Working Futures
2010-2020

**Technical Report
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Working Futures 2010-2020:

TECHNICAL REPORT ON SOURCES AND METHODS

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Preface and Acknowledgements

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The projections have been developed at a time of considerable uncertainty about prospects for the economy and the labour market. They should be regarded as indicative of likely developments given a gradual recovery from recession and re-establishment of longer term trends, rather than precise forecasts of what will inevitably happen. Many of these trends are very robust and are not likely to be affected by even the very turbulent conditions currently being experienced. They assume a broad continuation of past patterns of behaviour and performance. The dramatic events in financial markets in the autumn of 2008 had a significant impact on many trends in the short term, although others appear to have continued relatively undisturbed. The continuing uncertainties associated with the sovereign debt crises in Europe continue to cloud the picture. The report analyses changes pre and post these crises. It presents a view of medium to longer term trends (5-10 years ahead), reflecting the likely path of recovery from recession and a gradual reversion towards longer-term trends. These issues are elaborated in more detail in the main body of the report. The results should be regarded as a robust benchmark for debate and used in conjunction with a variety of other sources of Labour Market Information. The opinions expressed in this report are those of the authors and do not necessarily reflect the views of the UK Commission.

Contents

List of Tables   Page

List of Figures   Page

1 Introduction

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 2010-2020.*[1] These projections have been prepared by the Institute for Employment Research (IER) and Cambridge Econometrics (CE) on behalf of the UK Commission for Employment and Skills (UKCES). They update those produced in 2008.[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 other projections.

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

- The *Working Futures 2010-2020* 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.

- The **Sectoral Report** which discusses the projections for 22 aggregated industries for the whole of the UK. These industries are defined using Standard Industrial Classification 2007 divisions.

- The main **Technical Report** (this present document).

- A more detailed **Qualifications Technical Report** describes the detailed models and methods used to develop the estimates of the demand for and supply of skills (as measured by qualifications).[4]

- A **Technical Report on Development of Projections for the Local Enterprise Partnerships,** describing the development of projections for five Local Enterprise Partnerships (LEP) areas. This is pilot research on what analysis and results are feasible at the local area level.

- **Excel workbooks** and 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 2010-2020* are presented in the workbooks.

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[1] Wilson *et al.* (2011) *Working Futures 2010-2020,* UKCES.

[2] Wilson *et al.* (2008) *Working Futures 2007-2017, LSC.*

[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.

[4] Bosworth and Wilson (2012).

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 regional and LEP employment.

- Section 5 covers Labour Supply.

- Section 6 presents the categories and classifications used for defining industries and sectors, including those used for reporting. This section also describes how the SSA sector categories are defined.

- 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.

- 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 LEP areas and SSA secrtors. These provide the most detailed information available from the projections.

- Section 13 covers issues relating to statistical precision and the robustness of the estimates.

- Section 14 presents some warnings about confidentiality when accessing the more detailed data.[5]

- 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 deals with comparisons of the new projections with those presented in *Working Futures 2007-2017*.

- Section 17 covers general caveats on the employment estimates produced, including issues related to comparison with official estimates.

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.

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[5] Access to the most detailed results is limited to those covered by a Chancellor of the Exchequer's Notice.

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 multi-sectoral dynamic model of the economy (MDM) developed by Cambridge Econometrics (CE). Details of MDM and its relationship with other model components are given in Figure 1.

The figure summarises the models used by CE/IER for employment forecasting. MDM 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 UK results being obtained by summation. The level of disaggregation of commodities and industries is considerable by the standards of other models of the UK economy. 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. There are currently 41 main employing activities distinguished, defined using the SIC2003. These categories are based on the limitations of data available from the input-output tables.

For presentational purposes, the 41 sectors have been translated to 79 industries defined in SIC2007 using methods described below.

2.2 The employment output relationship

A key relationship is that between industry employment and output. 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 the figure. The macroeconomic model is, generally speaking, based upon quite sophisticated econometric analysis of long time series data sets. 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

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[6] For an example see Briscoe and Wilson (1991).

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 also involve further procedures, which allow for even greater detail. These include:

- Extension from 41 industries defined in SIC2003 to 79 industries defined in SIC2007;
- Development of results for detailed geographical areas, as well as the countries and regions of the UK.

These are described in greater detail in the following sections.

Figure 1: The Working Futures Models and Modules
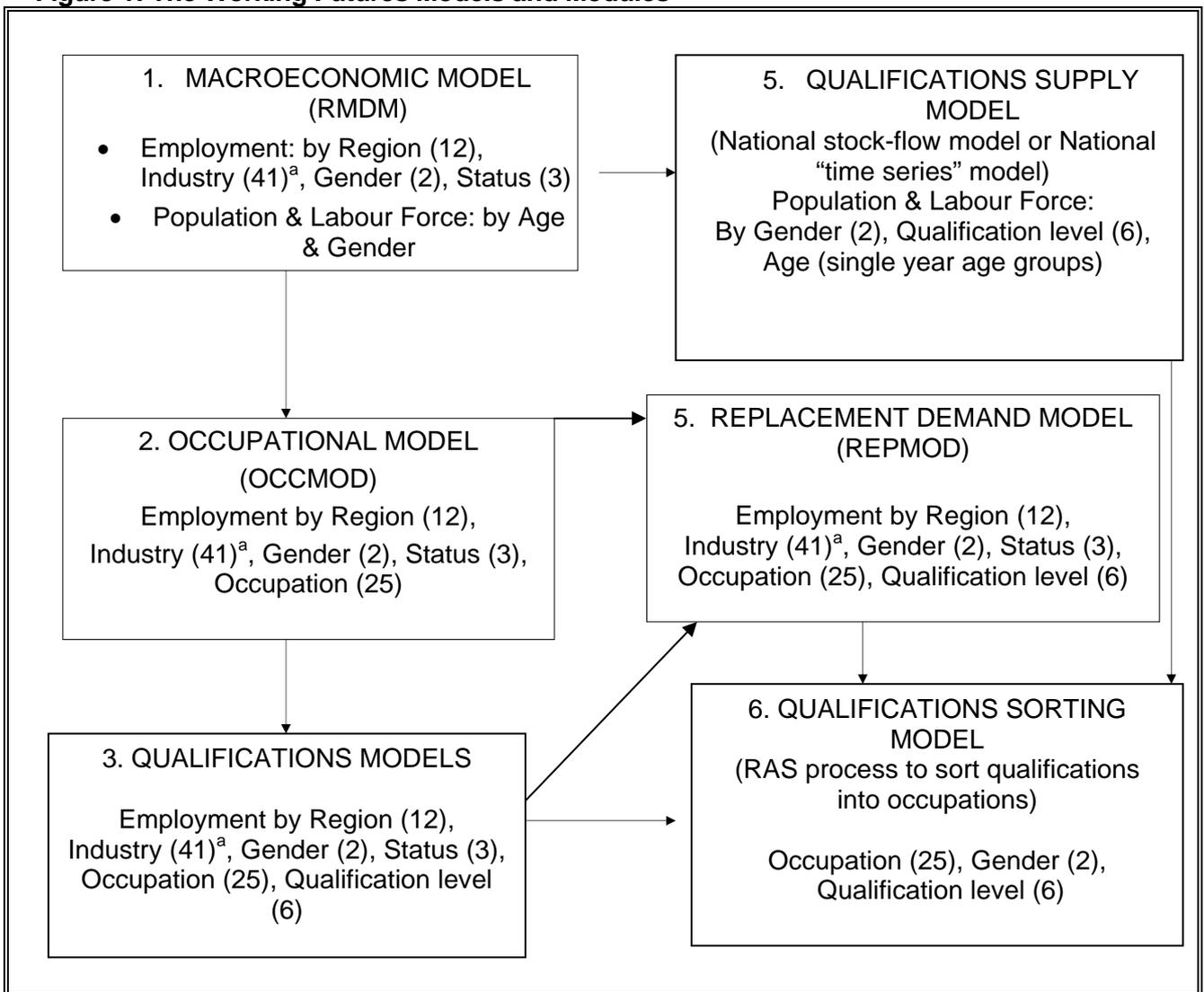
Notes: (a) These are extended to cover 79 industries defined in SIC2007, as described in Sections 3 & 4.

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 current version of the model is based on a "bottom-up" treatment of regional economic prospects. 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) and Wilson (1994).

The forecasts for *Working Futures 2010-2020* (often abbreviated here to *Working Futures IV* or *WF IV*) were prepared using the latest version of the Cambridge Econometrics Multi-sectoral Dynamic Model (MDM Revision 7146) which is based on the 2003 Standard Industrial Classification (SIC2003). The most recent National Accounts data (with chained volume measures, with reference year 2006), along with a consistent input-output table and classification converters, have been incorporated into MDM Revision 7146. 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 79 industries defined in SIC2007 divisions for presentational purposes.

3.2 The latest version of MDM (MDM Revision 7146)

MDM 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 models (the European model E3ME, the global model E3MG and the UK model MDM) and to implement changes required to make the models consistent with the most recent data and methods.

The number of industries in MDM 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 current industry classification, i.e. the list of industries distinguished in the model, is common to all CE sectoral-regional models and this facilitates the procedures for making international comparisons and consistency checks.

The MDM database incorporates the latest chained volume measure (CVM) data (see Sub-section 3.3) and the latest input-output estimates. So far it has not been possible to transform the model to use SIC2007 data throughout, as most of the data used in the model, especially the UK National and Regional Accounts, have not yet become available for SIC2007 divisions. At the time of writing the report, these data were expected to become available towards the end of 2011.

3.3 Incorporating National Accounts data in CVM form

The 2003 National Accounts saw the introduction of 'annual chain-linking', a method for constructing aggregate volume measures of economic growth which better reflect the

changing structure of industry and patterns of expenditure. The latest version of MDM (MDM Revision 7146) has been updated to incorporate the latest (2010) National Accounts data in CVM form.

Before the introduction of CVM series, the detailed estimates for growth for different industries were summed to a total by using information on how important each industry was in a fixed base year and according to the price structure in that base year (most recently 1995). Changes in relative prices and industry weights subsequent to the base year were not incorporated. The year from which this information on relative prices and industry weights was drawn was updated at 5-yearly intervals. This method produced constant-price series and is described as 'fixed base aggregation'.

'Annual chain-linking', has replaced the constant-price series with CVMs which use information for the price structure updated every year to give each industry the most relevant weight which can be estimated. CVM estimates of growth provide a more accurate picture of changes to the economy's structure. 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.

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 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.

3.4 Input-output table for 2003

An input-output table for 2003 in basic prices has been estimated from official data to provide the detail needed to model inter-industry purchases and sales. The additional 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.

3.5 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 SIC2003 indices of output data (see Sub-section 3.3). Input-output balances provide data for gross output by SIC2003 in the reference year 2006. A time series for gross output has been constructed based upon 1994-vintage gross output data, originally collected at the 123-industry level of detail corresponding to that of the 1990 input-output tables, which have been aggregated and reclassified to the MDM industry definitions (see Table 1). These data have been updated in line with short-term indicators for more recent years.

3.6 Reconciling final demand time series with ONS National Accounts

Since the introduction of the European System of (National) Accounts (ESA95), investment data are published at a much reduced level of detail. ONS has reduced the number of investing sectors for which investment data are available and so to reflect this, and because there is no supplementary information available to disaggregate the investing sectors further, the number of investing sectors distinguished in MDM is 27. The capital stock publication

from ONS contains investment data by investing sector and asset, at both constant prices (CVMs) and current prices.

In the ESA95 household final consumption expenditure is classified by 51 categories of purpose. The 51-functional category level for 'household' expenditure (which includes final consumption expenditure of non-profit institutions serving households) has been incorporated. Historical data published in detail in the UK National Accounts and Consumer Trends have been incorporated into the model.

The latest data from the ONS for exports and imports have also been incorporated into this forecast. These were linked to earlier data which had previously been reclassified, converted to 2006 CVMs and matched with 2006 data from the supply and use input-output tables for 2006.

The time-series data for years after 1990 were reconciled at an aggregate level with data from the ONS's Blue Book and more recent press releases.

