news.bbc.co.uk/1/shared/bsp/hi/pdfs/24_11_08_pbr_economiccycle.pdf

- A RAS procedure was used to ensure consistency with total employment by MDM-E3 industry in the regions and total employment by gender and status for the UK (for each year a matrix of 75 industries by 6 gender/status categories, using the RAS procedure in blocks).[16]

[16] RAS is a widely used iterative technique, which ensures that elements in a two-dimensional data array match target row and column totals. In many of the examples quoted, multi-dimensional arrays are used but the principles are the same. For further details see Section 11.

8. Occupational projections

8.1. Historical estimates

BRES, the ABI and its predecessors do not include information on occupational employment. Generating such estimates relies upon other sources such as the LFS. Because of the relatively small sample size of the LFS, such estimates are much less robust than those for industrial employment. The present results rely on the most up to date information on trends in recent years available from the LFS. These data have been used to calibrate recent historical trends and adjust the projected future trends.

Estimates from the LFS have been combined with industry employment data (distinguishing gender and status), in order to develop a comprehensive set of estimates. These are in the form of detailed industry (SIC) occupation (SOC) matrices. Details of how this is done are given in Section 8.2.

Effectively a series of SIC-SOC employment matrices were developed. The original **Database** used SOC2000 categories, based on conversion of data from previous surveys to the SOC2000 classification.[17] This was done using detailed converters developed by IER in collaboration with ONS.[18] These converters were applied in such a manner as to reflect differences across sectors, which make the application of a common converter inappropriate.

The whole database was then translated on to a SOC2010 basis using a set of aggregate convertors provided by ONS. The data for 2010-2014 were constrained to match estimates of employment by SOC2010 categories based on the official estimates published by ONS in the LFS.

The main **Database** therefore provides breakdowns to the 75 SIC2007 industry level as used in MDM-E3. This was extended to cover the 12 countries and English regions that make up the UK.

8.2. Projections of occupational structure at the 2-digit level

In theory it would be desirable to develop a full model of supply and demand for different occupations, taking into account the various behavioural factors which may influence future developments. In practice, severe data limitations preclude such an ambitious

[17] For further details see Sections 8 and 10.

[18] Professor Peter Elias of IER has played a leading role in the development of SOC2000.

approach. Throughout the world, most occupational employment forecasts are based on simplistic extrapolation of past trends.[19]

The availability of time series data from the LFS offers the possibility of a more sophisticated approach, based on econometric analysis of occupational shares (see Briscoe and Wilson, 2003[20]). In practice, although this analysis offers some insight into the sensitivity of the projections to certain key economic indicators, the results suggest that underlying trends are dominated by technological and organisational shifts, which can best be proxied by simple time trends. Moreover, such an approach cannot easily be extended to the more detailed sectoral and spatial level required here due to data limitations. The present projections are therefore still based on more conventional approaches, involving extrapolation of historical patterns of change at a very detailed industrial level.

The occupational employment projections are therefore generated by linking the industry employment results from MDM-E3 to the IER's occupational models, which produce projections of occupational employment shares based on extrapolative methods. The historical occupational by industry employment share (SIC-SOC) matrices are used to develop projections of occupational employment share in all future years. The occupational shares in each industry were then applied to the industry forecasts from the macroeconomic model to obtain the occupational employment levels (expansion demands). Details of the basic procedures were otherwise as described below in Box 8.1.

Changes in occupational employment levels between years both historical and projected can be analysed using shift-share analysis. This assesses the effects of aggregate employment change, changes in the industrial mix and a residual effect reflecting shifts in occupational structure within industries due to organisational and technological change.

Projections of occupational shares at this level, place considerable demands on the data available and the situation on the ground can be changed rapidly and substantially by technological and other changes. It is important to appreciate the assumptions used and the range of factors which it is felt are likely to influence immediate future trends, including, how these may diverge from previous patterns of change. These issues are discussed in more detail in the Main Report.

[19] For a review, see: Wilson, R. A. (2001) *Forecasting Skill requirements at National and company Levels*, in P. Descy and M. Tessaring (eds.) *Training in Europe (2nd report on Vocational Training Research in Europe 2000: Background Report, Volume 2)* CEDEFOP Reference Series, Luxembourg, Office for Official Publications of the European Communities, pp.561-609. .

[20] Briscoe, G., and R. A. Wilson, (2003). 'Modelling UK Occupational Employment'. International Journal of Manpower. 24(5), pp. 568-589.

Box 8.1: The IER's Occupational Employment Model

The approach to projecting occupational employment structure involves two stages. First, projections of the likely changes in industrial employment by region are made using the Multi-sectoral dynamic macroeconomic model of the economy. Second, projections of the occupational structure of employment within each industry are made using estimates from the Censuses of Population (basically extrapolations of past trends). These occupational coefficients are then combined with the projected levels of industrial employment to obtain projected levels of employment by occupation. All this is undertaken at a regional level for the 25 2-digit level sub-major Groups.

The occupational employment projections are therefore based on a sub-model which takes as input the regional/industrial projections produced by the macroeconomic model. It is a 'top-down" approach, the industrial and regional employment projections being disaggregated into the 25 2-digit level occupational categories for each industry.

The overall changes in aggregate occupational structure arise through a combination of shifting patterns of industrial employment structure and the changing occupational composition of employment within industries. The former can be regarded as primarily a reflection of the way in which the changing pattern of demands for commodities by consumers and companies impinges on occupational structure, while the latter is more a reflection of technological and organisational changes affecting the manner in which goods and services are produced and provided. The level of employment in a particular occupation can, therefore, change for two main reasons; either because the industries in which it is concentrated grow or decline, or because of changes in occupational composition within industries. The former may be termed the industrial effect, the latter the occupational effect.

The so-called occupational effect may arise for a number of reasons. Medium-term developments in technology may affect the structure of demand for certain skills. Demand may also change in response to changes in the relative rates of pay associated with certain trades, which may in turn be affected by the supply side of the labour market. In the short term the level of employment in each industry may depend upon the cyclical position in which it finds itself. Certain skills may be regarded as 'fixed' rather than 'variable' inputs in the production process for technological reasons. Furthermore, it is apparent that the costs of hiring and firing (that is costs associated with changing the level of employment) differ considerably between different occupations. Finally, the actual levels of employment observed at any particular time will reflect the balance of supply and demand; shortages for certain skills may result in divergence from the long-run structure of employment desired by firms. This again will be dependent upon current rates of pay, the scope for substitution of one skill for another in the production process, and the flexibility of wages.

In the absence of a formal econometric model encapsulating these behavioural influences, they are built into the projections in a more ad hoc fashion, using professional judgement based on a reading of the most important current

developments. A particularly important element here is the use of data from recent Labour Force Surveys. However, a variety of other sources are also used, including some more qualitative data.

This information is used to calibrate the occupational model over the recent past and to modify the projections. The LFS data are used to make an estimate of occupational structure in the base year. This is then compared with that emerging from the occupational model. The results of this exercise are used to modify the projected changes in the light of recent and current developments in occupational structure that may not reflect a simple continuation of long-term trends in the 1990s and beyond. The results should be regarded as indicative of general trends and not precise forecasts of what will happen in particular cases.

Table 2.1: SOC2010 Classification of Occupational Categories (Sub-major Groups)

	Major group		Sub-Major Groups	Skill level
1	Managers, directors and senior officials	11	Corporate managers and directors	4
		12	Other managers and proprietors	3
2	Professional occupations	21	Science, research, engineering and technology professionals	4
		22	Health professionals	4
		23	Teaching and educational professionals	4
		24	Business, media and public service professionals	4
3	Associate professional and technical occupations	31	Science, engineering and technology associate professionals	3
		32	Health and social care associate professionals	3
		33	Protective service occupations	3
		34	Culture, media and sports occupations	3
		35	Business and public service associate professionals	3
4	Administrative and secretarial occupations	41	Administrative occupations	2
		42	Secretarial and related occupations	2
5	Skilled trades occupations	51	Skilled agricultural and related trades	3
		52	Skilled metal, electrical and electronic trades	3
		53	Skilled construction and building trades	3
		54	Textiles, printing and other skilled trades	3
6	Caring, leisure and other service occupations	61	Caring personal service occupations	2
		62	Leisure, travel and related personal service occupations	2
7	Sales and customer service occupations	71	Sales occupations	2
		72	Customer service occupations	2
8	Process, plant and machine operatives	81	Process, plant and machine operatives	2
		82	Transport and mobile machine drivers and operatives	2
9	Elementary occupations	91	Elementary trades and related occupations	1
		92	Elementary administration and service occupations	1

Source: SOC2010: Volume 1: Structure and Description of Unit Groups, ONS.

Table 8.2: SOC2000 Classification of Occupational Categories (Sub-major Groups)

	Sub-major groups	Occupations	Occupation minor group number[a]
11	Corporate managers	Corporate managers and senior officials; production managers; functional managers; quality and customer care managers; financial institution and office managers; managers in distribution and storage; protective service officers; health and social services managers	111, 112, 113, 114, 115, 116, 117, 118
12	Managers/proprietors in agriculture and services	Managers in farming, horticulture, forestry and fishing; managers and proprietors in hospitality and leisure services; managers and proprietors in other service industries	121, 122, 123
21	Science and technology professionals	Engineering professionals; information and communication technology professionals	211, 212, 213
22	Health professionals	Health professionals, including medical and dental practitioners and veterinarians	221
23	Teaching and research professionals	Teaching professionals, including primary and secondary school teachers and higher and further education lecturers; research professionals (scientific)	231, 232
24	Business and public service professionals	Legal professionals; business and statistical professionals; architects, town planners, and surveyors; public service professionals; librarians and related professionals	241, 242, 243, 244, 245
31	Science and technology associate professionals	Science and engineering technicians; draughtspersons and building inspectors; IT service delivery occupations	311, 312, 313
32	Health and social welfare associate professionals	Health associate professionals, including nurses and other paramedics; therapists; social welfare associate professionals	321, 322, 323
33	Protective service occupations	Protective service occupations	331
34	Culture, media and sports occupations	Artistic and literary occupations; design associate professionals; media associate professionals; sports and fitness occupations	341, 342, 343, 344
35	Business and public service associate professionals	Transport associate professionals; legal associate professionals; financial associate professionals; business and related associate professionals; conservation associate professionals; public service and other associate professionals	351, 352, 353, 354, 355, 356
41	Administrative and clerical occupations	Administrative/clerical occupations: government and related organisations; finance; records; communications; general	411, 412, 413, 414, 415

	Sub-major groups	Occupations	Occupation minor group number[a]
42	Secretarial and related occupations	Secretarial and related occupations	421
51	Skilled agricultural trades	Agricultural trades	511
52	Skilled metal and electrical trades	Metal forming, welding and related trades; metal machining, fitting and instrument making trades; vehicle trades; electrical trades	521, 522, 523, 524
53	Skilled construction and building trades	Construction trades; building trades	531, 532
54	Other skilled trades	Textiles and garment trades; printing trades; food preparation trades; skilled trades n.e.c.	541, 542, 543, 549
61	Caring personal service occupations	Healthcare and related personal services; childcare and related personal services; animal care services	611, 612, 613
62	Leisure and other personal service occupations	Leisure and other personal service occupations; hairdressers and related occupations; housekeeping occupations; personal service occupations n.e.c.	621, 622, 623, 629
71	Sales occupations	Sales assistants and retail cashiers; sales related occupations	711, 712
72	Customer service occupations	Customer service occupations	721
81	Process plant and machine operatives	Process operatives; plant and machine operatives; assemblers and routine operatives	811, 812, 813
82	Transport and mobile machine drivers and operatives	Transport drivers and operatives; mobile machine drivers and operatives	821, 822
91	Elementary occupations: trades, plant and machine related	Elementary occupations: agricultural trades related; process and plant related; mobile machine related	911, 912, 913, 914
92	Elementary occupations: clerical and services related	Elementary occupations: clerical related; personal services related; cleansing services; security and safety services; sales related	921, 922, 923, 924, 925

Notes: (a) Standard Occupational Classification, ONS (2001).