Table 1: Classification of Industries in MDM (SIC 2003)

Industries	SIC2003
1. Agriculture	01,01,05
2. Coal etc.	10
3. Oil & gas	11,12
4. Other mining	13,14
5. Food, drink & tobacco	15, 16
6. Textiles, clothing & leather	17, 18, 19
7. Wood & paper	20, 21
8. Printing & publishing	22
9. Manufactured fuels	23
10. Pharmaceuticals	24.4
11. Chemicals n.e.s.	24 (ex 24.4)
12. Rubber & plastics	25
13. Non-metallic mineral products	26
14. Basic metals	27
15. Metal goods	28
16. Mechanical engineering	29
17. Electronics	30, 32
18. Electrical engineering & instruments	31, 33
19. Motor vehicles	34
20. Other transport equipment	35
21. Manufacturing n.e.s.	36, 37
22. Electricity	40.1
23. Gas supply	40.2, 40.3
24. Water supply	41
25. Construction	45
26. Distribution	50, 51
27. Retailing	52
28. Hotels & catering	55
29. Land transport	60, 63
30. Water transport	61
31. Air transport	62
32. Communications	64
33. Banking & finance	65, 67
34. Insurance	66
35. Computing services	72
36. Professional services	70, 71, 73, 74.1-74.4
37. Other business services	74.5-74.8
38. Public administration & defence	75
39. Education	80
40. Health & social work	85
41. Miscellaneous services	90-99
42. Unallocated	

3.7 Intermediate demand

The industrial absorption matrix for each region depends on the matrix of input-output coefficients. In the current version of the model, the UK input-output tables are used for all the regions. The coefficients are calculated as inputs of commodities from whatever source, including imports, per unit of gross industrial output; they are therefore applicable to the regional economies on the assumption that the regional technology and mix are the same as those for the UK for each industry.

In recent years ONS has invested resources in the production of annual UK input-output supply and use tables and has included these tables and the associated analyses in its annual Blue Book publication. The information from the more timely supply and use tables is used in conjunction with the more detailed analytical tables (last published for 1995) to construct the inputs that are required for MDM.

3.8 Detailed employment data consistent with the ABI

Employment data by gender and status and by industry consistent with the ONS Annual Business Inquiry (ABI) were processed and used in the model. The data refer to mid-year (June) levels. Self employment estimates draw upon LFS data.

3.9 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 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 and region. 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 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

3.10   Adjustments made to MDM

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 2011 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 oil & gas, electricity, gas and water industries.

- Expectations of consumer price inflation are included in the price and wage equations at the Government's target rate of 2% pa from 2011 onwards.

The multiplicative errors from the cointegrating 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.

3.11   The reliability of the forecast and improvements to output and trade data

The reliability of the forecast partly reflects the reliability of the data. In recent years, the implementation of ESA95 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 chainlinked estimates of GVA and its components in 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 1996-2003, 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.

3.12   Impact of ESA95

The introduction of the European system of (national) accounts (ESA95) made redundant several commonly used terms and conventions. The output measure of GDP value added at factor cost (i.e. excluding all taxes and subsidies on production) is no longer part of the system. The concept is replaced by value added at basic prices, which excludes taxes like excise duties, but not taxes like business rates that are not attributable per unit sold. Hence, the 'headline' measure of GDP becomes GDP at market prices (including all taxes less subsidies), while the key concept for industry analysis is GVA (gross value added) at basic prices.

3.13   Processing the UK output data and forecasts for 79 SIC2007 defined sectors

This section describes how the data and forecasts for UK output (value-added in chained volume measures) were processed for the 79 SIC2007 defined sectors, analysed in this project. The 79 detailed sectors are defined in Section 6, Table 3. As mentioned above, MDM distinguishes 41 industries, defined by the 2003 Standard Industrial Classification (SIC2003) (see Table 1). The input-output supply and use tables (SUTS), and the output measure of GDP, GDP(O), and Index of Production (IoP) series were used, where available, to translate the MDM industries to the 79 detailed industries. The input–output supply and use tables, provide current price data for gross value added for 2006, while the GDP(O) and IoP series are constant price indices of value added output (2006=100).

In all cases data for the 79 industries were processed to be consistent with the MDM industry data and forecasts and as closely as possible to the SIC2007 definitions of these industries.

The procedure followed was different according to the availability of data. There were four general treatments as follows:

Case 1: *There is a one to one mapping between a WF IV industry and an MDM industry.*

In this case no disaggregation is required and the WF IV industry output is set equal to the MDM industry output for all years. There were fourteen industries in this case.

Case 2: *A WF IV industry maps exactly to one or more of SIC2003 industries which in turn map to one of the 41 MDM industries.*
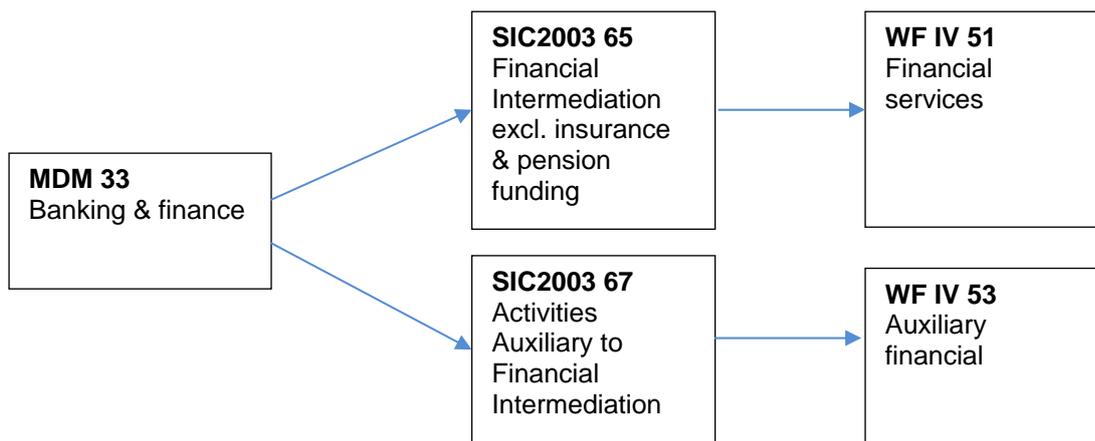
In this case current price SUTS data for 2006 are used to infer the composition of the MDM industry in terms of the disaggregated SIC2003 industries and to calculate the shares of these industries in the MDM industry output. Then the IoP or GDP(O) index (according to coverage) for the disaggregated SIC2003 industries is used to extrapolate these shares for the years the indices are available (see Table 2). Using these shares output values are calculated and scaled to the MDM data. In a second stage the shares, from the final estimates of output over the years for which the IoP/GDP(O) indices are available, are extrapolated over the years for which the index is not available ie earlier historical and forecast years. A ten-year rolling trend is used, taking care to prevent the shares from becoming implausibly large or small. Finally the shares are applied to the MDM industry and results are scaled to make sure that there is consistency of the WF IV industries output with the corresponding MDM industry output.

This methodology assumes that in 2006 the price of the WF IV industries was the same as for the MDM industry. Although this may not be a realistic assumption, no further data were available to construct more accurate estimates. Also for the earlier years and the forecast years, we assumed that the change in the industry shares followed the same trend as it did over the years for which detailed data are available.

Case 3: *A WF IV industry consists of indeterminate parts of one or more SIC2003 industries, which map to an MDM industry.*
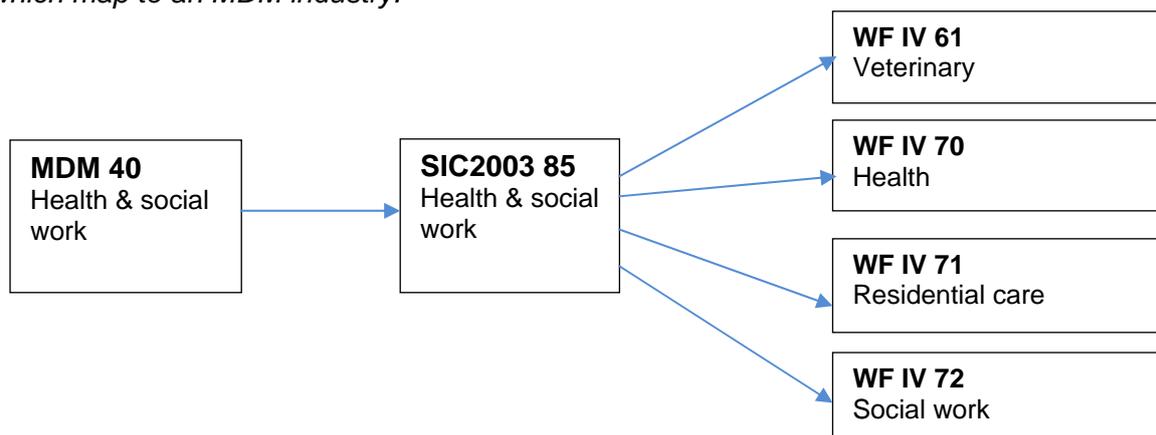
In this case IoP or GDP(O) data are not available and we use GVA estimates in current prices available from the Annual Business Survey (ABS). An initial estimate of productivity for the disaggregated sectors in 2008 and 2009 is calculated using "approximate GVA" from the ABS and ONS employment data. Then the productivity ratios of the detailed industries to their aggregate industry for 2008 and 2009 are linearly projected backwards to 2000 and over 2010-2020. Restrictions are placed to make sure that these ratios do not become too small or too large relative to the values based on data. These productivity ratios are applied to the productivity of the MDM industry to create a first estimate of the productivity of the WF IV industries. Using these productivity estimates and employment estimates, first estimates of GVA for the disaggregated sectors are calculated. Finally, these estimates are scaled to ensure consistency with GVA in the corresponding MDM industry.

Again this methodology assumes that in 2008 and 2009 the price of the WF IV industries was the same as the MDM industry. Further for the earlier years and the forecast years trend in the productivity of the these industries relative to productivity in the MDM industry is based on very limited information. However no other data were available to construct more accurate estimates.

Case 4: *A WF IV industry consists of indeterminate parts of one or more SIC2003 industries and maps into part of two or more of the 41 MDM industries.*
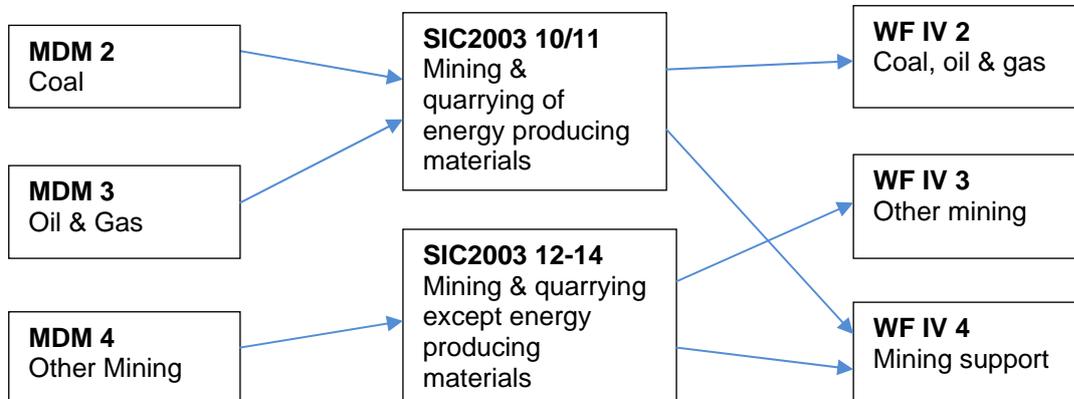
As in Case 3, IoP and GDP(O) series are not available at a sufficient level of disaggregation to infer the shares of the WF IV industries. The disaggregation in Case 4 is further complicated by the fact that a given WF IV industry is split between parts of more than one MDM industry. As in Case 3, we calculate an estimate of productivity for each of the WF IV industries using GVA estimates in current prices from the ABS. However because we cannot attribute a subset of WF IV industries to a single MDM industry, instead, the productivity ratio for a given WF IV industry is constructed with respect to productivity in the subset of industries to which is related. These ratios are linearly projected, as in Case 3, and applied to productivity in the group of MDM industries to which the WF IV is related to. This produces an estimate of productivity in the WF IV industry which can be applied to employment to obtain an estimate of GVA. Finally once these estimates are obtained for all the disaggregated industries, scaling takes place to ensure that the sum of GVA in a set of related WF IV industries does not exceed the sum of GVA in their corresponding related MDM industries.

Table 2 lists the 79 WF IV industries and the information we used to map the MDM industries to these detailed SIC2007 industries.