Table 3: SOC1990 Classification of Occupational Categories (Sub-major Groups)

	Sub-major groups	Occupations	Occupation minor group number[a]
1.1	Corporate managers and administrators	General managers and administrators in national and local government, large companies and organisations; executive officers in the civil service; production managers in manufacturing, construction mining and energy industries; specialist managers; financial institution and office managers; managers in transport and storing; protective service officers; managers and administrators n.e.c.	10, 11, 12, 13, 14, 15, 19
1.2	Managers/proprietors in agriculture and services	Managers and proprietors in service industries; managers in farming, horticulture, forestry and fishing	16, 17
2.1	Science and engineering professionals	Natural scientists; engineers and technologists.	20, 21
2.2	Health professionals	Health professionals, including medical and dental practitioners and veterinarians.	22
2.3	Teaching professionals	Teaching professionals, including primary and secondary school teachers and higher and further education lecturers	23
2.4	Other professional occupations	Legal professionals; business and financial professionals; architects and surveyors; professional occupations n.e.c.	24, 25, 26, 27, 29
3.1	Science and engineering associate professionals	Draughtspersons, scientific technicians, quantity and other surveyors; systems analysts and computer programmers; associate professional and technical occupations n.e.c.	30, 31, 32
3.2	Health associate professionals	Health associate professionals, including nurses and other paramedics.	34
3.3	Other associate professional occupations	Legal associate professionals; business and financial associate professionals; social welfare associate professionals; literary artistic and sports associate professionals; librarians and related associate professionals	33, 35, 36, 37, 38, 39
4.1	Clerical occupations	Administrative/clerical officers and assistants in the civil service and local government; numerical clerks and cashiers; filing and general clerks; clerks (not elsewhere specified);	40, 41, 42, 43, 44, 49

	Sub-major groups	Occupations	Occupation minor group number[a]
		stores and despatch clerks, storekeepers; clerical and secretarial occupations n.e.c.	
4.2	Secretarial occupations	Secretaries, personal assistants, typists, word processor operators; receptionists, telephonists and related occupations	45, 46
5.1	Skilled construction trades	Building trades.	50
5.2	Skilled engineering trades	Metal machining, fitting and instrument making trades, electrical/ electronic trades	51, 52
5.3	Other skilled trades	Textile, garments and related trades; printing and related trades; woodworking trades; metal making, welding and related trades; vehicle trades; food preparation trades; other trades n.e.c.	53, 54, 55, 56, 57, 58, 59
6.1	Protective service occupations	NCOs and other ranks, armed forces; security and protective service occupations (including the police and fire brigade)[b]	60, 61
6.2	Personal service occupations	Catering occupations (including chefs); travel attendants and related occupations; health and related occupations; childcare and related occupations; hairdressers, beauticians and related occupations; personal service occupations n.e.c.	62, 63, 64, 65, 66, 67, 69
7.1	Buyers, brokers and sales representatives	Buyers, brokers and related agents; sales representatives and agents.	70, 71
7.2	Other sales occupations	Sales assistants and check-out operators; mobile, market and street sales persons; sales occupations n.e.c.	72, 73, 79
8.1	Industrial plant and machine operators, assemblers	Food, drink and tobacco process operatives; textiles and tannery process operatives; chemicals, paper, plastics and related process operatives; metal working process operatives; assemblers/line workers; other routine process operatives; machine and plant operatives n.e.c.	80, 81, 82, 83, 84, 85, 86, 89
8.2	Drivers and mobile machine operators	Road transport operatives; other transport, and machinery operatives.	87, 88

	Sub-major groups	Occupations	Occupation minor group number[a]
9.1	Other occupations in agriculture, forestry and fishing	Other occupations in agriculture, forestry and fishing	90
9.2	Other elementary occupations	Other occupations: in mining and manufacturing; in construction; in transport and in services; postmen/women, mail sorters, messengers; other occupations n.e.c.	91, 92, 93, 94, 95, 99
82	Transport and mobile machine drivers and operatives	Transport drivers and operatives; mobile machine drivers and operatives	821, 822
91	Elementary occupations: trades, plant and machine related	Elementary occupations: agricultural trades related; process and plant related; mobile machine related	911, 912, 913, 914
92	Elementary occupations: clerical and services related	Elementary occupations: clerical related; personal services related; cleansing services; security and safety services; sales related	921, 922, 923, 924, 925

Notes: (a) Standard Occupational Classification. OPCS (1990).

8.3. Extension to 4-digit level of SOC2010

In the LMI for All project,[21] historical data from the LFS were used to compute shares of 4-digit occupations within 2-digit groups for All Industries. These patterns were then applied to all industries and for all future years. The aim is to expand the occupational results from 25 2-digit occupations by 75 industries to the 369 4-digit ones by 75 industries.

This runs into the problem that some 4-digit occupations are clearly industry specific. Applying the method above results in anomalous outcomes (e.g. the largest numbers of some textile operatives appearing in the industry food drink and tobacco rather than in the textiles industry). If industry specific shares are used instead of the all industry ones the problem is (in principle) resolved. However, there are at least two problems with this alternative:

First, using distinctive shares for (say) the 6 broad industry groups fails to resolve the problem since the differences above do not become apparent at this level (for example,

[21] See: http://www.lmiforall.org.uk/

applying shares based on the whole of the manufacturing instead of all industries will not make the differentiation between textiles and clothing and food drink and tobacco). To avoid that problem a much finer industry differentiation is needed (ideally at the 75 industry) level!

But this raises a second problem, notably that the LFS sample size is inadequate to produce robust shares at the 75 industry level. The only way around this impasse is to generate a set of industry specific shares that is consistent (as far as possible) with the all the information available.

The "knowns" that the final estimates need to be consistent with are as follows:

1. the 75 industry employment totals;
2. the 2-digit occupational totals;

and within those:

3. the 75 industry x 2-digit occupational total;

are all available in the standard Working Futures database:

i. for all years.

They are also available:

ii. by gender and status;
iii. by region/country;
iv. by qualification.

Ideally, the expansion to the 4-digit level needs to cover all these dimensions.

Extension to ii. - iv poses more problems, not least in terms of the scale of the computations and programming required. Such extensions are however desirable since the detailed occupational patterns are likely to vary across these dimensions (see below).

The other "known" it is important to take account of (in principle at least) is information on the overall pattern of employment by 4-digit occupation (shares of 4-digit within 2-digit categories) when aggregated across all industries, all regions and all gender/status types.

This was the aggregate information used in the approach to developing 4-digit level projections in the LMI for All project (as outlined in the paragraph above). In principle, this aggregate information could be extended to cover region and /or industry (for example the 6 broad sectors). Ideally, it can be further extended to differentiate the shares for each of the 75 industries. However this results in a very sparse data set, with many "gaps" where the LFS has no entries (yet it is almost certain that there are people employed in those categories).

A compromise solution has been adopted which computes more detailed shares than was done in the LMI for All project, but without trying to impose the final aggregate 4-digit level constraint (which requires a further RAS process).

The details of the algorithm developed to fill the gaps are summarised in Figure 8.1. The main steps are as follows:

- Step 1 - using the LFS data (combining years) generate a set of shares of 4-digit within 2-digit categories for each 75 industry category and covering dimensions ii - iv above for categories where data are available.
- Step 2 – where there are gaps use the nearest equivalent (more aggregate category).
- Step 3 – apply the final shares to the existing Working Futures employment data to generate a full data array of employment levels - 4-digit occupation by 75 industries. Step 3 effectively constrains this array to match the "knowns" in points 1 – 3, above.

The detailed occupational shares are extracted and applied as in the LMI for All project to the 2-digit occupational totals (but now differentiated for each of the 75 industries (as well as by region, gender/status and occupation).

The final RAS process did not reach a unique solution due to irreconcilable differences between the aggregated summary of 369 4-digit occupations on the one hand and the detailed allocation of these within all the 48,600 categories/dimensions (industries in particular). The final set of results is fully consistent with all the other dimensions used in the published Working Futures estimates (region / country; industry (75 level) gender, status, SOC 2-digit occupational category and qualification level). The final discrepancies at the 4-digit level were small and concentrated in just two sub-major groups.

Figure 8.1: Algorithm for developing the 4-digit occupational database

Expanding the 25 SMGs in Working Futures to 369 SOC Unit groups

Working Futures data		**Labour Force Survey data**	
1990-2024		**10 quarters combined**	
2	genders	2	genders
3	statuses	3	statuses
75	industries	75	industries
9	qualifications	6	qualifications
25	SMGs	369	SOC unit groups
12	regions		

From the LFS data, the shares for each unit group within each SMG is calculated. The Working Futures employment level for that SMG is shared out to the Unit groups. The share is applied to each nation/region and year

Where the LFS has is no value in a cell, aggregations are tried in order:

- all statuses;
- both genders;
- both genders and all statuses;
- all industries (by gender and status);
- both genders and all statuses all industries.

Shares are calculated separately within the six qualification categories and applied to the appropriate more detailed 9 qualification categories in the Working Futures data.

9. Replacement demands

9.1. The importance of replacement demands

Estimates of replacement demands have been a key feature of IER occupational projections for many years. Net changes in occupational employment (or expansion demand as they are referred to in the main reports) are only one indicator of future changes in the pattern of demand for skills. Another measure, which is equally important for assessing education and training provision, is the replacement demand needed to offset outflows due to retirements, occupational mobility, etc.

The analysis of occupational trends and prospects provides predictions of the changes in the number of people employed in particular occupational categories. However, education and training requirements are not simply dependent on which occupations are growing rapidly. The projected net change in employment (expansion demand) tells only a part of the story in terms of future skill requirements. It is crucial to recognise that there will be many job openings and important education and training requirements for many occupations where employment levels are expected to fall. These arise because of the need to 'replace' the existing skills that will be 'lost' as a result of retirements and other aspects of the normal process of labour turnover. Even in those occupations where employment levels are expected to decline substantially, there may be a need to train, simply to maintain the existing stock of skills at the required level. In addition to examining likely net changes in the numbers in each occupational category, it is also important, therefore, to assess replacement demands. These represent the numbers needed to maintain the existing stock of skills due to losses resulting from retirements and other outflows.

The scale of replacement demand typically outstrips the scale of expansion demand, in the present projection by a factor of around eight to one. This varies across occupations and sectors but, even where substantial job losses are projected, the replacement demand elements are usually more than sufficient to offset this. It is essential, therefore, for employers, education and training providers, and public agencies to recognise the different characteristics and requirements of these two different components of future skill needs.

9.2. Methods of estimating replacement demands

IER has developed procedures to produce such estimates, linked to the main occupational projections. These are summarised in Box 9.1. The various elements of replacement demand depend upon the rates of flows from employment due to factors such as retirement and occupational and geographical mobility, as set out in Box 9.1. The main source of information on the various flows (as well as information on age structure), which are used to generate replacement demand estimates, is the LFS. This

is used to generate information on outflows over the past 12 months. Such estimates account, therefore, for some, but not all labour turnover (since many jobs are filled within a 12 month period). The total number of job openings is likely to be substantially greater than the estimates developed here. Nevertheless they provide a useful benchmark for thinking about the number of new entrants to jobs that will need to be found.

While the LFS can provide useful information across all sectors and regions combined, its sample size is inadequate to provide specific data for particular sectors and regions at a detailed level. The Census of Population offers the potential for obtaining more robust estimates, at a much more detailed level. However, these results are already becoming somewhat dated. The present analysis draws upon both sets of data, using the more robust Census data for 2011 to get a better fix on different patterns at a point in time while relying more upon the LFS to reveal how these patterns are changing over time.