Table 2: Disaggregation of MDM Industries to Detailed SIC2007 Industries

Ind79	Ind79 name	SIC2007	ONS series	Data available since	2006 Weights	Input-output data 2006
1	Agriculture, etc	01-03			yes	yes
2	Coal, oil & gas	05-06	ABS, current price	2008-2009	n/a	n/a
3	Other mining	07-08	ABS, current price	2008-2009	n/a	n/a
4	Mining support	09	ABS, current price	2008-2009	n/a	n/a
5	Food products	10	IoP, constant price, 2006=100	1999-	yes	yes
6	Beverages & tobacco	11-12	IoP, constant price, 2006=100	1999-	yes	yes
7	Textiles	13	IoP, constant price, 2006=100	1979-	yes	yes
8	Wearing apparel	14	IoP, constant price, 2006=100	1979-	yes	yes
9	Leather, etc	15	IoP, constant price, 2006=100	1979-	yes	yes
10	Wood & cork	16	IoP, constant price, 2006=100	1979-	yes	yes
11	Paper, etc	17	IoP, constant price, 2006=100	1979-	yes	yes
12	Printing & recording	18	ABS, current price	2008-2009	n/a	n/a
13	Coke & refining	19			yes	yes
14	Chemicals,etc	20			yes	yes
15	Pharmaceuticals	21			yes	yes
16	Rubber & plastic	22			yes	yes
17	Other non-metallic	23			yes	yes
18	Basic metals	24			yes	yes
19	Metal products	25	ABS, current price	2008-2009	n/a	n/a
20	Computers, etc	26	ABS, current price	2008-2009	n/a	n/a
21	Electrical equipment	27	ABS, current price	2008-2009	n/a	n/a
22	Machinery, etc	28	ABS, current price	2008-2009	n/a	n/a
23	Motor vehicles, etc	29	ABS, current price	2008-2009	n/a	n/a
24	Other trans. equipment	30	ABS, current price	2008-2009	n/a	n/a
25	Furniture	31	ABS, current price	2008-2009	n/a	n/a
26	Other manufacturing	32	ABS, current price	2008-2009	n/a	n/a
27	Repair & installation	33	ABS, current price	2008-2009	n/a	n/a
28	Electricity, gas, etc	35			yes	yes
29	Water	36			yes	yes
30	Sewerage	37	ABS, current price	2008-2009	n/a	n/a
31	Waste management	38-39	ABS, current price	2008-2009	n/a	n/a
32	Construction	41	ABS, current price	2008-2009	n/a	n/a
33	Civil engineering	42	ABS, current price	2008-2009	n/a	n/a
34	Specialised construction	43	ABS, current price	2008-2009	n/a	n/a
35	Sale of motor vehicles	45	ABS, current price	2008-2009	n/a	n/a
36	Wholesale trade	46	GDPO, constant price, 2006=100	1979-	yes	yes
37	Retail trade	47	GDPO, constant price, 2006=100	1979-	yes	yes
38	Land transport, etc	49	ABS, current price	2008-2009	n/a	n/a
39	Water transport	50			yes	yes
40	Air transport	51			yes	yes
41	Warehousing, etc	52	ABS, current price	2008-2009	n/a	n/a
42	Postal, etc	53	ABS, current price	2008-2009	n/a	n/a

Sources: a) GDP(O), constant price, 2006=100; IoP, constant price, 2006=100; Input-Output Supply and Use tables.

Table 2 continued: Disaggregation of MDM Industries to Detailed SIC2007 Industries

Ind79	Ind79 name	SIC2007	ONS series	Data available since	2006 Weights	Input-output data 2006
43	Accommodation	55	ABS, current price	2008-2009	n/a	n/a
44	Food & beverage services	56	ABS, current price	2008-2009	n/a	n/a
45	Publishing activities	58	ABS, current price	2008-2009	n/a	n/a
46	Film & music	59	ABS, current price	2008-2009	n/a	n/a
47	Broadcasting	60	ABS, current price	2008-2009	n/a	n/a
48	Telecommunications	61	ABS, current price	2008-2009	n/a	n/a
49	Computing services	62	ABS, current price	2008-2009	n/a	n/a
50	Information services	63	ABS, current price	2008-2009	n/a	n/a
51	Financial services	64	GDPO, constant price, 2006=100	1975-	yes	yes
52	Insurance & pensions	65			yes	yes
53	Auxiliary financial	66	GDPO, constant price, 2006=100	1975-	yes	yes
54	Real estate	68	ABS, current price	2008-2009	n/a	n/a
55	Legal & accounting	69	ABS, current price	2008-2009	n/a	n/a
56	Head offices, etc	70	ABS, current price	2008-2009	n/a	n/a
57	Architectural & related	71	ABS, current price	2008-2009	n/a	n/a
58	Scientific R&D	72	ABS, current price	2008-2009	n/a	n/a
59	Advertising, etc	73	ABS, current price	2008-2009	n/a	n/a
60	Other professional	74	ABS, current price	2008-2009	n/a	n/a
61	Veterinary	75	ABS, current price	2008-2009	n/a	n/a
62	Rental & leasing	77	ABS, current price	2008-2009	n/a	n/a
63	Employment activities	78	ABS, current price	2008-2009	n/a	n/a
64	Travel, etc	79	ABS, current price	2008-2009	n/a	n/a
65	Security, etc	80	ABS, current price	2008-2009	n/a	n/a
66	Services to buildings	81	ABS, current price	2008-2009	n/a	n/a
67	Office admin.	82	ABS, current price	2008-2009	n/a	n/a
68	Public admin. & defence	84			yes	yes
69	Education	85			yes	yes
70	Health	86	ABS, current price	2008-2009	n/a	n/a
71	Residential care	87	ABS, current price	2008-2009	n/a	n/a
72	Social work	88	ABS, current price	2008-2009	n/a	n/a
73	Arts & entertainment	90	ABS, current price	2008-2009	n/a	n/a
74	Libraries, etc	91	ABS, current price	2008-2009	n/a	n/a
75	Gambling & betting	92	ABS, current price	2008-2009	n/a	n/a
76	Sport & recreation	93	ABS, current price	2008-2009	n/a	n/a
77	Membership organisations	94	ABS, current price	2008-2009	n/a	n/a
78	Repair of goods	95	ABS, current price	2008-2009	n/a	n/a
79	Other personal service	96	ABS, current price	2008-2009	n/a	n/a

Sources: a) GDP(O), constant price, 2006=100; IoP, constant price, 2006=100; Input-Output Supply and Use tables.
b) Current price GVA £m, Annual Business Survey.
c) n/a indicates not applicable.

3.14 Employment data and forecasts for the UK detailed SIC2007 industries

Employment data and forecasts for the detailed 79 industries were based on information provided by ONS including the ABI.

Historical estimates were created directly from data received from ONS and ABI data. These data cover Great Britain employment by all six types. Data were also provided for Northern Ireland for the same industrial detail for male and female employees in employment and male and female self-employment; in addition data for employees in employment by gender and status are available for 17 sectors. Average shares for Great Britain were used to make first estimates of Northern Ireland employees in employment by status for the 79 detailed industries; these initial estimates were made consistent with the detailed data by gender provided and the 17-industry data by gender and status, both provided by ONS.

The starting point for the forecasts for the 79 industries is the forecasts of employment for the 41 industries produced from MDM as described above. There were three stages in producing forecasts for total (i.e. across all gender/status categories) employment for the 79 detailed SIC2007 industries:

- The historical shares of the components of each of the 79 industries in the 41 MDM industries were calculated for each type of employment in Great Britain where the maximum detail of data is available;

- The shares were extrapolated over the forecast period, taking care to reduce the speed of increase/decline in the share in cases where the proportions were approaching either one or zero;

- These proportions were applied to the projections of employment by type in the industry concerned to generate initial estimates of employment by type necessary to create projections for the 79 industries;

- These initial estimates of employment by type were then scaled to become consistent with the forecasts for the 41 MDM industries by type derived from the model;

- A similar process was used to create employment forecasts by type for Northern Ireland;

- The sum of Great Britain employment and Northern Ireland employment gave us UK employment for 79 SIC2007 industries by gender and status.

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 of the constituent economies (henceforth referred to here as "regions". The regionalized version of MDM (RMDM) and the data underlying the regional analysis were developed by Cambridge Econometrics.

The model has a clear economic structure allowing incorporation of incomplete and partial data in a similar manner to the procedure followed in general equilibrium modelling, but at the same time validating the model's projections against the available data for employment and output. RMDM is a development of the Cambridge Multi-sectoral Dynamic Model of the UK economy (MDM). Barker and Peterson (1987) provide an account of version 6 of the model and Barker et al (2001) provide a recent account of the RMDM. The latter is a time-series, cross-section (input-output) model distinguishing, *inter alia*, 41 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 (Revision 7146) has been re-estimated on the latest Regional Accounts data and the 2010 National Accounts (chained volume measures with reference year 2006) using a consistent input-output table and classification converters.

4.2 Development of a UK Regional Econometric Input-Output Model

Due to the absence of inter-regional trade data and the generally poor quality of regional data, a model of the regional economies of the UK with significant economic content inevitably entails a substantial exercise in data construction. Some considerable reduction of data requirements can be made by adopting Leontief's approach, in which each region trades with all the rest as a group rather than with each other region separately, but there remains a need for data on each region's exports and imports in total. The data requirements involved in a full inter-regional model are of a higher order of magnitude (Polenske, 1980). However the approach does allow important economic relationships to be embedded in the model. For example, in the input-output model, regional output can be determined from regional exports and domestic demand (depending on tradability); and regional employment can be determined from output.

The construction of such a model has been ambitious in relation to the available data and the resources required. The approach has been to build up a regional econometric input-output model and database, as an integral part of the MDM model and MDM database. The model has a clear economic and accounting structure, uses incomplete and partial data, and applies techniques drawn from general equilibrium modelling. The forecasts and projections for the recent past are calibrated so as to reproduce the 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 the classifications adopted in the regional sub-model are as far as possible those of MDM, and that the regional variables and data are consistent with the UK variables and data. This means that a 41-industry classification has been adopted for the commodity and industry variables in the regionalised MDM (such as gross output, GVA, employment, regional exports and imports).

4.3 Advantages of modelling regional markets

Regional output responds to changes in regional final demand. Thus, for example, the link between a slump in household spending in the South East and output in the same region, or other regions, is explicitly identified.

The treatment allows the calculation of full regional accounting balances for commodity supply and demand, exactly corresponding to the balances for the whole UK including the Continental Shelf. These balances cover inter-regional trade and an allocation of the UK commodity imbalances across the regions. They are in current prices and chained volume measures (CVMs), under the assumption that annual changes in prices for each commodity are the same for all the regions. These commodity balances provide an important consistency check on any forecasts of regional output and the components of regional final demand.

The approach also allows full feedback from the regional economies to the UK economy. This facility is especially important in modelling those areas of economic life where markets are restricted by costs of travel or other costs associated with distance. For example, it is clear from the data that there are distinct regional differences in patterns of saving and spending; this approach allows total household expenditure by region to be estimated and solved and UK household expenditure to be formed as the sum of the regional expenditures. Another example is in the operations of the labour market which tend to be restricted to travel-to-work areas; here it has been possible to estimate regional employment and wage rate equations to reflect different conditions in each of the regional labour markets. UK employment and the UK rate of wage inflation can then, in principle, be derived from the regional rates.

Such feedbacks, however, are an option in the software and in the current version of the model they are only operative in the case of employment. The regional forecasts depend on the UK forecasts and if necessary they are scaled to add up to the UK forecasts.

4.4 Incorporation of distance and location effects

In the regionalised MDM, distance and location have three main influences:

- Economic distance determines the regional export activity indices, such that the closer one region is to another in economic distance, the more its domestic demand affects the other region's exports;

- For certain location-based activities, such as transport and distribution, the location of the infrastructure in the form of transport links and warehousing determines the regional supply;

- The locations of large new investment projects, e.g. tidal barrages, are introduced directly into the regional investment projections.

4.5 Inter-industry links and the use of partial regional information

One of the great strengths of I-O models is their simulation of inter-industry links, allowing the calculation of industrial multiplier effects. These multipliers show the effects on the industrial structure of changes in exogenous variables, or in behaviour, for example an increase in the propensity to save in one particular region. They show, under simplifying assumptions, how extra demand is transmitted from one industry to another. For example increases in output of cars from the Nissan plant in Sunderland will have effects on suppliers of parts, and in turn effects on steel and glass production and imports.

It is also much easier to incorporate partial and incomplete information into a fully specified economic model than into a reduced form model. For example, estimates are available for costs and impacts of infrastructure projects, which will have strong regional effects. If investment is fully specified in the model, such exogenous increases can be introduced explicitly into the forecast. Similarly, estimates of the local multiplier effects of, for example, the Nissan car plant in Sunderland can be directly implemented in the model.

4.6   Problems with regional data

This approach has not been adopted by most forecasters, despite the obvious advantages, because of the poor quality (if not the absence) of much of the required 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.

Where no data exist, they have been imputed from other regional data, as in the case of trade flows, or from UK data, as in the case of the input-output coefficients. The methods adopted have been applied systematically for all the Government Office Regions and this provides a further check in the case of Scotland, Wales and Northern Ireland, where more detailed data are available.

4.7   Commodity and trade balances in the regional model

The model comprises: the accounting balances; the various fixed allocations to the regions of UK government expenditure, stock levels and commodity residuals; and 7 sets of time-series econometric equations (commodity exports, total household expenditure, disaggregated household expenditure, industrial fixed investment, industrial employment, industrial wage rates and population change). In general, the regional equations follow their UK counterparts in terms of the explanatory variables, with the UK totals added as a further variable.

Commodity balances for each region are given by equating regional output plus imports (commodity supply) with commodity demand, where the values for the components are chained volume measures with reference year 2006. Regional demand for each commodity comprises household expenditure, government final current expenditure, investment in fixed assets, exports, industrial absorption, stockbuilding, and residual imbalance. The latter term is determined by the aggregate UK commodity imbalance, which is allocated across the regions according to their share in total supplies. Using the current price magnitudes of the supply and demand components, regional commodity balances can be expressed in current prices.

There is also an accounting balance for net regional trade (the inter-regional export-import balance) and UK trade with the rest of the world. In other words, taking all UK regions together, regional imports plus imports of the rest of the world (i.e. UK exports) are equal to regional exports plus exports of the rest of the world (i.e. UK imports). This balance is enforced in the projections of the model, as an adding-up constraint on regional exports.

4.8   Employment

Employment is treated as a demand for labour, derived from the regional demand for goods and services. Regional employment equations were estimated, relating industrial

employment in each industry to its output in the region, to wage rates in the region relative to output prices and to national variables such as average hours worked. 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.

4.9 Average wage rates

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. The dependent variable in the wage equation in RMDM is the gross nominal wage, that is, the contractual wage which is a common component of real wages for the main players in the labour market. The external influences on wage bargaining in an industry are divided into those from other industries in the same region, and those from the same industry in other regions. Regional average wage rates by industry are also determined by national price inflation, benefit rates and regional unemployment rates.

4.10 Data for regional employment, unemployment and nominal GVA

The model and forecast are based on the latest National Accounts (chained volume measures with reference year 2006) 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 2010 and consistent with the 2010 National Accounts have been incorporated in the forecasts.

Data for nominal GVA, household expenditure and household incomes are included for the Government Office regions, Wales, Scotland and Northern Ireland. These data are available only since 1989. Previous regional accounts (for Standard Statistical regions) have been available since 1971 with some disaggregated series available only since 1978. Some data at disaggregated level exist for 1971-78 but these are on the SIC1968 basis and many other data are on the SIC1980 basis; in the process of creating long-term series these were all translated to SIC2003 categories and Government Office regions.

The source for employment and unemployment data is also the ONS. Employment is defined as the total of employees in employment, self-employment and HM Forces and is the June count seasonally unadjusted. Unemployment is defined by the annual average, seasonally adjusted, of benefit claimants aged 18 and over. Other data such as regional population, working-age population and migration are obtained from the ONS and the Registrars General for Scotland and Northern Ireland.

4.11 Processing the regional output data

GVA data for the regions were obtained from the ONS for some 30 sectors. These data were disaggregated to the MDM 41 industries using information from other sources, such as the census of production and the ABI, and information from the more detailed employment data and other detailed information available for the UK. Current price data at the 41 industry level were deflated using the corresponding national deflators.

4.12 Modelling of employment at regional level

Regional econometric modelling adopts the same procedures as at the UK level, and as outlined in general terms in Sections 4.7-4.9 above. The employment measure used in the model is establishment based (workplace/jobs), while the output indicator is the residence based GVA measure, (described in Sections 4.10 and 4.11). Both indicators are consistent with the official ONS published data. There are no official estimates of output by sector on an establishment basis, although aggregate measures are available. In practice, GVA under both definitions is essentially the same in all regions apart from London, South East and East of England, where the difference between the two measures reflects the significance of commuting flows.

Although not ideal from a modelling perspective, this slight difference in spatial coverage of the employment and output measures does not have any major consequences for the modelling and projection of employment, since any changes in the short- or long-run relationship between (workplace-based) employment and (residence-based) output will be captured by changes in the other variables in the model (wages, hours and the time trend) and in the error term. The systematic component of the relationship is captured within the model coefficients. This implicitly assumes no significant changes in commuting patterns between countries and regions within the UK that are not captured implicitly by such measures.

4.13 Constructing regional employment data and forecasts for the detailed SIC2007 industries

The regional employment data were based on official estimates for SIC2007 divisions published by ONS. These data cover total employees in employment, and self-employment by gender. ABI data and data for employees by gender and status for aggregate sectors (19 sectors) also published by ONS were used to create detailed estimates for employees in employment by gender and status for the 79 industries used in this project. A series of iterative RAS[7] procedures were used to ensure that the final data set was consistent with all totals published by ONS including detailed data for Great Britain. Further details of the development of the employment database are given in Section 10.

Regional employment forecasts for the 79 sectors were obtained by analogous methods to those for the UK. These used historical trends to obtain initial estimates. A RAS procedure was then used to ensure consistency with regional employment forecast from the model and forecasts by gender and status for the detailed 79 industries in the UK.

Regional employment forecasts for the 79 industries were created as follows:

- *Total employees*

  The historical trends in proportions of the detailed industries in the corresponding MDM 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 Great Britain 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

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

corresponding MDM 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 sectors using the RAS procedure.

- *Employees by gender and status*

  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, 2008 and 2009 were used to split MDM 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 Great Britain forecasts by type by 79 industries and the regional projections by type for the MDM sectors.

4.14   *Regional output data and projections for the detailed 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 Annual Business Survey (ABS). These productivity ratios were applied to the MDM industries productivity from the model to create initial GVA estimates by detailed 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 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 79 detailed industries to one of the MDM industries, GVA was set equal to the GVA from the MDM industry for both history and forecast.
- For the remaining sectors a relative productivity of the detailed industry in the corresponding MDM industry was estimated in 2008 using GVA from the Annual Business Survey 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, to create initial estimates of productivity.
- These were then applied to the regional employment time series at the 79 industry level to yield an initial estimate of output.
- The RAS procedure was finally used to create consistency of the estimates with GVA by detailed industry in the UK and regional GVA for the MDM 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 sector, in a given region, holds throughout the entire history and forecast period. Further, in some cases the ABS offers insufficient coverage of regional GVA. In such cases the productivity ratio of 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.

4.15 Data and projections for the Local Enterprise Partnerships (LEPs) by detailed SIC2007 sectors

The LEPs projections were developed in a similar fashion. Firstly LEPs data and projections were developed for the MDM industries using Cambridge Econometrics Multi-Local Area Forecasting Model and then data and projections for the 79 detailed SIC2007 industries were created. These were made consistent with the data and projections for the detailed industries in the corresponding region applying the RAS procedure.

Cambridge Econometrics (CE) have previously developed models and procedures that allow the generation of estimates for smaller geographical areas, such as those defined in this project. These provide a firm foundation upon which to build the kind of database required for the LEPs in Great Britain. Using these methods, the regional results have been disaggregated to generate information on output and employment for the four LEPs in Great Britain.

- *Total employment and GVA historical data and projections for MDM sectors*

CE have developed a full **Database**, which includes employment data for local authority districts by 41 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 ABI employment data for the local authority districts for 41 sectors. Available GVA data for aggregate sectors and regional productivity by the MDM industries are used to create a complete set of GVA by the 41 MDM industries for local authority districts.

This full **Database** is the foundation for the projections for the LEPs specified under this project. 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.

- *Total employment and GVA historical data and projections for 79 SIC2007 detailed industries*

Total employment by MDM industry was disaggregated using initial estimates based on the disaggregation of the corresponding region. Rates of growth from these estimates were applied to detailed industry data for 2008 and 2009 from BRES. The resulting data and projections were made consistent with regional employment by 79 industries and LEP total employment by 41 MDM sectors using the RAS procedure.

For GVA first estimates were based on employment by detailed industry and productivity in the same industry in the corresponding region. Using the RAS procedure these initial estimates were made consistent with GVA in the detailed industries in the region and the LEP GVA by MDM industry.

- *Employment by gender and status for 79 SIC2007 industries*

Historical data of employment by 6 types for 42 MDM sectors were used initially to create projections for LEPs by gender and status for these sectors. The projections were created using multi-local area procedures as developed by CE/IER for the Local Economy Forecasting Model (LEFM). These procedures have as a starting point historical trends in

employment by gender and status in the LEP areas and the regional forecasts for the MDM industries by gender and status.

Data for employees in employment by gender and status by detailed industry were obtained from ABI for 2007 and 2008. Initial historical estimates and projections of employees by type and gender were then created by applying trends in the corresponding MDM industry to these data. Self-employment data were created assuming that the ratio of employees to self-employment by gender in an industry in the LEP is the same as in the corresponding industry in the region. The RAS procedure was finally applied to ensure consistency between LEP employment estimates by type and gender in the 79 industries with estimates of LEP total employment by detailed industry, and regional employment by gender and status by detailed industry.

Further details are given in Section 10 below.

5 Labour Supply

5.1 Introduction

This section describes the methodology used to develop CE's Multi-Sectoral Dynamic Model of the UK economy (MDM) to provide more 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, focussing 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 by region and age-band/gender in MDM. The specification of these equations draws upon earlier work that IER undertook on behalf of DfEE[8] which underlies the systems used by DfES to construct the official projections of economic activity rates published in *Labour Market Trends.*[9] 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.

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

- workplace based employment jobs is determined using the existing MDM equations (see Section 4);

- the regional labour force is determined by activity rates multiplied by the population of working-age;

- regional activity rates (by age-band/gender) are modelled as a function of unemployment and other variables, e.g. house prices relative to wages

- regional unemployment (ILO) = is determined from regional unemployment (claimant count);

- the Labour Force Survey measure of employment (employed residents) is determined from regional labour force minus regional unemployment (ILO);

- the labour market residual (one component of which is net commuting) is determined from workplace employment minus the Labour Force Survey measure of employment (employed residents).

Figure 2 presents definitions of the various terms used. The model is expressed more formally in the remainder of this section.

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[8] Briscoe, G and R Wilson (1992) 'Forecasting economic activity rates', *International Journal of Forecasting*, pp201-217.
[9] See *Labour Market Trends*, January, 2006, pp 13-26).

Key to prefixes and variable names

The prefixes used and the variable names are as follows:

LA   7 age-bands (0-15; 16-24; 25-34; 35-44; 45-59; 60-64; 65+) and 2 genders

L   2 gender categories

R   12 English Government Office Regions, Wales, Scotland and Northern Ireland

RLAW   Working-age population by region and age-band/gender

RLAE   Economic activity rates by region and age-band/gender

RLAF   Labour force (as reported by LFS) by region and age-band/gender

RLF   Labour force (as reported by LFS) by region and gender

RLIU   ILO unemployment by region and gender

RLUN   ILO unemployment rate by region and gender

RLGT   Work-related government training by gender (exogenous)

RLE   Employment (as reported by LFS) by region and gender

RE   Employment (workplace-based) by region and type

RLRS   Labour market residual by region and gender

RUNE   Claimant count unemployment by region

UNEM Claimant unemployment (scalar)

UNER   Residual between claimant and ILO unemployment levels

Construction of historical data

Historical data are determined as follows:

- RLE = RLF-RLGT-RLIU
- RLRS = sum to genders (RE) – RLE
- RLAE = RLAF/RLAW
- RLUN = 100*RLIU/RLF
- UNER = sum across regions and genders (RLIU) – UNEM

Derivation of the projections

The projections are derived as follows:

RLIU = f(RUNE)

RLUN = 100*RLIU/RLF

RLAE = f(RLIU, other variables such as house prices relative to wages)

RLAF = RLAE*RLAW

RLF = sum across age-bands (RLAF)

RLE = RLF – RLUN

RLRS = RE – RLE

As noted above, the difference between the Labour Force Survey (LFS) measure and the workforce measure of employment is accounted for in the labour market residual (RLRS). 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".

In MDM, total working-age population for each region is determined by the natural increase in working-age population plus net working-age migration. Regional in and out-migration of working-age population are both assumed to be affected by the same economic factors. The migration is modelled as occurring from the region to the outside world and vice versa. The explanatory variables used include a measure of regional surplus labour relative to the UK, the mortgage rate, relative wages and a linear time trend.

ONS projections of population are used to calculate shares by gender and by age-band. These shares are applied to the MDM forecasts of total population to produce projections of population by gender and by age-band.

5.3   *Estimation of the regional equations and programming the model code*

The exact form of the stochastic equations to forecast the economic activity rates by region and age-band/gender (RLAE) includes a number of explanatory variables including unemployment. These are generally *regional*-specific variables, rather than age-band/gender specific. The differences between age-bands/genders are picked up in a constant specific to those groups. A strong effect coming from the characteristics of the region is incorporated (notably, how tight the labour market is, and how expensive it is to live there). The equations are estimated across regions, since that is where the variation is largest.

5.4   *Labour force projections for the LEP areas*

The projections of the labour force for local areas can in principle be built up from projections made at unitary authority (UA) and local authority district (LAD) level. Projections can then be produced by age-band (0-15, 16-24, 25-34, 35-44, 45-59, 60-64, 65+) and gender for each UA/LAD, and then aggregated to labour force by gender and age-band for each local area.