In principle, there is no problem in providing such estimates in considerable detail, distinguishing sector, gender/status and geographical area. It is possible to generate customised estimates of replacement demand for any industry or spatial area, recognising unique features, including the age structure of the workforce and rates of flow. Such estimates are likely to vary significantly, depending upon these factors.

In practice, it is very difficult to obtain reliable data on these factors, which would enable such customised estimates to be produced. The current analysis is based on LFS data on labour market flows at national level. Attempting a breakdown for the countries and English regions within the UK, or for broad sectoral groups at a UK level, faces problems of empty cells in the LFS data. The LFS, even with its enhanced size, does not provide a sufficiently large sample to generate sensible estimates for individual sectors at a rather broad level, let alone breaks by region or LEP area. Indeed, as noted below, the estimates of occupational mobility from the LFS proved inappropriate for use at all but the most aggregate national level. The lack of availability of data from national sources therefore severely limits the extent to which such estimates can be customised for particular groups (sectors, geographical areas, etc.).

However, this should not be seen as an insurmountable problem. The key point in producing replacement demand estimates is to emphasise the importance of replacing those retiring, even in declining sectors and occupations. While these results are, of course, sensitive to the particular assumptions adopted, they can be regarded as indicative. Results are therefore provided at a considerable level of detail, based on a set of benchmark assumptions about age structures and flow rates. The main replacement demand estimates in the published reports use a “standard” set of assumptions about flow rates, which are common to all sectors and geographies.[22]

[22] In principle, such assumptions could be differentiated at a much more detailed level, distinguishing individual sector, gender status category and LEP area.

Occupational mobility estimates were used initially in calculating overall replacement demands at national level. However, when attempts were made to use the same assumptions about flow rates for individual sectors and regions, this led to implausible results. This is because of the very different occupational structures across sectors and the imprecision of some of the flow estimates, even at national level. In order to provide a comparable set of results at all levels, the occupational mobility estimates were therefore set by assumption to zero (as was the case for geographical mobility).

The estimates published in the various reports are therefore based on the heroic assumption that the general patterns of age structure and rates of flow are common across all sectors and regions. This enables a certain level of consistency. In particular, it ensures that disaggregated estimates will sum to more aggregate totals. These benchmark estimates provide a starting point for thinking about such issues. In particular, they emphasise the quantitative importance of replacement demands compared with the structural changes projected.

The estimates of replacement demands over the coming decade presented in the reports are generally over a third of the opening stock (employment levels at the start of the period under consideration).

This proportion depends on:

i. the length of period covered (the longer it is the greater the outflows)[23];
ii. the age structure in each occupation (older work forces will see greater outflows, all else equal);
iii. Outflow rates (these are age and gender specific but may also vary across other dimensions).

ii. and iii are (initially) assumed to be common to all industrial and geographical categories although they might vary a lot in reality. The reasons for this are not that it is thought that such differences are unimportant. It is simply that the LFS data used to measure ii and iii are inadequate to measure these differences systematically and consistently across all the dimensions of the database.

In practice, it is likely that patterns of age structure and rates of flow will be very different for particular sectors or locations. The procedures and tools developed allow those with access to the more detailed data to explore alternative scenarios, by using industry specific or area specific assumptions about age structures or flow rates. These can draw on non-official data as well as the limited range of alternatives directly provided. In this manner users can, for example, explore alternative scenarios, based on “local” knowledge about particular difficulties faced where a workforce is rapidly ageing.

[23] The present estimates are based on a 10-year period of outflows.

9.3. Estimating replacement demands at the 4-digit level

Replacement demands at the 4-digit level are assumed to have the same outflow rates as the corresponding 2-digit category to which they belong. This is a strong assumption unlikely to hold true in practice as the age structures of the 4-digit occupations are likely to differ significantly from their 2-digit averages. However, this assumption allows the presentation of an initial assessment of the potential scale of such effects.

Box 9.1 Estimating Replacement Demand by Occupation

Measuring replacement demand

The projections of occupational employment 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 'gainers' and 'losers', they can 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 are still likely to be employed in the future, then employers will need to replace those employees who leave because of retirement, career moves, mortality or other reasons. This so called 'replacement demand' may often dwarf any 'structural demand' resulting from growth in employment in a particular category and 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 from one state to another. Yet it is measurement of such flows which is essential to estimating replacement demands.

However, use can be made of readily available statistics in order to provide indicative estimates. Ideally, one requires a full set of demographic accounts which 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 does not exist even at national level. However, the LFS now provides a sufficiently large sample to obtain rough 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 (and other reasons for leaving the workforce);
  - inter-occupational mobility;
  - mortality.

Age structure

Data on age structure are required since many of the flows, especially retirements and mortality, 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 biased to 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 will clearly influence likely losses due to mortality and retirement which are age related.

Retirement rates
Retirement rates vary by gender and by age. By using data for the whole of the UK estimates of likely rates of outflow can be made. Data are not distinguished for different occupational groups since sample numbers are too small to allow for meaningful estimates. The estimates are based on data from the LFS, which show the % 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 outflow for younger age groups associated with family formation.

Mortality
Another potential outflow is due to mortality. Information on mortality rates is available by age and gender from ONS. 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 of time. The rates used are again based on data for the whole of the UK. However, mortality rates are unlikely to vary very much across occupations.

Occupational mobility
Occupational mobility is an important source of loss for some occupations although not for all. The full occupational mobility flow matrix indicates that some occupations such as corporate managers and administrators tend to gain employment as people are promoted from other occupations. This means that many of the losses due to retirement are ‘automatically’ dealt with by the normal process of promotion and upward occupational mobility. However, for those occupational categories which provide the people who are promoted this means that losses due to retirement will understate the overall replacement demands. These data are based on an analysis of information for the whole of the UK.

Replacement demand
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. For the projections constant rates of flow are assumed. The tables in the main text provide estimates of replacement demands over the forecast period. The first column of the table indicates the scale of structural demand (which in some cases may be negative). Column 2 estimates losses due to retirement and mortality. It is notable that these figures are substantial in comparison with the expansion demand element and that in most cases they offset any negative change.

10. Developing the employment and output database

10.1. Background

When the first Working Futures exercise was undertaken a prime objective was the provision of much more detailed projections of employment than produced hitherto. This included additional detail by industry (including other characteristics such as gender and employment status), occupation and geographical area. Previous projections produced for DfES (Wilson, 2001a, 2011b[24]) had included a spatial analysis down to individual country and regional level. The Working Futures projections were also intended to serve the interest of various other bodies. In particular, the then extant Learning and Skills Council (LSC) and its local arms required results at local Learning & Skills Council (LLSC) level.

The latest thinking focuses attention on so called "Local Enterprise Partnership" (LEP) areas in England (and corresponding geographies in the developed administrations, but the problems are basically the same. There are various technical and methodological issues that constrain the amount of detail that can be provided. These methodological problems are discussed here, as well as the solutions adopted to deal with them.

The earlier analysis was based on a variety of different data sources, including the various sectoral data produced by the ONS, as well as a broad range of other data relating to occupational employment and skills produced by various Government Departments and other bodies.[25]

To provide statistically robust estimates for all the possible categories would involve an enormous project, including new primary data collection to obtain the relevant occupation by industry data in statistically robust form. At present statistically precise data are not available for all the detailed sectoral categories from official sources. This is before developing breaks by occupation and geography. Moreover, there are also important issues of confidentiality as well as statistical reliability, in making such detailed data available in the public domain. These are discussed in more detail in Sections 13 and 14 below.

[24] Wilson, R. A. (ed.) (2001a). *Projections of Occupations and Qualifications, 2000/2001*. Department for Education and Employment/University of Warwick, Institute for Employment Research, Coventry.; Wilson, R. A. (ed.) (2001b). *Projections of Occupations and Qualifications, 2000/2001: Regional Results*. Department for Education and Employment/University of Warwick, Institute for Employment Research, Coventry.

[25] Section 11 summarises the sources used.

10.2. Development of greater sectoral and spatial detail

The standard sectors used in MDM-E3 have been set out in Tables 3.1 and 3.2. The reason for a different sectoral disaggregation at the regional/country level reflects data availability and reliability. These categories are based on data available from ONS in various official sources, especially those data relating to input-output information, which is central to MDM-E3. They are classified according to the 2007 Standard Industrial classification (SIC2007).

In the present exercise the main analysis is presented using 75 industries based on SIC2007. ONS have placed data at this level of detail into the public domain, so it is regarded by them as non-disclosive.

The Development of the Database has therefore involved a number of key elements:

- establishing consistent historical time series of sectoral employment and output by the nations and English regions within the UK;
- expanding this to cover all 75-sector SIC categories;
- expanding the geographical coverage;
- development of occupational data relating to the new sectors and geographical areas.

In addition to this it was necessary to develop a number of related models and procedures, including:

- forecasting models and procedures to generate consistent projections across these various dimensions (described in Sections 2 and 4);
- development of a replacement demand module to generate replacement demand estimates across all the various dimensions (described in Section 9);
- treatments of Labour Supply (Section 5); and
- qualifications (Section 15).

10.3. The core Database: employment and output by 75 industries

Historical estimates of output and employment by gender and status were based on various official sources, including quarterly workforce jobs (employee jobs and self-employment jobs) and BRES and ABI (for employees) data. These detailed employment data, covering all the main dimensions concerned, provide the core of the **Database**.

Employment for 75 industries: The main MDM-E3 employment estimates are based on detailed SIC2007 categories used in the CE MDM-E3 model. This covers the 12 nations

and regions of the UK, gender and status. These data series have been developed over many years and are as consistent as can be achieved with all the official published sources upon which they are based.[26]

For earlier time periods (before 1998), growth rates from the data from previous editions of Working Futures, which were based on previously released ONS data, were applied.

10.4. Occupations (25) within industries

The starting point was information taken from the Censuses of Population (CoP) since 1981. This has been supplemented and in more recent years replaced by information from the LFS. Initially (in previous rounds of Working Futures) industry by occupation employment estimates were produced for 1981, 1991 and 2001 for the standard regions (SSRs). Details of the occupational groupings are shown in Tables 8.2-8.3.

Sectoral data were based on the Census of Employment, the Annual Employment Survey (AES) and most recently the ABI and BRES. Together with information from the CoP and LFS, these sources were used to generate a series of occupation by industry employment matrices, initially based on 41 industries (SIC2003) and the old 22 SOC1990 Sub-Major occupational groups. These were then converted first to the 25 SOC2000 sub-major groups using data from ONS to give the occupational categories shown in Table 8.3 and then to the SOC2010 categories as in Table 8.2.

The conversion process is based on matrices from the Census or LFS developed by IER in collaboration with ONS. These matrices distinguish gender. They cross-classify the detailed (2-digit) occupational categories by, SOC1990, SOC2000 and SOC2010 categories. The matrices for the earlier years were then customised to reflect variations in detailed occupational composition, within sectors and over time, to develop a series of convertor matrices at a SOC sub-major group level, by MDM-E3 industry and by year. This approach avoids the worst implications of applying a fixed convertor. For the most recent translation to SOC2010 a simple fixed convertor has been used.

For Working Futures 2014-2024 the industry coverage was extended to include 75 industries based on SIC2007, building on the previous work on SIC2007 based categories in Working Futures 2010-2020 and 2012-2022. For Working Futures 2017-2027 this level of industry coverage is maintained.

Historical data on occupational employment for the Government Office Regions areas were then developed by assuming the same occupational structure within industries as for the old SSRs. RAS procedures were used to ensure that these all added up consistently.