The starting point for the projections would be the 2001 Census of Population activity rates by age band and gender for each UA/LAD. These activity rates can then be projected forwards, using the activity rate projections for the appropriate Region, as produced by the Cambridge Econometrics' (CE) Regionalised Multi-Sectoral-Dynamic (MDM) model of the UK economy.

These activity rate data and projections can then be applied to Office for National Statistics (ONS) sub-regional population projections[10] (by age-band, gender and UA/LAD) to generate labour force estimates for 2001-2020.

The final projections of the labour force by age-band, gender for the UA/LADs can then be aggregated to provide labour force by gender for the LEP areas.

However this has not been done yet.

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[10] The estimates are based on ONS regional and sub-regional 2008-based population projections.

Figure 2: 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 2010-2020* the following definitions are used:

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

Workplace basis: measured at place of work (as in the Annual Business Inquiry (ABI)) and Business Register and Employment Survey (BRES)).

Workplace employment (number of jobs): these are typically estimated using surveys of employers, such as the ABI, focussing 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 Job Seeker'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 16-59 (females), (residence basis). The retirement age of females increases from 59 in 2011 to 64 in 2020.

6 Detailed Industry Categories and Choice of Sectors for Reporting

6.1 Background

The sectoral analysis derives directly from the Multi-sectoral Regional Macroeconomic Model of the economy (MDM) as described in Sections 3 and 4. This extended version of MDM 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 2003 Standard Industrial Classification (SIC2003). The reasons for using SIC2003 are given in section 3.2. In all, 41 industries are distinguished in the standard version of MDM, as set out in Table 1. For reporting, however, these are translated on to a SIC2007 basis.

The estimates and projections of employment produced are consistent with official data published by the Office for National Statistics (ONS). The latest figures incorporate information from the 2009 Annual Business Inquiry (ABI) and its predecessors (as published in *Labour Market Trends*) and Business Register and Employment Survey (BRES). 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 provides forecasts for 41 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 Future IV* industries. These detailed 79 industries are shown in Table 3. This was achieved using a sub-modelling approach linking the two industrial classifications, as described in Sections 3 and 4. The methodology ensures that the results of the sub-model of SIC2007 outcomes are consistent, both with existing historical data and the forecast results for the 41 industries produced by the MDM. Historical data for output for SIC2007 industries were created for the UK using available information from time series data and/or from information derived from the ONS input-output tables. Regional series 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
- Practical considerations, including transparency and digestibility.

Table 3: Classification of Industries in Working Futures IV

Ind79	Ind79, WF IV name	SIC2007 Section	SIC2007 Division	Full industry name	Ind22	Ind6
1	Agriculture, etc	A	01-03	01-03: Agriculture, forestry and fishing	1	1
2	Coal, oil & gas	B	05-06	05-06: Coal, oil & gas	2	1
3	Other mining		07-08	07-08: Other mining and quarrying	2	1
4	Mining support		09	09: Mining support service activities	2	1
5	Food products	C	10	10. Food products	3	2
6	Beverages & tobacco		11-12	11: Beverages and tobacco products	3	2
7	Textiles		13	13: Textiles	5	2
8	Wearing apparel		14	14: Wearing apparel	5	2
9	Leather, etc		15	15: Leather and related products	5	2
10	Wood, etc		16	16: Wood and wood and cork products	5	2
11	Paper, etc		17	17: Paper and paper products	5	2
12	Printing & recording		18	18: Printing and reproduction of recorded media	5	2
13	Coke & petroleum		19	19: Coke and refined petroleum products	5	2
14	Chemicals,etc		20	20: Chemicals and chemical products	5	2
15	Pharmaceuticals		21	21: Pharmaceutical products	5	2
16	Rubber & plastic		22	22: Rubber and plastic products	5	2
17	Other non-metallic		23	23: Other non-metallic mineral products	5	2
18	Basic metals		24	24: Basic metals	5	2
19	Metal products		25	25: Metal products, except machinery and equipment	5	2
20	Computers, etc		26	26: Computer, electronic and optical products	4	2
21	Electrical equipment		27	27: Electrical equipment	4	2
22	Machinery, etc		28	28: Machinery and equipment n.e.c.	4	2
23	Motor vehicles, etc		29	29: Motor vehicles, trailers and semi-trailers	5	2
24	Other trans. equipment		30	30: Other transport equipment	5	2
25	Furniture		31	31: Furniture	5	2
26	Other manufacturing		32	32: Other manufacturing	5	2
27	Repair & installation		33	33: Repair and installation of machinery and equipment	5	2
28	Electricity, gas, etc	D	35	35:Electricity, gas, steam and air conditioning supply	6	1
29	Water	E	36	36: Water collection, treatment and supply	7	1
30	Sewerage		37	37: Sewerage	7	1
31	Waste management		38-39	38-39: Waste and waste management services	7	1
32	Construction	F	41	41: Construction of buildings	8	3
33	Civil engineering		42	42: Civil engineering	8	3
34	Specialised construction		43	43: Specialised construction activities	8	3
35	Motor vehicles trade	G	45	45: Wholesale and retail trade of motor vehicles and motorcycles	9	4
36	Wholesale trade		46	46.: Wholesale trade	9	4
37	Retail trade		47	47.: Retail trade	9	4
38	Land transport, etc	H	49	49: Land transport and transport via pipelines	10	4
39	Water transport		50	50: Water transport	10	4
40	Air transport		51	51: Air transport	10	4
41	Warehousing, etc		52	52: Warehousing and support activities for transportation	10	4
42	Postal & courier		53	53: Postal and courier activities	10	4

Notes: These are the 79 Working Futures IV industries defined in SIC2007 divisions.

Table 3 continued: Classification of Industries in *Working Futures IV*

Ind79	Ind79, WF IV name	SIC2007 Section	SIC2007 Division	Full industry name	Ind22	Ind6
43	Accommodation	I	55	55: Accommodation	11	4
44	Food & beverage services		56	56: Food and beverage service activities	11	4
45	Publishing activities	J	58	58: Publishing activities	12	5
46	Film & music		59	59: Motion picture, video and music publishing	12	5
47	Broadcasting		60	60: Programming and broadcasting activities	12	5
48	Telecommunications		61	61: Telecommunications	13	5
49	Computer programming, etc		62	62: Computer programming, consultancy and related activities	13	5
50	Information services		63	63: Information service activities	13	5
51	Financial services	K	64	64: Financial service activities	14	5
52	Insurance & pensions		65	65: Insurance and pension funding	14	5
53	Auxiliary financial services		66	66: Activities auxiliary to financial services and insurance	14	5
54	Real estate	L	68	68: Real estate activities	15	5
55	Legal & accounting	M	69	69: Legal and accounting activities	16	5
56	Head offices, etc		70	70: Activities of head offices; management consultancy activities	16	5
57	Architectural & related		71	71: Architectural and engineering activities	16	5
58	Scientific research		72	72: Scientific research and development	16	5
59	Advertising, etc		73	73: Advertising and market research	16	5
60	Other professional		74	74: Other professional, scientific and technical activities	16	5
61	Veterinary		75	75: Veterinary activities	16	5
62	Rental & leasing	N	77	77: Rental and leasing activities	17	5
63	Employment activities		78	78: Employment activities	17	5
64	Travel, etc		79	79: Travel agency and tour operator activities	17	5
65	Security, etc		80	80: Security and investigation activities	17	5
66	Services to buildings		81	81: Services to buildings and landscape activities	17	5
67	Office admin.		82	82: Office administrative, office support activities	17	5
68	Public admin. & defence	O	84	84: Public administration and defence; compulsory social security	18	6
69	Education	P	85	85: Education	19	6
70	Health	Q	86	86: Human health activities	20	6
71	Residential care		87	87: Residential care activities	20	6
72	Social work		88	88: Social work activities without accommodation	20	6
73	Arts & entertainment	R	90	90: Creative, arts and entertainment activities	21	5
74	Libraries, etc		91	91: Library, archives, museums and other cultural activities	21	5
75	Gambling		92	92: Gambling and betting activities	21	5
76	Sport & recreation		93	93: Sport activities, amusement and recreational activities	21	5
77	Membership organisations	S	94	94: Activities of membership organisations	22	5
78	Repair of goods		95	95: Repair of computers and personal and household goods	22	5
79	Other personal service		96	96: Other personal service activities	22	5

Note: These are the 79 Working Futures IV industries defined in SIC2007 divisions.

6.4   *Reporting at national (UK) level*

Working Futures 2010-20 adopted 22 industry categories defined precisely in terms of the SIC2007. They are shown in Table 4. These categories are the main ones used for UK and regional level reporting of the *Working Futures 2010-2020* projections.

The 22-fold categorization was suggested by UKCES. However, a number of the categories used in Table 4 are very small (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 4 is within the guidelines adopted by ONS for headline statistics on employment (i.e. total numbers of employees). Within the *Sectoral Report*, even more detailed breaks within these categories were needed (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 *Sectoral Report* fall below this threshold. They are included in the absence of any better estimates. For further discussion on these issues see sections 10-14 below.

Table 4: Classification of 22 industries in Working Futures IV

Ind22	Ind22 name	SIC2007 Section	SIC2007 Division	Ind79
1	Agriculture	A	01-03	1
2	Mining & quarrying	B	05-09	2-4
3	Food drink & tobacco	C, part	10-12	5-6
4	Engineering	C, part	26-28	20-22
5	Rest of manufacturing	C, part	13-25, 29-33	7-19, 23-27
6	Electricity & gas	D	35	28
7	Water & sewerage	E	36-39	29-31
8	Construction	F	41-43	32-34
9	Whol. & retail trade	G	45-47	35-37
10	Transport & storage	H	49-53	38-42
11	Accommod. & food	I	55-56	43-44
12	Media	J, part	58-60	45-47
13	IT	J, part	61-63	48-50
14	Finance & insurance	K	64-66	51-53
15	Real estate	L	68	54
16	Professional services	M	69-75	55-61
17	Support services	N	77-82	62-67
18	Public admin. & defence	O	84	68
19	Education	P	85	69
20	Health & social work	Q	86-88	70-72
21	Arts & entertainment	R	90-93	73-76
22	Other services	S	94-96	77-79

6.5   Reporting at country and regional level

At country and regional level, the categories published by ONS for "Government Office Regions" are similar to that for Great Britain with respect to total employees in employment and self-employment. However data for employees by gender and status are only published for more aggregated sectors (19 sectors, see Table 5).

The 22-fold disaggregation has also been adopted for reporting for the regions. However, care needs to be taken in interpreting detailed estimates, especially trends over time.

6.6   Headline reporting at national (UK) level

For summary/ headline reporting, on grounds of brevity, a 6-fold categorization is used. This is shown in Table 6. The purpose of the reporting at this level is to give an overview of the main developments rather than provide sectoral detail (which is presented later in the *Main Report* and separate *Sectoral Report*). This represents a practical compromise, which can be replicated across regions for comparability, without becoming too burdensome for the reader. Table 6 also shows the relationship of the six aggregate sectors with the other groupings used in this *Working Futures* project.

6.7   Reporting on comparisons with Working Futures III

Table 7 defines six aggregate sectors in SIC2003 which are used to compare results from *Working Futures IV* with results from *Working Futures III*.

6.8   Sector Skills Agreement sectors

Table 8 defines the 15 Sector Skills Agreement sectors plus one unallocated residual category. These have been defined in terms of SIC2007 2 digit industries. The allocation has been agreed by UKCES and the various sectors concerned

Table 5: **Industries for which ONS supply employment data by gender and status for Countries and Regions in the UK**

		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: **Aggregate sectors in Working Futures IV**

Broad Sector	SIC2007 Section	SIC2007 Division	Industry full name	Ind22	Ind79
1. Primary sector & utilities	A	01-03	Agriculture, forestry and fishing	1	1
	B	05-09	Mining and quarrying	2	2-4
	D	35	Electricity, gas, steam and air conditioning	6	28
	E	36-39	Water supply; sewerage, waste management	7	29-31
2. Manufacturing	C	10-33	Manufacturing	3-5	5-27
3. Construction	F	41-43	Construction	8	32-34
4. Trade, accom. & transport	G	45-47	Whol. and retail trade; repair of motor vehicles etc	9	35-37
	H	49-53	Transport and storage	10	38-42
	I	55-56	Accommodation and food activities	11	43-44
5. Business & other services	J	58-63	Information and communication	12-13	45-50
	K	64-66	Financial and Insurance activities	14	51-53
	L	68	Real estate activities	15	54
	M	69-75	Professional, scientific and technical activities	16	55-61
	N	77-82	Administrative and support service activities	17	62-67
	R	90-93	Arts, entertainment and recreation; other services	21	73-76

	S	94-96	Other service activities	22	77-79
6. Non-market services	O	84	Public administration and defence etc	18	68
	P	85	Education	19	69
	Q	86-88	Human health and social work	20	70-72

Table 7: **Aggregate Sectors for comparisons with Working Futures III**

Broad Sector	**SIC2003**	**MDM Industries**
1 Primary sector and utilities	A, B, C, E	1-4, 22-24
2 Manufacturing	D	5-21
3 Construction	F	25
4 Distribution, transport etc.	G, H, I	26-32
5 Business and other services	J, K, P	33-37,41
6 Non-marketed services	L, M, N, O	38-40

Note: As used in Wilson et al. (2008) *Working Futures 2007-17*, LSC.

Table 8: Sector Skills Councils (SSA sectors)

SSA industry [SIC]	SIC2007 2-digit industry
1 Agriculture, forestry and fishing [01-03,75]	01 Crop and animal production, hunting and related service activities
	02 Forestry and logging
	03 Fishing and aquaculture
	75 Veterinary activities
2 Energy production and utilities [05-09,35-39]	05 Mining of coal and lignite
	06 Extraction of crude petroleum and natural gas
	07 Mining of metal ores
	08 Other mining and quarrying
	09 Mining support service activities
	35 Electricity, gas, steam and air conditioning supply
	36 Water collection, treatment and supply
	37 Sewerage
	38 Waste collection, treatment and disposal activities; materials recovery
	39 Remediation activities and other waste management services
3 Manufacturing [10-33,72]	10 Manufacture of food products
	11 Manufacture of beverages
	12 Manufacture of tobacco products
	13 Manufacture of textiles
	14 Manufacture of wearing apparel
	15 Manufacture of leather and related products
	16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	17 Manufacture of paper and paper products
	18 Printing and reproduction of recorded media
	19 Manufacture of coke and refined petroleum products
	20 Manufacture of chemicals and chemical products
	21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
	22 Manufacture of rubber and plastic products
	23 Manufacture of other non-metallic mineral products
	24 Manufacture of basic metals
	25 Manufacture of fabricated metal products, except machinery and equipment
	26 Manufacture of computer, electronic and optical products
	27 Manufacture of electrical equipment
	28 Manufacture of machinery and equipment n.e.c.
	29 Manufacture of motor vehicles, trailers and semi-trailers
	30 Manufacture of other transport equipment
	31 Manufacture of furniture
	32 Other manufacturing
	33 Repair and installation of machinery and equipment
	72 Scientific research and development

Table 8: Sector Skills Councils (SSA sectors) (continued)

SSA industry [SIC]	SIC2007 2-digit industry
4 Construction [41-43,71]	41 Construction of buildings
	42 Civil engineering
	43 Specialised construction activities
	71 Architectural and engineering activities; technical testing and analysis
5 Wholesale and retail trade [45-47,77]	45 Wholesale and retail trade and repair of motor vehicles and motorcycles
	46 Wholesale trade, except of motor vehicles and motorcycles
	47 Retail trade, except of motor vehicles and motorcycles
	77 Rental and leasing activities
6 Transportation and storage [49-53]	49 Land transport and transport via pipelines
	50 Water transport
	51 Air transport
	52 Warehousing and support activities for transportation
	53 Postal and courier activities
7 Accommodation, food and tourism activities [55,56,79,92,93]	55 Accommodation
	56 Food and beverage service activities
	79 Travel agency, tour operator and other reservation service and related activities
	92 Gambling and betting activities
	93 Sports activities and amusement and recreation activities
8 Information and communication [61-63,95]	61 Telecommunications
	62 Computer programming, consultancy and related activities
	63 Information service activities
	95 Repair of computers and personal and household goods
9 Creative media and entertainment [58-60,73,74,90,91]	58 Publishing activities
	59 Motion picture, video and television programme production, sound recording and music publishing activities
	60 Programming and broadcasting activities
	73 Advertising and market research
	74 Other professional, scientific and technical activities
	90 Creative, arts and entertainment activities
	91 Libraries, archives, museums and other cultural activities
10 10 Financial, insurance & other professional services [64-66,69,70]	64 Financial service activities, except insurance and pension funding
	65 Insurance, reinsurance and pension funding, except compulsory social security
	66 Activities auxiliary to financial services and insurance activities
	69 Legal and accounting activities
	70 Activities of head offices; management consultancy activities
11 11 Real estate and facilities management [68,80,81]	68 Real estate activities
	80 Security and investigation activities
	81 Services to buildings and landscape activities
12 12 Government [84,94,99]	84 Public administration and defence; compulsory social security
	94 Activities of membership organisations
	99 Activities of extraterritorial organisations and bodies
13 13 Education [85]	85 Education
14 14 Health [86]	86 Human health activities
15 15 Care [87,88]	87 Residential care activities
	88 Social work activities without accommodation
16 16 Not within scope of SSA [78,82,96-98]	78 Employment activities
	82 Office administrative, office support and other business support activities
	96 Other personal service activities
	97 Activities of households as employers of domestic personnel
	98 Undifferentiated goods- and services-producing activities of private households for own use

7 Modelling Gender and Status

7.1 Historical estimates

All official data on employment include breaks by gender. Employment status is more problematic. Office for National Statistics (ONS) estimates, based on the Annual Business Inquiry (ABI), 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 Labour Force Survey (LFS) and the Census of Population (CoP). 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 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 & status shares

As described in Section 2, forecasts of total employment by (MDM 41) industry, by region, were produced using econometric equations. Changes of employment by gender and status were projected by extrapolating recent trends. First, the change over the past seven years in the shares of employment by gender and status was calculated. These 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. This was done for each (MDM 41) industry and region. Aggregates (e.g. UK totals) were calculated by summing the component parts.

Employment forecasts by type (gender/status) for the additional 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.
- A RAS procedure was used to ensure consistency with total employment by MDM industry in the regions and total employment by gender and status for the UK (for each year a matrix of 79 industries by 6 gender/status categories, using the RAS procedure in blocks).[11]

Results for the LEP areas were obtained by analogous methods.

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[11] 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

The Annual Business Inquiry (ABI) and its predecessors do not include information on occupational employment. Generating such estimates relies upon other sources such as the Labour Force Survey (LFS) and the Census of Population (CoP). Because of the infrequent nature of the CoP and the small sample size of the LFS, such estimates are much less robust than those for industrial employment.

The 2001 CoP provided important data on changes in occupational structure at the beginning of the millennium. This is use in conjunction with more up to date information on trends in recent years from the LFS. Together these data have been used to calibrate recent historical trends and adjust the projected future trends.

Estimates from the LFS and CoP were 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** uses SOC2000 categories, based on conversion of data from previous surveys on to the SOC2000 classification.[12] This was done using detailed converters developed by IER in collaboration with ONS.[13] 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 were constrained to match an estimate of employment by SOC2010 categories based on the first official estimates produced by ONS in 2011 using the LFS.

Data from the 2011 CoP will eventually be used to calibrate the database further but these were not available at the time of writing.

The main **Database** therefore provides breakdowns to the 41 SIC2003 industry level as used in MDM. This was extended, as described in Section 10, to cover the full set of 79 industries defined using SIC2007 and to the 12 countries and English regions that make up the UK.

8.2 Projections of occupational structure

The methods for projecting occupational employment change are based on less sophisticated procedures than for sectoral employment. The present methodology is set out in Figure 3. It is based on the use of the SOC2000 classification as set out in Table 10. Projections were developed for the 25 Sub-major Groups. The final result are then translated to a SOC2010 basis for presentational purposes, using a fixed convertor based on LFS data for 2011 (see sheet 'LFSconverters' in

n:/DataDev/Classifications/SOC/SocConvert.xlsx).

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[12] For further details see Section 10.

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

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 approach. Throughout the world, most occupational employment forecasts are based on simplistic extrapolation of past trends.[14]

The availability of time series data from the Labour Force Survey has offered the possibility of a more sophisticated approach, based on econometric analysis of occupational shares (see Briscoe and Wilson (2003)). 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 were generated, therefore, by linking the industry employment results from RMDM to the IER's occupational models, which generate projections of occupational employment shares based on such extrapolative methods. The occupational by industry employment share (SIC-SOC) matrices were 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 in Figure 3.

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*.

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[14] For a review, see Wilson (2001c).

Figure 3: 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 (LFS). 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 9: 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: *SOC 2010: Volume 1: Structure and Description of Unit Groups, ONS.*

Table 10: *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
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 11: 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); stores and despatch clerks, storekeepers; clerical and secretarial occupations n.e.c.	40, 41, 42, 43, 44, 49
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
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).

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 Figure 4. 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 Figure 4. 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 2001 CoP 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 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. For those with access to the more detailed data, a range of alternatives can be provided. Such users can explore alternatives based on their own assumptions. 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 (RD) estimates in the published reports use a "standard" set of assumptions about flow rates, which are common to all sectors and geographies.[15]

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.

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

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);
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.

Figure 4: 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 Labour Force Survey 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 percentage of those employed one year ago who have retired from employment, either temporarily or permanently. For males the main outflows are associated with retirement *per se*. For females, in particular, there is significant 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.

Customised Results for Particular Sectors or Geographies

The Replacement demand module enables the development of customised results for any sector or geographical area.

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 & b) 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, 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 Office for National Statistics (ONS), as well as a broad range of other data relating to occupational employment and skills produced by various Government Departments and other bodies.[16]

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.

10.2   Development of greater sectoral and spatial detail

The standard sectors used in MDM have been set out in Table 1. The reason for the choice of the 41 sectoral disaggregation 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. They are classified according to the 2003 update of the 1992 Standard Industrial classification (SIC2003), (see Table 1).

For the purposes of *Working Futures 2004-2014*, an analysis based on the footprints covered by the then newly established SSCs was required. This in turn demanded a detailed analysis, extending the sectoral coverage to include all the 2-digit categories based on the SIC2003.   The inclusion of employment in private households and extra territorial organisations expanded the total number of sectors to 67.[17] These were the groupings for which the most detailed analysis was undertaken. This was repeated for *Working Futures 2007-2017.*

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[16] Section 11 summarises the sources used.

[17] However, output and employment data were not available for uranium mining and extra-territorial organisations. Effectively, therefore, there were 65 substantive industries for which comprehensive data were developed.

In the present exercise an analogous analysis is presented using some 79 industries based on SIC2007.

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 countries and English regions within the UK;
- Expanding this to cover all 2-digit 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 (RD) module to generate RD estimates across all the various dimensions (described in Section 9).

These procedures were further extended in *Working Futures 2004-2014* to include treatments of Labour Supply (Section 5) and Qualifications.

10.3   The core Database: employment & output by 41 industries

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

Employment for 41 industries: The main MDM employment estimates are based on the 41 SIC2003 categories used in the CE RMDM 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.[18]

Estimates for the old Standard Statistical Regions (SSRs) were converted on to a GOR basis for those regions which are different from the SSRs. This was done using historical estimates of employment for male and female, full-time and part-time by 41 industries for local authority districts. Over the years, Cambridge Econometrics has developed employment series by type and gender for Local Authority Districts (LADs) based on data from NOMIS. These were used to convert series from SSRs to GORs.

Regional productivity by industry, and employment data for counties, were used to make estimates of GDP for the area which had to be reallocated from one SSR to another in order to define GORs. Other variables were treated in an analogous fashion, using data from CE's counties databank to do the reallocation and create historical data.

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[18] 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.

10.4   Occupations (25) within industries (41)

The starting point was information taken from the Census of Population (CoP) for 1981, 1991 and 2001. This was supplemented by information from the Labour Force Survey (LFS). 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 9-11.

Sectoral data were based on the Census of Employment (CoE) the Annual Employment Survey (AES) and most recently the ABI. Together with information from the Census of Population and LFS, these sources were used to generate a series of occupation by industry employment matrices 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 10 and then to the SOC2010 categories as in Table 9.

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 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. More detailed data will be available in due course to do a more sophisticated mapping

Historical data on occupational employment for the Government Office Regions (GOR) 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.

The publication of data from the 2001 Census allowed a reassessment of the first part of conversion process described above. It is clear from this review that the conversion process did not track the changes in occupational structure with great precision. By 2001 a gap had opened up between the converted data and the Census 2001 estimates of occupational employment structure. A further series of adjustments were therefore applied in to allow for "conversion error". This was undertaken just at an aggregate level, over all sectors. A similar adjustment is likely to prove necessary once the results of the 2011 Census are made available in 2012, but for the time being the estimates presented here are the best available.

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 *Working Futures* **Database** had to be extended to cover additional 2-digit SIC2003 categories. Since the cornerstone of the employment projections is RMDM, 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 industrial employment elements from the 41 industries used in RMDM to 2-digit categories involved disaggregating each of the 41 industries which comprise more than a single 2-digit SIC category. In principle, this is straightforward, although it is not quite so easy in practice. ONS currently publish sectoral employment data

at this level of detail (based on the Annual Business Inquiry (ABI)). But the latest data are now on the basis of the SIC2007. The full **Database** has therefore been translated on to this basis for presentational purposes. The ABI data include breakdowns by gender and full-time /part-time status. However, self employment data are not available. Breaks by occupation and spatial area are also much more problematic. Gaps in the official data were filled by using LFS data and assuming common patterns to those in the nearest available aggregate group. 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 67 *Working Futures III* or 79 *Working Futures IV* detailed industries is problematic. Ideally, it would involve 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 current analysis, historical figures for the additional industries were estimated using information already to hand.[19] 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.