[26] Complete consistency is not possible since the various official sources are themselves inconsistent, not least because some have been subsequently revised and updated by ONS.

10.5. The detailed industrial estimates

In order to meet the requirements to extend the occupational analysis to a more detailed industrial level, the original **Database** had to be extended to cover additional 2-digit SIC2007 categories for Working Futures 2012-2022. Since the cornerstone of the employment projections is MDM-E3, this implied the need to obtain industrial data on output as well as employment. An extended employment (and output) **Database** was developed specifically in order to meet this requirement. This has been updated for the present set of projections.

The extension of the historical regional industrial employment elements from the 46 industries used in MDM-E3 to 75 categories involved disaggregating each of the 46 industries which comprise more than a single 75-sector category. ONS currently publish sectoral employment data (employees) at this level of detail (based on the BRES) and ABI). The ABI data include breakdowns by gender and full-time /part-time status, but the latest BRES data only provide such breakdowns by full-time/ part-time. Also, self-employment data are not available. Breaks by occupation and spatial area are also much more problematic. Gaps in the official data were filled using various methods, as described elsewhere in this report. RAS procedures were used to ensure everything added up to the official published figures.

10.6. Extending the occupational analysis to cover detailed industries

Extending the historical data on occupations to cover the 75 Working Futures 2012-2022 detailed industries was problematic. Ideally, it would have involved going back to the 1991 Census (and indeed 1981 as well) and extracting data for the additional industries and local areas. As described above, the original employment estimates produced for the DfES projections did this for the 41 industries. In practice, extending this data set to cover additional industries is problematic for a number of reasons. Most importantly both SIC and SOC have changed significantly. In addition, the earlier data were only made available for 10 per cent (hard copy) or 2 per cent (electronic) sub samples, which makes obtaining robust estimates at this level of detail difficult, if not impossible, in many cases. The LFS sample size is only adequate to obtain reliable estimates at a UK level, and even here is not able to provide robust estimates for many of the additional industries required, (which almost by definition tend to be small).

In the previous analysis for Working Futures 2010-2020, 2012-2022, and 2014-2024 historical figures for the additional (79/75) industries were estimated using information

already to hand.[27] These historical series were then constrained to match the other estimates at more aggregate levels. Given that most of the new industries are normally small components of larger parts, this procedure generates reasonably plausible results. An RAS iterative procedure was then used to ensure that everything still adds up to the published headline totals by industry, occupation, region, etc. This RAS adjustment is not a trivial process. The software used to generate a consistent **Database** runs to thousands of lines of complex computer code. This procedure avoids the major inconsistencies that would otherwise emerge between the published headline figures reported by ONS and the sum of the detailed parts.

For Working Future 2017-2027, this process has been updated using the set of 75 industries defined in Sections 3, 4 and 6.

[27] A more comprehensive reassessment of the historical record, involving re-interrogation of old Census records could be undertaken. However, given time and resource constraints this was not feasible in this project.

11. Sources and general methods

11.1. Main sources

The Office for National Statistics (ONS) is responsible for most of the economic and labour market statistics upon which this analysis is based. Many of the data are made available via the National Online Manpower Information System (NOMIS).

ONS is responsible for most of the key economic statistics upon which MDM-E3 is based, including the UK National and Regional Accounts and the Input-output Tables. This includes indicators such as:

- output and related indicators;
- wages and prices;
- trade statistics;
- UK Balance of Payments;
- Regional Accounts.

ONS is also responsible for workforce jobs (including employee jobs and self-employment jobs) data, and the BRES and ABI. BRES has replaced the ABI since December 2010 and provides annual employment figures on the 2007 Standard Industrial Classification (SIC2007) basis only. BRES and ABI are the most important sources of information on detailed industry employment levels at regional level and below.

ONS also undertakes the LFS, as well as the more infrequent Census of Population. These two sources provide information on key aspects of employment structure, such as occupational employment and the various information on flows and age structure needed for replacement demand estimates.

11.2. General approach and methods

The general approach adopted can be summarised in a few words:

- Underlying the whole set of projections is the use of a detailed Multi-sectoral macroeconomic model. This is described in Sections 3 and 4 above.
- All published official data on employment have been used. The data within the models and data base are constrained to match the official sources.
- Where there are inconsistencies between official sources, the industrial information (currently from Workforce Jobs and BRES/ABI data) is given precedence.

- All the employment data are constrained to match headline figures published by ONS through it's website. This is achieved using so called RAS iterative methods, as described below.
- Where no official data are published, estimates are generated by assuming common patterns to the next level of aggregation up at which official estimates are available.
- Occupational estimates and self-employment estimates (where data are not available from the Workforce Jobs series) are based on information from the Census of Population and the LFS.

The sectoral and spatial level data are therefore consistent with ONS estimates available at the time the analysis was conducted. Information on occupations and qualifications is based on LFS data available at the same time. The latter is constrained to match the sectoral data, using the RAS process (described below) so the numbers will no longer match the original LFS information, although the general patterns are fully consistent. Therefore the numbers by sector, region, occupation and qualification may not match the latest ONS estimates for a number of reasons:

- revisions and changes made by ONS since the analysis was conducted;
- differences in classification – the published Working Futures database is entirely on SIC2007 and SOC2010;
- modifications introduced as a result of the RAS process (this affects only the occupational and qualification patterns).

The Working Futures database provides a complete and consistent picture across all dimensions of employment that is not available from any other source.

11.3. The RAS Iterative Process

The detailed employment data can be conceived of in terms of multi-dimensional arrays with the following dimensions:

- industries (75 2-digit SIC2007 categories);
- geographical areas (9 English regions plus the 3 devolved nations within the UK);
- occupations (25 sub major groups of SOC2000 or SOC2010)
- gender;
- employment status (full-time, part-time, self-employment);
- time (years from 1990-2027).

ONS publish various headline statistics for certain aggregate elements of these arrays (typically sums across one or more dimensions).

An iterative process, based on the so-called RAS procedure,[28] is used to develop the detailed elements within the arrays in such a way that the various constraints are met. In two dimensions, a RAS procedure involves taking a two dimensional matrix of numbers and progressively and alternatively:

- forming row or column totals;
- calculating a ratio of these compared with some target values (typically provided by ONS figures);
- multiplying the rows or columns of the array by that ratio;
- re-summing and repeating the process.

Typically this process delivers a new array which matches the desired row and column totals within a comparatively few iterations (normally 20-30). In developing the database complex procedures have been developed which repeat this essentially simple process across all the dimensions above simultaneously, using constraints, which are, more often than not, incomplete.

11.4. Treatment of Agriculture

The Agriculture, Forestry and Fishing sector poses some particular problems. There is a paucity of data in official sources for this sector. The BRES and its predecessors have all had problems in obtaining comprehensive coverage of this sector. There is a difference in data availability at regional and sub-regional level. MAFF have undertaken their own surveys, which are on a somewhat different basis (including “unpaid” family workers, for example). ONS and IER/CE are aware of these problems and have attempted to take them into account when providing overall employment estimates by adopting scaling procedures to ensure that spatial disaggregates sum to national and regional totals. However, the limitations of these estimates need to be flagged up to users.

ONS now provide general employment data for UK and the nations and regions at different levels of industrial disaggregation for 1996 onwards. Estimates for agriculture are available for all the above areas. Before 1996, information from the old MDM-E3 industries were used. At the local level ABI/BRES data, as well as agricultural labour force data from the Department for Environment, Food & Rural Affairs (DEFRA) are used and scaled to match the regions.

[28] For a general discussion of RAS methods see: Lahr, M. L., and De Mesnard, L. (2004). Biproportional Techniques in Input–Output Analysis: Table Updating and Structural Analysis. *Economic Systems Research*, 16(2), pp.115-134.; McMenamin, D.G., and Haring, J. E. (1974). An Appraisal of Nonsurvey Techniques for Estimating Regional Input-Output Models. *Journal of Regional Science,* 14(2), pp. 191-205. ; Miller, R., and Blair, P. (2009). *Input–Output Analysis. Foundations and Extensions,* Second Edition, Cambridge University Press: Cambridge.; Toha, M-H. (1998). The RAS Approach in Updating Input–Output Matrices: An Instrumental Variable Interpretation and Analysis of Structural Change. *Economic Systems Research*, 10(1), pp. 63-78.

12. Generating results for Local Areas

12.1. Rationale for producing local level projections and their limitations

These notes are intended to accompany the detailed occupational employment projections produced for particular sub-regional (England) and sub-national (Wales) areas (Local Enterprise Partnerships (England), Economic Areas (Wales)). They explain how the numbers have been generated and their limitations.

The changing policy environment for skills has placed renewed emphasis on the local level, resulting in a demand for ever more detailed information, focusing on local trends. The main aim of generating local projections is to provide a quantitative benchmark of labour market prospects for the local area concerned. This is based on the same macroeconomic scenario and assumptions as for the broader national projections.

It is important to emphasise that these local level projections are based solely on secondary data sources as described below. The local results are tied to the particular national and regional scenario described in the main report. They do not incorporate any specific local knowledge or insight and are intended as a starting point for further analysis rather than a projection of what is most likely to happen. They represent one possible future, based on the assumption that employment patterns in the local area continue to maintain the same relationship with the regional level as in the recent past. Sectors which have performed relatively poorly are assumed to continue to do so, and vice versa. This is not inevitable. In particular it does not take into account any local "surprises". These may be welcome (such as a major inward investment), or not (as in the case of a major closure). Moreover, local agencies and organisations may be able to break away from past trends. The results should be seen as providing a starting point for debate rather than the final word.

Key drivers of changing skill requirements at local level are similar to those at national level. These include:

- technological change - especially information and communications technology (ICT), automation and digitalisation, which are affecting both the products and services produced as well as the way they are produced, resulting in increased demands for IT skills across a range of sectors and occupations;
- competition and changing patterns of consumer demand - which have increased the emphasis on customer handling skills;
- structural changes - including globalisation, sub-contracting and extension of supply chains, emphasising the need for high quality managerial skills (across a greater range than previously and at a greater depth) at various levels;

- working practices - such as the introduction of team- or cell-based production in engineering, and call centres in financial services, resulting in increased demand for communication and team working skills; while more generally there has been an increase in labour market flexibility; and
- regulatory changes - as well as increased concern about environmental issues, which have made important skill demands upon staff for some key sectors, including construction and finance; (survey evidence suggests that regulatory/legislative change is a particularly important driver of skills change in the public sector).

The results at a local level reflect all these factors although they are not dealt with explicitly in the local case.

The production of such a set of projections for a particular local area should not be seen as the end of the process. Rather it is best regarded as part of an ongoing process of improving understanding about what is going on in the local area. This understanding can then guide local policy makers and other actors (including individual workers, students and employers) to better decisions. The main benefits can be summarised as follows:

- The aims and objectives of policy intervention can be made clearer and the ability to evaluate policy can help, hopefully, to establish a virtuous circle.
- Such projections can provide a focus for discussion and co-operation and may help to breakdown old misperceptions about local markets.
- The projections should enable those involved to take more strategic actions, rather than a fire-fighting approach to problems, as the implications of current trends and outcomes for the future are explored explicitly.
- Finally, the projections can also provide guidance to individual actors (including employers and (potential) employees) enabling them to make better decisions about their own futures.

12.2. Limitations of the data

As noted above, the Working Futures projects have involved forecasting large numbers of individual time series.[29] This has involved generating a very detailed employment database – by far the most detailed ever produced for the UK – and in this respect, the projects have already generated considerable value added.

[29] For *Working Futures 2004-2014* there were over half a million (that is: Sector (67) * occupation (25) *geographical area (47 local areas plus Scotland, Wales and Northern Ireland) * gender/status (6) = 512,550 separate time series). For *Working Futures 2017-2027* the main projections cover 135,000 series but this excludes qualifications, and the extension to 4-digit occupations as well as the sub-regional analysis.

However, it is important to recognise that the data are not without limitations. This gives rise to a number of concerns about how the data should be used and reported. The limitations arise from two elements of the procedure which has been used to produce the projections.

- First, the projections are based upon survey data that were not originally designed or developed to produce precise estimates at this level of disaggregation.
- Second, the survey data have been used to calibrate an econometric forecasting model and a set of disaggregation procedures. Forecasting is as much an art as a science and requires considerable judgement on the part of the researcher especially when the forecast horizon is as much as 10 years ahead. Any errors in the forecaster's ability to predict the future will result in inaccuracies in the projections. These will be amplified the further into the future that the projections are considered, due to the inter-linkages between the sectors and regions, and the feedback mechanisms, which permeate the model structure. The extent to which the historical base is inaccurate due to the data limitations further exacerbates this problem.

It is important to note that the greater the sectoral and spatial disaggregation the more sensitive the results will be, as some sectors are expected to be very small and at the same time exhibiting large variations.

When considering the question of data limitations a distinction needs to be made between statistical reliability and the provision of useful labour market information at a detailed level. If strict rules regarding statistical robustness are applied to decide what level of sectoral and occupational disaggregation can be provided at LEP level, there is a danger of throwing the baby out with the bath water. The official surveys carried out by ONS are (with a few exceptions) not designed to provide statistically robust estimates at this level of detail. Following such rules would restrict what might be reported to very broad aggregates, which are not very helpful to those in LEP areas or to bodies charged with monitoring detailed trends at a sectoral level.

IER/CE have addressed this issue for a number of years in providing results based on their LEFM methodology. This is based on the notion of providing "benchmark" estimates and projections, using the most detailed data where they are available for the local level, in combination with broader national and regional trends where they are not. While not subject to the normal tests of statistical precision, such estimates can provide useful and informative LMI for those operating at the local level. Other consultants have adopted similar solutions.

In providing such information it is important that the user is aware of its limitations (as well as avoiding any problems of confidentiality). However, this is arguably much more useful than suppressing the detail at an early stage. This solution requires that such detailed information is only made available to a restricted audience. It is also necessary

to ensure that this audience is aware of its limitations and responsible in its use and dissemination.

Thus, while the projections of employment are based on best practice, both the historic patterns of employment and the forecast projections have inbuilt uncertainties of differing kinds. These uncertainties need to be considered when utilising the data. Forecasts of this kind should not be regarded as suitable for detailed manpower planning. Rather they should be considered to be benchmarks for consideration of likely future trends.[30] Above and beyond this general caution, it is useful to provide users with some additional guidelines to interpreting and utilising the historic and forecast data.

The next sub-section outlines the issues involved in developing such guidelines, and suggests some 'rules of thumb' for publication and for unpublished data analysis. There are two main issues to consider when developing a set of guidelines to interpreting and using the data:

- statistical precision and robustness;
- confidentiality.

The first issue is discussed in Section 13 and the second discussed in Section 14.

12.3. Problems and issues in developing guidelines

First, it should be emphasised that any recommended guidelines can only ever be 'rules of thumb', rather than based on precise statistical analysis. Given the nature of the data, which have been constructed from a variety of different sources, it is not possible to attach precise margins of error to the historic estimates. For example, while the full-time/part-time status information comes from the ABI, the SE numbers are derived from the LFS. The latter is a considerably smaller database and thus has larger margins of error. Moreover, given the complexity of the forecasting model, and the subsequent RAS-based disaggregation methodologies, it is not possible to generate 'forecast errors' such as those that would be available from a single equation forecasting methodology. However, some general 'rules of thumb' can be recommended for using the data. These are based on the statistical rules adopted by ONS when publishing employment estimates.

ONS recommend using minimum cell sizes of 10,000 (grossed up), when presenting data based on the LFS. This is based on standard statistical theory and reflects the size and structure of the LFS sample. This is therefore a sensible 'rule of thumb' to adopt when publishing estimates which are based on such data. Given that there are 25 SOC Sub-Major group occupations to be distinguished in each sector, this suggests a minimum

[30] As an example, if a proportion is forecast to change from, say, 47% to 53% over the course of the next decade, this should be interpreted as saying that the proportion will remain around one half (and possibly rise), rather than concluding that it is going to increase by precisely 6 % points.

size for an industry of approximately 250,000. The sectors chosen as the basis for reporting in the Main Report generally all meet this criterion. In some cases the data reported in the Workbooks fall below this threshold. They are included in the absence of any better estimates.

The full Database provides estimates of employment at a much greater level of detail than this criterion would permit. These have been constructed by using the information that ONS are prepared to publish, including the raw ABI data and subsequent official estimates (which are subject to frequent revision). Such estimates can provide useful information and intelligence to users about detailed employment levels and trends. However, some caution is required when using such data and there are strict limitations on what can be published by the user due to concerns about confidentiality.

The Working Futures employment estimates reflect the latest BRES, ABI and related revisions. ONS publish revised aggregate time series data on an SIC2007 basis and these have also been incorporated into the estimation procedures. The time series data currently made available by ONS for Great Britain are adequate to provide most, but not quite all, of the detailed industry categories (see the discussion in Section 13 below).

At a regional level, the problems are more acute. ONS are not prepared to release data at such a detailed industrial level when cross-classified by region. Apart from construction, the categories normally separated out by ONS all form part of the service sector. Only broad aggregates are made available for the other sectors.

These problems are even more severe at a local level. For LEP areas, a number of the more detailed (75) industries would fall well **short** of the 10,000 criterion (again, see the discussion in Section 13 for further details). Even at a devolved country/regional level, a number of the detailed industries are problematic. In many cases, this is because there simply is no employment in that category. In others the numbers are too small to satisfy ONS's concerns about confidentiality. In particular, many of the detailed industry categories would fall foul of the terms of Statistics of Trade Act at an LEP level, even if the estimates were statistically robust.

The above discussion highlights that there are real problems in developing reliable data at the levels of detail that analysts and policy makers would ideally like to have access to.[31] One response to this would be to limit the amount of detail at which the projections work is undertaken. This would be very restrictive and would severely limit the level of detail that could be made available to those with an interest in such information, both within sectors and at an LEP level. Instead, a less restrictive approach has been adopted here. When generating the projections, full details have been maintained, while

[31] Note also that this discussion refers to total employment, across all occupations. Adding an occupational dimension exacerbates the problem enormously.

maintaining a strict control on the release of such data into the public domain to prevent misuse.

A clear distinction needs to be made between statistical reliability and the provision of useful labour market information (LMI) at a detailed level. If strict rules regarding statistical robustness are applied to decide what level of sectoral and occupational disaggregation can be provided at the LEP level, it would not be possible to provide much detailed data at all. The official surveys carried out by ONS (with a few exceptions) are not designed to provide statistically robust estimates at this level of detail. Following such rules would restrict what might be reported to very broad aggregates, which are not very helpful to most users. However, in providing such detailed information it is important that users are aware of its limitations (as well as avoiding any problems arising over confidentiality). Nevertheless, it is arguable that this is more useful than suppressing the detail.

The reliability of both the historical and forecast data will fall with greater sectoral and spatial disaggregation. Accordingly, it is helpful to provide guidelines about at what level of aggregation public access should be made available and what restrictions need to be placed upon the use of the data and the further dissemination of information based on this material. These considerations need not inhibit the presentation of the most detailed information, complete with the appropriate caveats, to groups of users within LEP areas, for example. However, such users need to be made aware of the limitations of these data and of the legal constraints on their use.

In order to stay within the terms of the Statistics of Trade Act, in previous rounds of Working Futures limits were imposed on how far to go in placing the most detailed data into the public domain. For published documents and information generally available on public websites, the 22 industries defined in the Main Report set the limits at a UK level. This is broadly consistent with the limits set by ONS for the LFS, given the requirement to report on occupational detail within industry. At regional level, a more limited number of sectors was regarded as appropriate. Any data to be published at an LEP level needs (in principle) to be even more aggregated. In developing the current guidelines, three possibilities were explored:

- The first was to adopt a common set of categories across all geographies that ensure that all the data provided were both statistically robust and did not fall foul of the confidentiality constraints, regardless of the level of spatial detail. This would ensure that comparable data are available for all areas. However, it would have implied quite draconian criteria in order to ensure that the smallest areas meet the constraints, especially when breakdowns by gender, employment status and occupation are included.
- The second alternative was to try to develop a general set of rules regarding dis-aggregation based on individual cases. This would allow for more detail in some local areas than in others but would make comparison across areas more

problematic. However, it would be incredibly time-consuming to develop such a piecemeal scheme and for this reason it was not adopted.

- The third possibility was to allow users to access different levels of sectoral and other detail, depending upon the geographical area covered and the size of employment in the cells concerned. Using the rules adopted by ONS for publication of LFS and other data as a guide, rules of thumb have been developed to guide users as to what is publishable and what is not.

The basic rule adopted is that individual cells to be reported should not contain fewer than 10,000 people. In most cases, the broader categories adopted in the Main Report meets this criterion (as long as the data are not cross-classified by another major dimension such as occupation). For example, the 22-fold industry breakdown used in the published reports is generally feasible for most of the regions and countries of the UK, if occupation is not also used. However, including occupation as well poses serious risks of problems of statistical imprecision.

Thus for data to be published, it is recommended that a general rule of a minimum of 10,000 individuals per cell be adopted. While the ABI would technically permit a smaller minimum for the historic series on industrial employment estimates, the projections also use LFS data to supply self-employed statistics as well as breaks by occupation. There is also the issue of forecast errors in any analysis involving projections for the future. Using a single criterion provides a simpler rule than adopting different criteria according to whether historic or future projections are being analysed. However, this is a general guideline and, occasionally, it may be breached for some cross-classifications of the data.

For any unpublished analyses of the projections, then a more lenient criterion can be adopted. While essentially arbitrary (given that it is not possible to assign precise forecast errors), a sensible absolute minimum cut-off could be 1,000 individuals. Figures are rounded within the Main Report to the nearest 1,000, and thus it would be inappropriate to consider levels or changes which are less than this. However, some degree of decision making on the part of the user still needs to be made, since, for disaggregated sectors, a change of 1,000 may be, proportionately, very large, albeit not robust.

For cases in between 1,000 and 10,000, it is difficult to prescribe general rules, and an element of judgement is required of the user. At an industry level, and focusing just on employees, the limits set by ONS in publishing ABI data can be used as a general guide. If ONS do not regard estimates as publishable then the equivalent figures **should not be published**. Where the focus is on self-employment or upon occupations an even more stringent cut off should be applied, since these are based on LFS data.

Summary of guidelines

- **PUBLISHED DATA: Ideally, a minimum of 10,000 individuals per cell**
- **UNPUBLISHED DATA: An absolute minimum of 1,000 individuals per cell**

12.4. Confidentiality

There are a number of important issues regarding the release of very detailed information on employment into the public domain, which need to be carefully considered in the context of this project. It is essential to recognise that, because of confidentiality problems, there are **legal restrictions**, which limit the extent to which official data collected under the terms of the **Statistics of Trade Act, 1947** (and its successors) can be published. The Act prohibits publicly collected data being disseminated in such a manner as to enable the identification of individual enterprises or individuals.

The present set of estimates is based on data which ONS have placed into the public domain in various places. The requirements for very detailed analysis of skill demand by sector and spatial area have resulted in the development of a very detailed Database, which has been made available to users under strict conditions.

13. Statistical robustness

13.1. Background

The discussion in Sections 10 and 11 highlighted the problems raised by trying to develop an employment **Database** with so many dimensions, given the current data available from official sources. The main problems relate to:

- statistical precision and robustness; and to
- confidentiality.