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[19] A more comprehensive reassessment of the historical record, involving re-interrogation of old Census records could be undertaken. However, given time and resource constraints, it was decided not to attempt this.

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 RMDM 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 the Annual Business Inquiry (ABI) and the Business Register and Employment Survey (BRES). BRES has replaced the ABI since December 2010 and provides annual employment figures on the 2007 Standard Industrial Classification (SIC 2007) basis only. As well as providing information on output, ABI and BRES are the most important sources of information on industry employment levels.

ONS also undertakes the Labour Force Survey (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, self-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 ABI/BRES based) is given precedence.

All the employment data are constrained to match headline figures published by ONS in the *Economic and Labour Market Review* (ELMR) and similar publications.[20] 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.

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[20] ONS ceased publishing the ELMT as separate document in May 2011, focusing instead on making data available via its main website which delivers statistics and articles online.
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Occupational estimates and self-employment estimates 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 (the summer of 2011). 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 SOC 2010;

- 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 (79 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 SOC 2010)

- Gender;

- Status (full-time, part-time, self-employment);

- Time (years from 1990-2020).

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, 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 ABI 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 GB, UK, and the regions at different levels of industrial disaggregation over 1996-2010. Estimates for agriculture are available for all the above areas. Before 1996 information from the 42 old MDM industries were used. At the local level ABI/BRES data are used, scale to match the regions.

11.5 Northern Ireland

Data for Northern Ireland are collected and published on a different basis to those for Great Britain. The present estimates make use of all published data. Gaps are filled by the same kinds of procedures adopted for producing the additional sectors and geographical areas as described in Section 10. Employment and GVA data for districts in Northern Ireland are provided for 19 aggregate sectors as there is no consistent information to use to create the 79 WF IV industries. The estimates for Northern Ireland should be regarded as indicative of general trends and not precise estimates of employment levels.

12   Generating Results for Local Enterprise Partnership 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 Local Enterprise Partnership (LEP) areas. 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, focussing 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 LEP 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), which is 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   LEP 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 explicitly explored.
- 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.[21] 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.

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.

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[21] 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).

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 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 SSA sectors 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 Local Economy Forecasting Model (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.[22] 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 more general terms in Section 13. The second is discussed in detail 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 FT/PT status information comes from the ABI, the SE numbers are derived from the LFS. The latter is a considerably

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[22] 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 percentage points.

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 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 a few case the data reported in the *Sectoral Report* 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 2009 ABI and related revisions. ONS have recently published 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 (79) industries fall **short** of the 10,000 criterion (again, see the discussion in Section 13 for further details). Even at a 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.[23] 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 maintaining a strict control on the release of such data into the public domain to prevent misuse.

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

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 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 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. Note that all users must be covered by a Chancellor of the Exchequer's 'Notice' (as is required for access to the ABI data via NOMIS).

In order to stay within the terms of *the Statistics of Trade Act,* limits have had to be 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 is appropriate. Any data to be published at an LEP level would need to be even more aggregated.

In developing the rules, three possibilities were explored:

i.   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.

ii.   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.

iii.   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, as iis the case in some tables in the *Sectoral Report.*

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 focussing 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 and which need to be carefully considered in the context of using the data. In particular, there are legal restrictions which limit the extent to which such information can be published. Contravening these limits would fall foul of the terms of the *Statistics of Trade Act, 1947* (and its successors), which prohibit publicly collected data being disseminated in such a manner as to enable the identification of individual enterprises or individuals.

The level of detail provided, particularly for the more highly disaggregated series, would allow individual enterprises to be identified in some cases, and thus access has to be restricted.

Users should read Section 14 carefully to ensure that they understand their legal obligations.

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 UK Commission 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.[24] 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 "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.

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[24] 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).

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 LEP area) at the 41 industry level of detail. Detailed information on self employment is even less reliable, being based on the Labour Force Survey (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 ABI data (which have been subject to frequent revision).[25]   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/IER's Local Economy Forecasting Model (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 current employment estimates reflect the 2009 ABI and related revisions. ONS have also recently published revised aggregate time series data on an SIC2007 basis. These data are also used to constrain the **Database.** The time series data currently made available by ONS for Great Britain are adequate to provide most, but not quite all, of the 79 categories required. However, ABI and other data can be used to fill this gap. [26] Most of the additional categories are quite large and so the concerns about statistical reliability and confidentiality are less of problem than for some other SIC 2-digit categories.

At a regional level, the problems are more acute. ONS are not prepared to release data at anywhere near so detailed a sectoral level, when cross-classified by region. Apart from construction, the categories normally separated out by ONS all form part of the service sector (see Table 5). Only broad aggregates are made available for the other sectors.

These problems are much more severe at a local level. For LEP areas 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.[27] 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 an LEP level.   Instead, a less restrictive line has been adopted here.

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

[26] As noted in Section 9, even using the full Annual Business Inquiry (ABI), there are problems in obtaining sufficient data to publish estimates for a few of these sectors at GB level.

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

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 LEP 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 Local Economy Forecasting Model (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 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 LEP areas and the Sector Skills Agreement sectors.

13.4 *Rules adopted for publication and release of detailed data*

As noted in Section 14, in order to stay within the terms of the *Statistics of Trade Act,* limits have had to 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 22 industries as they are defined in the *Main Report* set the limits at a UK level. This is consistent with the limits set by ONS for the LFS, given the requirement to report on occupational detail *within* sectors. At regional level a more limited number of sectors may be appropriate, but the 22 industries have also been used here with a *caveat emptor* warning to users.

Any data to be published at an LEP level should, in principle, be even more aggregated. 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 annexes.

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 under controlled terms. Access is strictly limited to those in possession of a Chancellor of the Exchequer's Notice (as is applies to similar data available via NOMIS). Such users need to be aware of the limitations of these data and of the legal constraints on their use. ***All users must be covered by a Chancellor of the Exchequer's "Notice".***

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 is indicative:

Industry employment levels 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 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 percentage 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.[28]

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.

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[28] See Wilson and Briscoe (2002) for further discussion.

14   Confidentiality

14.1   General Issues

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 such information can be published. Doing so would fall foul of the terms of the ***Statistics of Trade Act, 1947*** (and its successors), which prohibit publicly collected data being disseminated in such a manner as to enable the identification of individual enterprises or individuals.

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 very strict conditions.

14.2   ONS practice on publication of data

It is informative to consider ONS's own practice in releasing data from the ABI. Table 12 sets out the time series data made available by ONS for Great Britain via NOMIS, showing how these map to the 67 SIC2003 categories. In a number of cases the time series detail made available by ONS is not sufficient to produce some of the "67" categories required. These are indicated by the term "split".   However, ABI and other data can be used to fill this gap.

Even using the full Annual Business Inquiry (ABI) dataset there are problems in a few cases at GB level. However, there are no problems, in principle, in extending the main dataset used for the projections to cover the 67 SIC2003 industry categories. Many of the additional categories are quite large and so the concerns about statistical reliability and confidentiality are not too big a problem, although the inclusion of all the 2 digit categories does involve a number of very tiny sectors. This, however, is for totals across all gender status and occupational categories.

Table 5 has already summarised the position at a regional level. This highlights the fact that ONS are not prepared to release data at anywhere near so detailed a sectoral level when cross-classified by region. Apart from the construction sector, the categories distinguished all form part of the service sector. Only broad aggregates are available for the other sectors.

At a regional level, a number of industries are problematic. These problems are much more severe at a local level. Many of the 67 categories would fall foul of the *Statistics of Trade Act* at an LEP level. Even at national level there are problems for some of the 67 industries. 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 and statistical reliability. A very large number of the detailed sectors are problematic at this level.

Once breaks by gender, status and occupation are added, the number of cases where there are confidentiality and statistical issues rises enormously.

The discussion above highlights that there are real problems in developing reliable data at the levels of detail that analysts and policy makers would ideally like. 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, which could be made available to those with an interest in such information, both within sectors and at an LEP level.

Instead, a less restrictive line has been followed. This involves generating the projections in great detail, while maintaining a strict control on the release of the data into the public domain to prevent misuse.

Table 12: Employment by Detailed Industries (Ind79)

Great Britain	Employees	
Industries 1-40	Fulltime	Parttime
1 Agriculture, etc	148,518	55,499
2 Coal, oil and gas	17,506	624
3 Other mining	16,523	760
4 Mining support	19,126	729
5 Food products	291,466	40,213
6 Beverages and tobacco	37,112	3,147
7 Textiles	47,403	7,289
8 Wearing apparel	18,653	9,465
9 Leather, etc	6,237	884
10 Wood and cork	55,631	3,772
11 Paper, etc	48,079	3,588
12 Printing and recording	107,275	13,569
13 Coke and petroleum	9,078	315
14 Chemicals, etc	98,183	6,432
15 Pharmaceuticals	32,291	2,832
16 Rubber and plastic	136,516	10,041
17 Other non-metallic	81,531	5,532
18 Basic metals	71,264	2,732
19 Metal products	285,185	22,902
20 Computer, etc	109,131	9,591
21 Electrical equipment	72,390	5,191
22 Machinery n.e.c.	163,019	10,967
23 Motor vehicles, etc	130,899	3,654
24 Other transport equipment	129,535	3,754
25 Furniture	76,067	5,268
26 Other manufacturing	76,616	8,674
27 Repair and installation	86,614	5,507
28 Electricity, gas, etc	102,273	8,650
29 Water	26,625	2,414
30 Sewerage	16,124	1,645
31 Waste management	97,644	8,419
32 Construction	317,581	40,831
33 Civil engineering	192,162	15,349
34 Specialised construction	624,140	72,613
35 Motor vehicle trade	377,758	60,224
36 Wholesale trade	922,547	139,579
37 Retail trade	1,178,381	1,570,359
38 Land transport, etc	403,708	90,254
39 Water transport	12,517	2,094
40 Air transport	57,825	16,375

Table 12: Employment by Detailed Industries (Ind79) continued

	Employees	
Industries 41-79	Fulltime	Parttime
41 Warehousing, etc	311,244	40,341
42 Postal and courier	220,999	56,572
43 Accommodation	213,632	150,371
44 Food and beverage services	549,892	850,353
45 Publishing activities	121,708	30,334
46 Film and music	57,155	25,780
47 Broadcasting	20,127	1,621
48 Telecommunications	191,135	23,122
49 Computing services	394,096	53,331
50 Information services	50,476	4,683
51 Financial services	427,851	109,616
52 Insurance and pensions	91,248	15,464
53 Auxiliary financial services	331,844	59,459
54 Real estate	291,249	106,873
55 Legal and accounting	403,090	106,292
56 Head offices, etc	412,694	79,547
57 Architectural and related	342,126	60,684
58 Scientific research and development	103,515	11,823
59 Advertising, etc	98,483	37,823
60 Other professional	99,001	28,410
61 Veterinary	24,925	16,062
62 Rental and leasing	113,736	19,665
63 Employment activities	526,725	223,840
64 Travel, etc	63,769	21,414
65 Security, etc	146,002	30,234
66 Services to buildings	249,450	347,336
67 Office administrative	224,569	64,283
68 Public administration and defence	1,133,118	351,718
69 Education	1,285,749	1,202,678
70 Health	1,135,804	816,370
71 Residential care	344,745	267,459
72 Social work	470,136	388,222
73 Arts and entertainment	38,688	25,699
74 Libraries, etc	54,842	46,453
75 Gambling and betting	46,346	36,593
76 Sport and recreation	164,254	226,831
77 Membership organisations	131,060	90,542
78 Repair of goods	34,966	5,844
79 Other personal service	185,811	99,723
Total	17,807,397	8,405,204

Source: NOMIS, BRES data, 2009.

15   Skill Supply and Demand Projections

15.1   Conceptual issues

There are many conceptual difficulties in modelling labour supply by level of skill. 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, focussing 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:

i.	total population;
ii.	population aged 16 and over;
iii.	working age population;
iv.	labour force;
v.	workforce;
vi.	ILO unemployment;
vii.	claimant unemployment;
viii.	employed residents;
ix.	workplace employment;
x.	labour market residual.

A set of stochastic behavioural equations to forecast economic activity rates by region and age-band/gender has been incorporated into RMDM. These include a number of explanatory variables including unemployment. These are generally regional-specific variables, rather than age-band/gender specific. The differences between age-bands/genders are picked up in a constant specific to those groups. A strong effect coming from the characteristics of the region is incorporated (notably, how tight the labour market is, and how expensive it is to live there). The equations are estimated across regions, since that is where the variation is largest.