The first issue is addressed here, the second in the following section.

13.2. Statistical robustness

Although it has been possible to develop a very detailed employment **Database**, covering all the various dimensions of interest to the Department and its partners, it is important to recognise that this has its limitations. Given the various dimensions required (sector, gender, employment status, occupation and local area), the full **Database** comprises huge numbers of time series.[32] Such detailed breakdowns can only ever be indicative, since they are based on survey estimates that were not designed to produce precise estimates at this level of detail.

The rules ONS adopt when publishing employment estimates are briefly summarised below. These can be used as guidelines in assessing the robustness and precision of the data in the **Database**.

It is important to recognise that, without enormous resources, it is not possible to monitor and quality assure every one of these series. CE/IER have checked to ensure that the basic trends and structural features of the data are sound but it is impossible to check and validate every series, especially at local level. The detailed projections are therefore provided on a caveat emptor basis. The aim is to provide a useful benchmark for consideration rather than a fully thought out, local level forecast for particular LEP areas.

Given the nature of the **Database**, which has been constructed from a variety of different sources, it is not possible to attach precise margins of error to the estimates. In order to help users in deciding what weight to attach to the various estimates, some general

[32] For *Working Futures 2004-2014* there were over half a million (that is: Sector (67) * occupation (25) *geographical area (47 local areas plus Scotland, Wales and Northern Ireland) * gender/status (6) = 512,550 separate time series). For *Working Futures 2017-2027* the main projections cover 135,000 series but this excludes qualifications, and the extension to 4-digit occupations as well as the sub-regional analysis.

"rules of thumb" have been developed. These are based loosely on the statistical rules adopted by ONS when publishing employment estimates.

As noted in Section 12, ONS recommend using minimum cell sizes of 10,000 (grossed up), when presenting data based on the LFS. This is relevant for the **Database,** since the occupation estimates and self-employed numbers are based primarily on this source. Given that there are 25 occupations to be distinguished in each sector, this suggests a minimum size for an industry of approximately 250,000 if occupational data are to be published.

These rules have been used to decide on the levels of detail, which should be published and in indicating the reliability of the more detailed data.

13.3. ONS practice on release of employment data

ONS do not publish consistent time series information on employment cross-classified by region (let alone by sub-area) at a very detailed industry level. Detailed information on self-employment is regarded as even less reliable, being based on the LFS, the sample size of which is inadequate to provide the kind of detail required here. Because of differences in the way data are collected for Northern Ireland, information for the whole of the UK is not available on a consistent basis.

Nevertheless, it is possible to generate **estimates** at this level of detail, which are informative, and of use to labour market analysts. These can be constructed by using the information ONS **are** prepared to publish, including the raw BRES/ABI data (which have been subject to frequent revision).[33] This involves various procedures of interpolation and adjustment to fill in gaps and to ensure consistency with published headline figures. Such procedures lie at the heart of CE's LEFM service, which has been supplying such detailed data to various organisations for many years. While not strictly precise in a statistical sense, such estimates can provide useful information and intelligence to users about detailed employment trends. However, the use of such data needs to be handled with care and, as noted above, there are strict limitations on what can be published due to concerns about confidentiality. The latter are discussed in more detail in the next section.

The employment estimates incorporate the quarterly Workforce Jobs and annual BRES. These data are also used to constrain the **Database.** The time series data currently made available by ONS for the UK are adequate to provide all of the 75 categories required.

At a regional level, the problems are more acute. ONS are not prepared to release data (the quarterly Workforce Jobs series) at anywhere near so detailed a sectoral level, when cross-classified by region. Apart from construction, the categories normally separated

[33] The levels of detail which ONS typically provide for public dissemination are summarised in Section 14.

out by ONS all form part of the service sector (see Table 6.3). Only broad aggregates are made available for the other sectors. To provide the necessary sectoral detail, annual BRES data at 2-digit SIC07 is used and then scaled to the workforce jobs series.

These problems are much more severe at a local level. For the sub-areas published in Working Futures (LEPs, etc), the position is that a very large number of the detailed sectors are problematic. Even at a regional and national level a number of industries are problematic. In many cases this is because there simply is no employment in that category. In others the numbers are too small to satisfy ONS's concerns about confidentiality. Many of the detailed categories would fall foul of the terms of Statistics of Trade Act at an LEP level.

This discussion highlights that there are real problems in developing reliable data at the levels of detail that analysts and policy makers would ideally like.[34] One response to this would be to limit the amount of detail at which the projections work is undertaken, so as to avoid these types of concern. This would be very restrictive and would severely limit the level of detail that could be made available to those with an interest in such information, both within sectors and at sub-area level. Instead, a less restrictive line has been adopted here. When generating the projections, full details have been maintained, while maintaining a strict control on the release of such data into the public domain to prevent misuse. Details of what is available are given in Sections 10 and 12.

When considering this question a distinction needs to be made between statistical reliability and the provision of useful LMI at a detailed level. If strict rules regarding statistical robustness are applied to decide what level of sectoral and occupational disaggregation can be provided at sub-area level, it would not be possible to provide much detailed data at all. The official surveys carried out by ONS are (with a few exceptions) not designed to provide statistically robust estimates at this level of detail. Following such rules would restrict what might be reported to very broad aggregates, which are not very helpful to those on the ground.

IER/CE have addressed this issue for a number of years in providing results based on their LEFM methodology. This is based on the notion of providing "benchmark" estimates and projections, using the most detailed data where they are available for the local level, in combination with broader national and regional trends where they are not. While not subject to the normal tests of statistical precision, such estimates can provide useful and informative LMI for those operating at the local level. Other consultants have adopted similar solutions.

In providing such information it is important that users are aware of its limitations (as well as avoiding any problems of confidentiality). Nevertheless, IER/CE would argue that this is more useful than suppressing the detail at an early stage. This solution requires that

[34] Note also that this is total employment, across all occupations. Adding an occupational dimension exacerbates the problem enormously.

such detailed information is only made available to a restricted audience. It is therefore necessary to restrict access to the more detailed results.

Presenting detailed historical and projected data in a 'free access' public website or other media also raise other important issues apart from the confidentiality ones. The reliability of historical and projected data will inevitably fall with greater sectoral and spatial disaggregation, and will certainly be less reliable in levels terms for output data than for employment data. Accordingly it has been necessary to agree precisely at what level of aggregation public access should be made available and what restrictions need to be placed upon its use and dissemination. These considerations need not inhibit the presentation of the most detailed information, complete with the appropriate caveats, to groups of users within sub-areas.

13.4. Rules adopted for publication and release of detailed data

As noted in Section 14, in order to stay within the spirit of the Statistics of Trade Act, limits should be imposed on how far to go in placing the most detailed data into the public domain. As far as published documents and what is generally available on public websites are concerned, the 75 industries as they are defined in the Main Report set the limits at a UK level. At a sub-regional level a more limited number of sectors may be appropriate, the 22 industries have also been used here with a caveat emptor warning to users. In practice how far one can go will vary considerably from one case to another. The information made available on public websites is limited to those provided in the published reports and related workbooks.

As far as making data available at LEP area and for more detailed sectors is concerned, users can gain access to the fullest level of detail available via the Department for Education. Access is limited to those agreeing to the terms and conditions of use applied by the Department for Education. Such users need to be aware of the limitations of these data and of the legal constraints on their use.

13.5. Rules of thumb to be used when using the data

Using the rules adopted by ONS for publication of LFS and other data as a guide, rules of thumb have been developed to guide users as to what level of detail for employment is publishable and what is not. The basic rule adopted is that individual cells should not contain fewer than 1,000 people. Indeed for most purposes a much larger cell size is needed to be reasonably confident about the estimate. As noted above, a cell size of 10,000 is ideally required. Anything between 1,000 and 10,000 should be regarded as subject to a large and uncertain margin of error. The point estimates provided in the database are the best the authors can provide, based on the data available.

In most cases, the broader categories adopted in the Main Report meet this criterion (as long as the data are not cross-classified by another major dimension (e.g. occupation)). For example, the 22-fold industry division breakdown used in the published reports is certainly feasible for most of the regions and countries of the UK, if occupation or aspects of employment status such as self-employment are ignored. However, including occupation or status as well poses serious risks of problems of statistical imprecision.

It is important to note that the greater the sectoral, occupational and spatial disaggregation the more sensitive the results will be, as some sectors are very small and at the same time exhibit large variation over time.

Changes, which are based on two levels, each of which may be subject to different errors, are even more problematic. Too much should not therefore be read into slight difference or changes between two categories.

Forecast data will also bear a further margin of uncertainty associated with forecast error. Projected numbers will therefore be subject to wider error margins than the historical estimates.

13.6. Margins of error

The employment estimates make use of a wide variety of sources, as described in more detail in Section 10. As a consequence, it is not possible to calculate precise margins of error. From an analysis of previous projections it is clear that these margins can be quite large. The results of this analysis are indicative:

Industry employment levels (at the 22 industry level) are typically projected within ±10 per cent over a 5-10 year horizon. The directions of change are projected correctly in around 90 per cent of cases. The errors in terms of annual percentage growth rates are usually of the same order of magnitude as the observed changes.

Occupational employment levels (at the 2r sub-major group level) are typically projected with ±7 per cent over a 5-10 year horizon. The direction of change is correctly projected in about 80 per cent of all cases. Occupational shares are usually projected within ±2 % points. (The typical share is around 4 percentage points).

Historical revisions to the data account for a very large part of the forecast errors. It is important to appreciate that the purpose of the projections is not to make precise forecasts of employment **levels**. Rather, the aim is to provide policy analysts with useful information about the general nature of **changing employment patterns** and their implications for skill requirements.

The results provide a useful benchmark for debate and policy deliberations about underlying employment trends. However, they should not be regarded as more precise than the general statements in the text. Many years of international research have

demonstrated that detailed manpower planning is not a practicable proposition. The results presented here should be regarded as indicative of general trends and orders of magnitude, given the assumptions set out in detail in this Technical Report and in the Main Report, rather than precise forecasts of what will necessarily happen.[35]

Changing patterns of employment by sector and occupation (as represented by shares of total employment) are largely dominated by longer-term trends rather than the cyclical position of the economy. The results from the current set of projections can therefore be used as a robust guide to likely future developments in the structure of employment, even though the effect of the slowdown and subsequent recovery on employment **levels** may remain somewhat uncertain. The current Working Futures results present a plausible picture of future developments over the coming decade.

[35] For further discussion see: Briscoe, G., and R. A. Wilson, (2003). 'Modelling UK Occupational Employment'. *International Journal of Manpower.* 24(5), pp. 568-589.

14. General caveats on the employment estimates

14.1. Statistical matters

Some general caveats on the employment estimates are in order. When using data based on raw LFS data ONS recommend using minimum cell sizes of 10,000 (grossed up), in presenting employment estimates. Given that there are 25 occupations to be distinguished in each industry, this suggests a minimum size at UK level of at least 250,000. In a few cases the data reported below fall below this threshold. This is a particular problem in the Primary sector and utilities group. The results for individual occupations or other categories within these industries therefore fall well below the 10,000 guideline figure. They are included here in the absence of any better estimates. For further discussion on these issues see the more detailed discussion above, especially Sections 10-14.

This highlights that there are real problems in developing reliable data at the levels of detail that analysts and policy makers would ideally like to have access to. One response to this would be to limit the amount of detail at which the projections work is undertaken. This would be very restrictive and would severely limit the level of detail that could be made. Instead, a less restrictive approach has been adopted. When generating the projections, full details have been maintained, while maintaining a strict control on the release of such data into the public domain to prevent misuse.

A clear distinction needs to be made between statistical reliability and the provision of useful labour market information at a detailed level. If strict rules regarding statistical robustness are applied to decide what level of sectoral and occupational disaggregation can be provided, it would not be possible to provide much detailed data at all. The official surveys carried out by ONS are not designed to provide statistically robust estimates at the level of detail required in Working Futures, across all dimensions simultaneously. Following the ONS rules as described above would restrict what might be reported to very broad aggregates, which are not very helpful to most users. However, in providing such detailed information it is important that users are aware of its limitations (as well as avoiding any problems arising over confidentiality). This is more useful than suppressing the detail.

14.2. Comparison with official estimates

The estimates are all based on published official data on employment but they have been adjusted to produce a consistent set of estimates across all the dimensions of interest (sector, occupation, qualification, gender, status (full-time and part-time employee or self-employed) and region.

Where there are inconsistencies between official sources, the industrial information is given precedence. All the employment data are constrained to match headline figures published by ONS in the UK and regional labour market statistics bulletins and similar publications. This is achieved using so called RAS iterative methods, as described in the Working Futures Technical Report. Where no official data are published, estimates are generated by assuming common patterns to the next level of aggregation up at which official estimates are available. Occupational estimates, information on qualifications and self-employment estimates are based primarily on information from the LFS.

The sectoral and spatial level data are consistent with ONS estimates available at the time the analysis was conducted (the summer of 2018). Information on occupations and qualifications is based on LFS data available at the same time. The latter are constrained to match the sectoral data, using the RAS process described above. One important point to note here is that the Working Futures estimates refer to June and the data for all areas are made consistent with the level above. The data for regions are consistent with the GB data but also with the ONS released data for the regions for aggregate sectors. All scaling is done by type. Local area data are scaled to the regional data which are for June, not for September.

As a result the Working Futures numbers may no longer match the original information, although the general patterns are fully consistent. The numbers by sector, region, occupation and qualification may differ from the latest ONS published estimates for a number of reasons:

- revisions and changes made by ONS since the analysis was conducted;
- inconsistencies in the various official estimates from different sources;
- differences in classification – the published Working Futures database is entirely on SIC2007 and SOC2010;
- differences in timing (mid-year (June) as opposed to other periods);
- modifications introduced as a result of the RAS process (this affects only the occupational and qualification patterns).

The estimates from the Working Futures database provide a complete and consistent picture across all dimensions of employment that is not available from any other source.

15. Skill supply and demand projections

15.1. Conceptual issues

There are many conceptual difficulties in modelling labour supply by level of skill (as measured by qualifications held). Most occupations are undertaken by people with a bewildering range of formal qualifications. This is partly a function of age, with older workers generally relying more upon experience than formal qualifications. 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, focusing on the flows of people through the education and training system, but boundaries are too blurred and transitory to enable quantitative modelling. Much the same is true for the concept of supply of labour to a sector.

For these reasons, the development of supply estimates and projections by occupation and/or sector are not regarded as a practicable proposition. As in previous Working Futures exercises, the approach adopted is to focus on general projections of population and overall labour supply (those economically active) by gender for each geographical area, and to then disaggregated these by the highest levels of qualification held using stock-flow modelling and other techniques.

The project updates the previous projections using the methodologies developed in previous Working Futures exercises. The first step was to produce projections of economic activity rates, labour supply and unemployment, for each of the countries and English regions within the UK. The projections provided focus upon total labour supply by gender and broad age group. These reflect the move to 16-64 as the new official working age definition. The methodology is described in detail in Section 5 above.

15.2. Labour supply by age and gender

Labour supply projections are developed for the various geographical areas and include:

- total population;
- population aged 16 and over;
- working age population;
- labour force;
- workforce;
- ILO unemployment;
- claimant unemployment;
- employed residents;

- workplace employment;
- labour market residual.

A set of stochastic behavioural equations to forecast economic activity rates by age-band/gender is incorporated into MDM-E3. These include a number of explanatory variables including unemployment. The remainder of the model required to construct the projections of overall labour supply indicators consists of a number of accounting equations to derive labour supply and unemployment from the existing labour market and demographic projections in MDM-E3.

The key stages to determine the labour supply indicators can be summarised as follows:

- UK activity rates (by age-band/gender) are modelled as a function of unemployment and lagged activity rates
- regional activity rates are projected forward using the growth in the equivalent UK age-band/gender group;
- the regional labour force is determined by activity rates multiplied by the population (by age-band/gender) - this is then scaled to UK labour force and the final regional activity rates are calculated;
- workplace based employment jobs is determined using the existing MDM-E3 equations (see Section 4);
- the LFS measure of employment (employed residents) is determined from workforce employment minus a labour market residual (note that one element of the residual is net commuting);
- some adjustments to the labour market residual are made in the projections to account for trend changes;
- regional LFS employment is taken away from regional labour force to determine regional unemployment (ILO).

The difference between the LFS measure and the workforce measure of employment is accounted for in the labour market residual. This includes net commuting which results from people travelling from their place of residence, across regional boundaries to their place of work.

The analysis described above provides projections of labour supply, for each of the countries and regions of the UK, by gender. The modelling work is undertaken by detailed age-band[36] so also delivers projections disaggregated by age-band.

[36] The age-bands distinguished are 0-15, 16-24, 25-34, 35-44, 45-59, 60-64, 65+.

15.3. Labour supply by highest qualification held

With regard to qualifications held by the workforce, IER has built up considerable experience of working with the qualification data available in the LFS, including work for Dearing, Leitch and the UK Commission for Employment and Skills (UKCES). While a number of different approaches can be adopted to modelling qualifications, the present approach is intentionally pragmatic and eclectic, making the most of the limited data available. This section provides a brief overview, building upon the work for Working Futures 2014-2024. For more details readers are referred to the separate Qualification Technical Report (Bosworth, 2015a[37]), which describe the detailed models and methods used to develop the estimates of the demand for and supply of skills (as measured by qualifications).[38] The main difference from the previous round is that the National Model results are now based on the times series alternative developed previously rather than the stock-flow model.

The results are internally consistent at the different levels of aggregation, and the modelling of the supply side, in particular, is complementary to the qualifications modelling previously carried out by the UKCES. It builds on the models developed for Working Futures 2014-2024, focusing upon both demand and supply. The present exercise focuses on the highest level of qualification held, as defined in previous work undertaken for the UKCES. The "supply of qualifications" focuses on the future flows of individuals in the population with different qualification levels (based upon the Regulated Qualifications Framework (RQF) which superseded the Qualifications and Credit Framework (QCF))[39].

A number of the eight main levels of the RQF have relatively small numbers of individuals, which makes some of the cell sizes very small when disaggregated by gender and year of age, let alone by other dimensions in the projections. So, for the main part of the qualifications modelling, qualification levels are aggregated such that in the present work: no qualification comprises entry level and no qualifications from the RQF; level 1 contains low level GCSE (grade 3 and under) and equivalent; level 2 contains high grade GCSE (grade 4 and higher); level 3 comprises A level and equivalent; level 4 is degree undergraduate level; and level 5 is postgraduate degree level.

An important distinction between the qualification results presented here and those developed for the UKCES as part of its annual assessment of employment and skills (e.g. Ambition 2020: the 2010 Report) is that the present work also considers the

[37] Bosworth, D. (2015a). *UK Qualifications Projections – Time Series Model: Technical Report, 2015.* Institute for Employment Research, University of Warwick: Coventry.
[38] These build upon earlier work as described in Bosworth and Wilson (2012).
[39] QCF was developed in parallel with the National Qualifications Framework (NQF) and withdrawn in 2015, for details see: https://www.gov.uk/government/consultations/withdrawing-qcf-regulatory-arrangements. For information on Regulations Qualifications Framework see: https://www.gov.uk/government/publications/regulated-qualifications-framework-a-postcard.

"demand side". This generates estimates and projections of population and active population rates by level of qualification, as well as the distribution of employment by sector, occupation and region.

This distinction between supply and demand is somewhat artificial, as the observed outcomes are the result of a combination of both demand and supply influences. The flow of individuals through qualification levels depends upon perceptions of current and future employment opportunities and wage rates. Likewise, employment by qualification is the outcome of the interaction between supply and demand.

In a previous round (Working Futures 2012-2022), comparisons were made between the results of this analysis and those based on the **National model** – a time series extrapolative approach (similar to models developed in earlier work by the authors for the Treasury (as part of the Leitch Review) and for the UKCES – and a pseudo-cohort, stock-flow model. On balance the **National model** was preferred as giving more robust results. The stock-flow model although conceptually superior, appears to underestimate the possibilities for qualification acquisition for older people. The **National** (time series) model is the one used to generate the Working Futures results. For more details of the two forms of model see Bosworth and Wilson (2011a, 2011b)[40].

The qualification data for migrants remain extremely weak despite the introduction of a separate question in the LFS about immigrant qualifications in 2011 (revised in 2014). The **National model** assumes, as a base line, the reported qualifications of individuals who were not resident in the UK one year prior to the survey. Nothing is known about the qualifications of emigrants, so the qualification mix of emigrants are assumed to be the same as the UK population as a whole. While the migration data are weak, sensitivity tests in previous rounds of Working Futures suggest that the overall projections are not particularly sensitive to changes in the migration assumptions. Given the political sensitivity to the question of migration, this is an important issue which requires exploration in more detail. Separate results are produced for men and women, as well as all individuals combined (the latter can be useful where the cell sizes are small by gender).

Given that the data for Northern Ireland and, to a slightly lesser extent, Wales are subject to small sample size problems, results for the four nation states have been produced by disaggregation of the UK projections at broader age groups than for the UK as a whole. Further disaggregation of the results is made to regional level, for example, apportioning the results for England to the regions of residence.[41] This is done by broad age group

[40] Bosworth, D., and Wilson, R. A. (2011a). *Projections of Employment by Qualification: Technical Report*. Institute for Employment Research, University of Warwick: Coventry; Bosworth, D., and Wilson, R. A. (2011b). *Working Futures 2010-2020: Qualifications Technical Report.* UK Commission for Employment and Skills: Wath on Dearne.

[41] Note that the regional breakdown of the supply side is potentially more disaggregated than on the demand side.

(rather than individual year of age), but small sample sizes for some regions pose problems for many of these more detailed results.

A **regional qualification model,** produces equivalent regional results (including results all for the individual countries and regions within the UK). This model focuses upon the shares of the active population who are qualified to various levels. It covers the following main dimensions: country/region (12); gender (2); qualification level (6). The results are constrained to sum to the UK total from the national model.

The **demand side** results are generated through the macro model and related occupational modules, which gives benchmark information on future employment prospects by occupation. Occupation is one of the main drivers of changing patterns of employment by qualification, as different occupations tend to have very different requirements (e.g. most professional occupations require higher level qualifications as a matter of course, etc). In addition there are often significant trends in these patterns within each occupational category which can be modelled and exploited to generate projections. The aggregate employment projections are then further disaggregated by a series of sub-models.

The **occupational/qualification shares model**, (QUALSHARE) develops projections of qualification shares within occupations.

In order to reconcile the supply and demand sides, a **sorting algorithm (SORT)** then sorts people into occupations such that the various results from the different parts of the modelling exercise are made consistent. In particular, this model is designed to reconcile the projections from the **National** model with those from QUALSHARE. The former can be regarded as essentially a view of supply side developments (the overall numbers of people acquiring qualifications), while the latter is more concerned with which occupations they end up in. The SORT model uses an iterative RAS procedure to reconcile the two sets of estimates, constraining the overall qualification shares from QUALSHARE to match those from STOCKFLOW, while maintaining the patterns of occupational deployment in QUALSHARE. The constraint is imposed at the 2-digit occupational level. The key dimensions are: occupations (25); gender (2); qualification levels (6). SORT operates at a UK level.

Finally, there is an extended **replacement demand module,** which generates estimates of qualification numbers for detailed industries and geographical areas. This final module provides the mechanism whereby the implications for individual sectors and regions are developed, focusing on replacement needs. The overall results from this module are calibrated to match the main results from the benchmark projections for the UK and its constituent countries and regions which emerge from SORT and REGQUAL. Data and parameters are provided for individual sectors and regions which enable customised projections for these categories to be developed. These include aggregate qualification and age profiles for individual sectors and regions (but not cross-classified). While data limitations mean that it is not possible to ensure that these results are consistent in every

respect with those from the national results, they provide reasonably robust and consistent implications at the more detailed regional and sectoral level. The key dimensions covered are: occupations (25); gender (2); qualification levels (6); regions (25); sectors (22).

Glossary

ABI	Annual Business Enquiry
ABS	Annual Business Survey
AES	Annual Employment Survey
BRES	Business Register and Employment Survey
CE	Cambridge Econometrics
CoP	Census of Population
CVM	Chained volume measure
DfES	Department for Education and Skills
DIUS	Department for Innovation, Universities and Skills
DTI	Department of Trade and Industry
ESA95	European System of (National) Accounts, 1995
GDP	Gross Domestic Product
GDPO	Gross Domestic Product (output)
GORs	Government Office Regions
GVA	Gross Value Added
IER	Institute for Employment Research
IoP	Index of Production
LAD	Local authority district
LEC	Local Enterprise Council
LEFM	Local Economy Forecasting Model
LEP	Local Enterprise Partnership
LFS	Labour Force Survey
LLSC	Local Learning and Skills Council
LSC	Learning and Skills Council
MAFF	Ministry of Agriculture Food and Fisheries
MDM-E3	Multi-sectoral Dynamic Model
NES	New Earnings Survey

nes	not elsewhere specified
nec (n.e.c.)	not elsewhere classified
NOMIS	National On-line Manpower Information System
ONS	Office for National Statistics
OPCS	Office of Population Censuses and Surveys
QCF	Qualifications and Credit Framework (see Section 15)
RAS	Iterative procedure (see Section 11)
RQF	Regulated Qualifications Framework (see Section 15)
SIC	Standard Industrial Classification
SOC	Standard Occupational Classification
SSCs	Sector Skills Councils
SSAs	Sector Skills Agreement sectors
SSR	Standard Statistical Region
SUTS	Supply and Use Tables
TEC	Training and Enterprise Council

Bibliography

The Working Futures 2017-2027 reports and documentation are:

Wilson, R. A., S-A. Barnes, M. May-Gillings, H. Bui and S. Patel, (2019). Working Futures 2017-2027: Main report. Department for Education.

Wilson, R. A., M. May-Gillings, S. Patel and H Bui, (2019). Working Futures 2017-2027: Technical report on sources and methods. Department for Education.

Wilson, R. A., D. Owen, S-A. Barnes, M. May-Gillings, S. Patel and H. Bui, (2019). Working Futures 2017-2027: Annexes. Department for Education.

Wilson, R. A., D. Owen, D Bosworth, S-A. Barnes, M. May-Gillings and S. Patel, (2019). Working Futures 2017-2027: Headline report (presentation). Department for Education.

Wilson, R. A., D. Owen, D. Bosworth, S-A. Barnes, M. May-Gillings and S. Patel, (2019). Working Futures 2017-2027: Interim headline report. Department for Education.

Wilson, R. A., (2019). Working Futures 2017-2027: Workbook User Guide. Department for Education.

Wilson, R. A, (2019). Working Futures 2017-2027: General Guidelines for using the workbooks. Department for Education.

Wilson, R. A. and D. Bosworth (2019). Working Futures 2017-2027 - Qualifications Projections. Department for Education.

Other References:

Barker, T., and Peterson, W. (1987). (eds.) The Cambridge Multi-sectoral Dynamic Model of the British Economy. Cambridge University Press: Cambridge.

Barker, T., Fingleton, B., Homenidou, K., and Lewney, R. (2001). The Regional Cambridge Multi-sectoral Dynamic Model of the UK Economy, pp. 79-96 in G. Clarke and M Madden (eds.). Regional Science in Business, Springer-Verlag, Heidelberg.

Bosworth, D. (2013a). The Changing Qualifications Mix of the UK to 2020, 2013. Report produced on behalf of UK Commission for Employment and Skills: Wath on Dearne.

Bosworth, D. (2013b). UK Qualifications Projections – Time Series Model: Technical Report, 2013. Report produced on behalf of UK Commission for Employment and Skills: Wath on Dearne.

Bosworth, D. (2013c). Regional Qualifications Projections – Apportionment Model: Technical Report, 2013, 2013. Report produced on behalf of UK Commission for Employment and Skills: Wath on Dearne.

Bosworth, D. (2015a). UK Qualifications Projections – Time Series Model: Technical Report, 2015. Institute for Employment Research, University of Warwick: Coventry.

Bosworth, D. (2015b). Four Nations Qualifications Projections – Apportionment Model: Technical Report, 2015. Institute for Employment Research, University of Warwick: Coventry.

Bosworth, D. (2015c). Regional Qualifications Projections – Apportionment Model: Technical Report, 2015. Institute for Employment Research, University of Warwick: Coventry.

Bosworth, D., and Wilson, R. A. (2011a). Projections of Employment by Qualification: Technical Report. Institute for Employment Research, University of Warwick: Coventry.

Bosworth, D., and Wilson, R. A. (2011b). Working Futures 2010-2020: Qualifications Technical Report. UK Commission for Employment and Skills: Wath on Dearne.

Briscoe, G., and R. A. Wilson, (2003). 'Modelling UK Occupational Employment'. International Journal of Manpower. 24(5), pp. 568-589.

Briscoe, G., and Wilson, R. A. (1991). Explanations of the Demand for Labour in the United Kingdom Engineering Sector. Applied Economics 23, pp.913-26.

Green, A., Homenidou, K., and Wilson, R. A. (2004). Working Futures: New Projections of Occupational Employment by Sector and Region, Volume 2, Regional Report. SSDA, DfES Publications: Nottingham.

Green, A., Homenidou, K., White, R., and Wilson, R. A. (2006). Working Futures 2004-2014: Spatial Report. Sector Skills Development Agency: Wath on Dearne.

Lahr, M. L., and De Mesnard, L. (2004). Biproportional Techniques in Input–Output Analysis: Table Updating and Structural Analysis. Economic Systems Research, 16(2), pp.115-134.

McMenamin, D.G., and Haring, J. E. (1974). An Appraisal of Nonsurvey Techniques for Estimating Regional Input-Output Models. Journal of Regional Science, 14(2), pp. 191-205.

Miller, R., and Blair, P. (2009). Input–Output Analysis. Foundations and Extensions, Second Edition, Cambridge University Press: Cambridge.

Toha, M-H. (1998). The RAS Approach in Updating Input–Output Matrices: An Instrumental Variable Interpretation and Analysis of Structural Change. Economic Systems Research, 10(1), pp. 63-78.

Wilson R. A. (ed.) (2000). Projections of Occupations and Qualifications, 1999/2000. Department for Education and Employment/University of Warwick, Institute for Employment Research, Coventry.

Wilson, R, A. (1999). EMTA Quantitative Forecasting Model: Detailed specification. Institute for Employment Research, University of Warwick: Coventry

Wilson, R, A. (1994). ‘Modelling and Forecasting the Structure of Employment in the United Kingdom’, in H. Heijke (ed.) Labour Market Forecasts by Occupation and Education. Massachusetts: Kluwer Academic, pp.9-35.

Wilson, R. A, (2014). Working Futures 2012-2022: General Guidelines for using the Workbooks. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A. (2001) Forecasting Skill requirements at National and company Levels, in P. Descy and M. Tessaring (eds.) Training in Europe (2nd report on Vocational Training Research in Europe 2000: Background Report, Volume 2) CEDEFOP Reference Series, Luxembourg, Office for Official Publications of the European Communities, pp.561-609.

Wilson, R. A. (2011). Working Futures 2010-2020: General Guidelines for using the Workbooks. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A. (ed.) (2001a). Projections of Occupations and Qualifications, 2000/2001. Department for Education and Employment/University of Warwick, Institute for Employment Research, Coventry.

Wilson, R. A. (ed.) (2001b). Projections of Occupations and Qualifications, 2000/2001: Regional Results. Department for Education and Employment/University of Warwick, Institute for Employment Research, Coventry.

Wilson, R. A., and Bosworth, D. (2006a). Working Futures 2004-2014: Qualifications Report. Sector Skills Development Agency: Wath on Dearne.

Wilson, R. A., and Bosworth, D. (2006b). Working Futures 2004-2014: Qualifications Technical Report. Sector Skills Development Agency: Wath on Dearne.

Wilson, R. A., and Dickerson, A. (2008). Working Futures 2007-2017: User Guide. Learning and Skills Council, National Office: Coventry.

Wilson, R. A., and Homenidou, K. (2011a). Technical Report on Development of Projections for the Local Enterprise Partnerships. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A., and Homenidou, K. (2011b). Working Futures 2010-2020: Technical Report. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A., and Homenidou, K. (2011c). Working Futures 2010-2020: Main Report. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A., Beaven, R., and May-Gillings, M. (2014a). Working Futures 2012-2022: Main Report. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A., Beaven, R., and May-Gillings, M. (2014b). Working Futures 2012-2022: Technical Report. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A., Beaven, R., May-Gillings, M., Perkins, S., Lee, M., and Sofroniou, N. (2016). Working Futures 2012-2022: Main Report. UK Commission for Employment and Skills: Wath on Dearne.

Wilson, R. A., Homenidou, K. and Dickerson, A. (2006). Working Futures 2004-2014: National Report. Sector Skills Development Agency: Wath on Dearne.

Wilson, R. A., Homenidou, K., and Dickerson, A. (2004a). Working Futures: New Projections of Occupational Employment by Sector and Region, 2002-2012., Volume,1 National Report. Sector Skills Development Agency/DfES Publications: Nottingham.

Wilson, R. A., Woolard, I., and Lee, D. (2004c). Developing a National Skills Forecasting Tool for South Africa, South African Department of Labour: Pretoria.

Wilson, R. A., Homenidou, K., and Dickerson, A. (2004b). Working Futures: New Projections of Occupational Employment by Sector and Region, 2002-2012. Technical Report on Sources and Methods. Sector Skills Development Agency/DfES Publications: Nottingham.

Wilson, R. A., Homenidou, K., and Gambin, L. (2008). Working Futures 2007-2017: Main Report. Learning and Skills Council, National Office: Coventry.

Wilson, R.A., May-Gillings, M., Pirie, J., and Beaven, R. (2016). Working Futures 2014-2024: Technical Report. UK Commission for Employment and Skills: Wath on Dearne.

Department for Education

Other outputs available from Working Futures include:

Working Futures 2017-2027 Main report and associated technical reports. Full details on sources and methods are to be found in the technical report.

The full length evidence report and associated Annexes contain:

- More detailed results for both sectors and occupations in the UK;
- Results for the various devolved administrations with the UK and the English regions;
- Comparisons with previous projections;
- Methodological details relating to the projections, including the macroeconomic model, methods used to derive implications for the demand for and supply of skills and the spatial analysis.
- Excel workbooks containing analysis for the UK, nations and English regions (to be published in due course).

For further details and to access the Working Futures 2017-2027 reports see www.gov.uk/government/publications and for previous Working Futures reports see warwick.ac.uk/fac/soc/ier/research/wf/.

Reference: DFE-RR970

ISBN: 978-1-83870-092-8

The views expressed in this report are the authors' and do not necessarily reflect those of the Department for Education.

For any enquiries regarding this publication, contact us at: www.education.gov.uk/contactus

This document is available for download at www.gov.uk/government/publications