The specification of the equations draws upon earlier econometric work that IER undertook on behalf of DfEE (which underlies the systems currently used to construct the official projections of economic activity rates). 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 RMDM.

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

i.   work-place based employment is determined using the existing RMDM equations;
ii.   regional labour force is determined by activity rates multiplied by working-age population;
iii. regional activity rates (by age-band/gender) are modelled as a function of unemployment and other variables, *e.g.* house prices relative to wages;
iv.   regional unemployment (ILO) = is determined from regional unemployment (claimant count);
v.   the Labour Force Survey measure of employment is determined from regional labour force minus regional unemployment (ILO);
vi.   the labour market residual (one component of which is net commuting) is determined from workforce (workplace) employment minus the Labour Force Survey measure of employment.

The difference between the Labour Force Survey (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.

In RMDM, total working-age population for each region is determined by the natural increase in working-age population plus net working-age migration. Regional in and out-migration of working-age population are both assumed to be affected by the same economic factors. The migration is modelled as occurring from the region to the outside world and vice versa. The explanatory variables used include a measure of regional surplus labour relative to the UK, the mortgage rate, relative wages and a linear time trend.

ONS projections of population are used to calculate shares by gender and by age-band. These shares are applied to the RMDM forecasts of total population to produce projections of population by gender and by age-band.

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[29] so also delivers projections disaggregated by age-band.

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. 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. For more details readers are referred to the separate **Qualifications Technical Report** , which describes the detailed models and methods used to develop the estimates of the demand for and supply of skills (as measured by qualifications).[30]

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 UK Commission. It builds on the models already developed for *Working*

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[29] The age-bands distinguished are 0-15, 16-24, 25-34, 35-44, 45-59, 60-64, 65+.
[30] Bosworth and Wilson (2012).

Futures 2004-2014 and for other work, focussing upon both demand and supply. The present exercise focuses on the highest level of qualification held, as defined in previous work for the Treasury and in the modelling undertaken for the UK Commission.

The "supply of qualifications" focuses on the future flows of individuals in the population with different qualification levels (based upon the new Qualifications and Credit Framework (QCF)),[31] using a stock flow / pseudo cohort modelling approach. An important distinction between the qualification results presented here and those developed previously for the UK Commission 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 "demand side". This generates estimates and projections of employment, unemployment and inactivity 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.

Modelling was attempted using both a stock flow model (STOCKFLOW), and a more simplistic approach based on extrapolation of trends in stocks (**National model**). The former distinguishes year of age, incorporating information inflows of newly qualified people and losses due to mortality retirement, *etc*, as reflected in LFS data, Inflows by qualification level are modelled using pseudo-cohort data from the LFS at the level of the UK. The results are then linked to the latest ONS (GAD) projections of the population and projections of the labour force by age and gender, as set out above.

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 UK Commission). On balance the **National model** is preferred as giving more robust results. The STOCKFLOW 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 see Bosworth and Wilson (2012).

While the **National model** assumes that the net effects of migration are neutral in terms of skills, this is an important issue which is explored in some 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*.[32] This is done by broad age group (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 uses a probabilistic approach

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[31] QCF has been developed in parallel with the National Qualifications Framework (NQF) see: www.qcda.gov.uk/resources/assets/qca-06-2298-nqf-web.pdf for details. The QCDA will close in March 2012. QCDA provide a link to the National Archives website:- http://webarchive.nationalarchives.gov.uk/20110813032310/http:/www.qcda.gov.uk/. Another site which is helpful in explaining the meaning of different qualification levels can be found at:- http://www.direct.gov.uk/en/EducationAndLearning/QualificationsExplained/DG_10039017.

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

(mprobit or mlogit) to modelling these shares which ensures that the estimates (and projected shares) sum to 100 per cent. 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, 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, focussing 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).

16   Comparison with Previous Projections

16.1   Comparison with previous results Sectoral Employment and Productivity

Figure 5 and Tables 13-16 compare the employment forecasts from *Working Futures 2010-2020* (WF IV) with the forecasts from *Working Futures 2007-2017* (WF III). Figure B.1 provides an overview of the difference in total employment and clearly illustrates the impact of the global financial crisis (GFC) and subsequent worldwide recession. Employment in total is probably around 2 million less than might have been the case if the GFC could have been averted. This clearly had a major impact on employment levels across the board. However the impact on employment patterns (shares) by sector and occupation have been less dramatically affected.

Table 13 presents data and forecasts for the broad industries as defined in WF III i.e. in SIC2003 definitions. WF III presented forecasts over the period 2007-17. However, in WF IV the change of employment over 2007-10 is based on official published data. These data use SIC2007 categories, and in Table 13 have been translated to SIC 2003 definitions in order to make comparisons with the WF III estimates. Comparisons are presented for two periods, 2007-10 and 2010-17.

The more recent WF IV analysis based on published data for 2007-2010, shows a decline of 2½ per cent in employment reflecting the impact of the 2008-09 recession. This is equivalent to a loss of about 827 thousand jobs and it is in sharp contrast with the forecast from the WF III where an increase of just under 2 per cent (around 568 thousand jobs) was predicted prior to the crisis. For most broad sectors the outturn is worse than the forecast from WF III. There are two exceptions: primary & utilities, partly reflecting a doubtful (but officially reported) very sharp increase in agricultural jobs, and in Non-market services as the government boosted employment in the public sector trying to counterbalance the effect of the recession on jobs in the private sector.

Comparing employment by type and the relative performances over 2007-10, perhaps the most distinctive feature in the WF IV data is the sharper decline in full-time jobs for females rather than for males over the recession (-6½ per cent). However, female self-employment seems to have performed better than was forecast in WF III (see Table 14).

Over the period 2010-17, there is a forecast increase in jobs by 862 thousand in WF IV, equivalent to just under 3 per cent. This is substantially less than the 1.4 million (4¼ per cent) forecast in WF III. The most important difference between the two forecasts comes from the decline in the jobs in government services now expected in WF IV (around -314 thousand) compared with an increase of equal size expected in WF III. This reflects the policies now being carried out to reduce the deficit in public sector finances. The other significant difference is the much milder decline expected in manufacturing jobs in WF IV compared with WF III.

Comparing employment by type, perhaps the important difference is in the increase in male full-time jobs. While the increase in female full-time jobs is similar in the two forecasts, the increase in full-time male in the WF IV is about one-quarter of the corresponding increase in WF III. The smaller increase in jobs forecast in WF IV mainly reflects fewer jobs for males in full-time jobs.

Figure 5: Impact of the recession on UK Total Employment
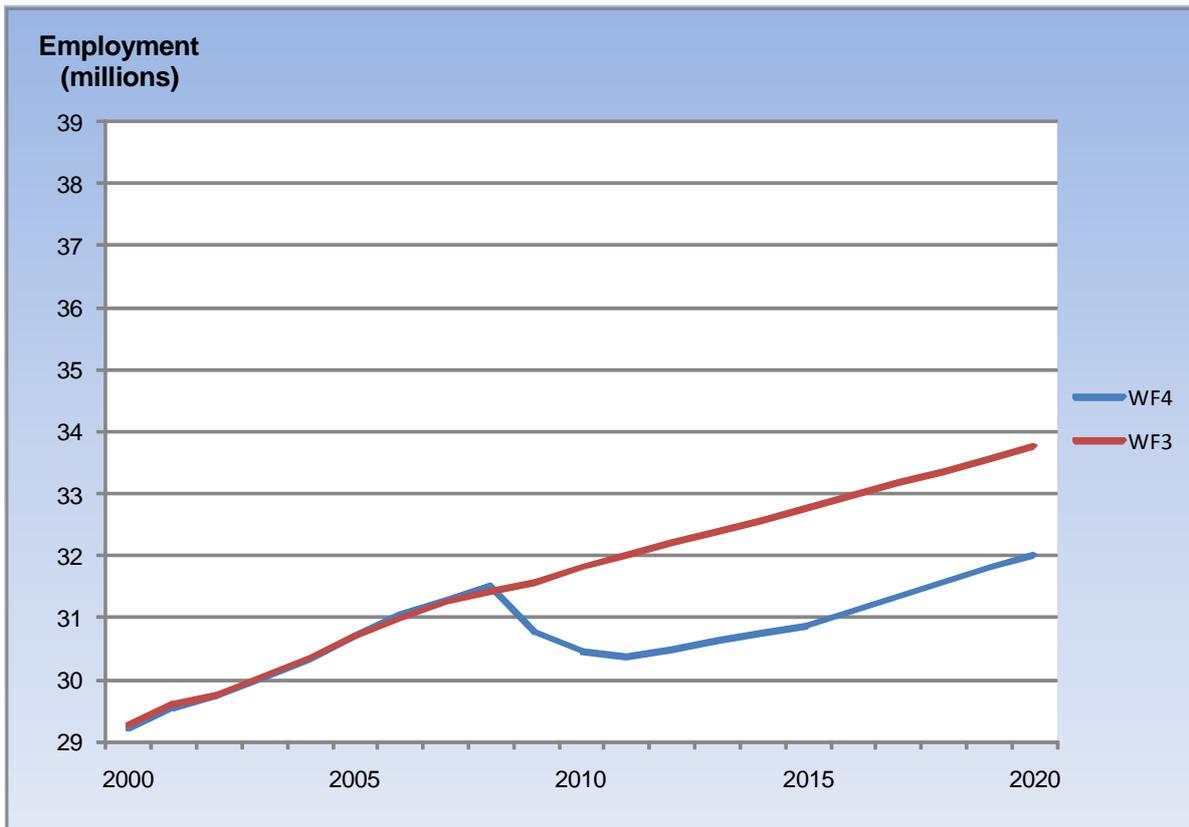
Comparing the employment forecast over the decade (i.e. WF IV 2010-20, WF III 2007-17) the main differences are:

- the increase in jobs in WF IV is lower over the decade than in WF III;

- government sector jobs fall in WF IV while they were projected to increase rapidly in WF III;

- growth in jobs in marketed services is slower in WF IV;

- growth in jobs in primary & utilities, manufacturing and construction performs better in WF IV, although in primary & utilities and manufacturing employment is still declining.

Table 13: Comparison of Working Futures IV with Working Futures III by Broad Sector

Working Futures III	2007	2010	2017	2020	2007-10	2010-17	2007-17	
						Employment ('000s)		
Primary & utilities	633	590	503	n.a.	-43	-87	-130	
Manufacturing	3,181	3,040	2,750	n.a.	-141	-290	-432	
Construction	2,187	2,256	2,361	n.a.	70	105	175	
Distribution, transport etc	8,881	9,024	9,418	n.a.	143	394	537	
Business & other services	8,573	8,949	9,879	n.a.	376	929	1,306	
Non-marketed services	7,977	8,140	8,454	n.a.	163	314	477	
Total	31,432	32,000	33,365	n.a.	568	1,365	1,933	
		Shares (per cent)			growth (per cent)			
Primary & utilities	2.0	1.8	1.5	n.a.	-6.8	-14.7	-20.5	
Manufacturing	10.1	9.5	8.2	n.a.	-4.4	-9.5	-13.6	
Construction	7.0	7.1	7.1	n.a.	3.2	4.6	8.0	
Distribution, transport etc	28.3	28.2	28.2	n.a.	1.6	4.4	6.0	
Business & other services	27.3	28.0	29.6	n.a.	4.4	10.4	15.2	
Non-marketed services	25.4	25.4	25.3	n.a.	2.0	3.9	6.0	
Total	100.0	100.0	100.0	n.a.	1.8	4.3	6.1	
Working Futures IV	2007	2010	2017	2020	2007-10	2010-17	2007-17	2010-20
						Employment ('000s)		
Primary & utilities	693	767	759	745	74	-8	66	-22
Manufacturing	2,966	2,518	2,421	2,347	-448	-97	-545	-170
Construction	2,302	2,092	2,259	2,329	-210	167	-43	237
Distribution, transport etc	8,431	7,977	8,257	8,392	-454	280	-174	415
Business & other services	9,103	8,909	9,745	10,103	-194	836	642	1,195
Non-marketed services	7,790	8,195	7,893	8,092	405	-302	103	-103
Total	31,285	30,458	31,333	32,008	-827	875	48	1,550
		Shares (per cent)			growth (per cent)			
Primary & utilities	2.2	2.5	2.4	2.3	10.7	-1.1	9.5	-2.9
Manufacturing	9.5	8.3	7.7	7.3	-15.1	-3.8	-18.4	-6.8
Construction	7.4	6.9	7.2	7.3	-9.1	8.0	-1.9	11.3
Distribution, transport etc	26.9	26.2	26.4	26.2	-5.4	3.5	-2.1	5.2
Business & other services	29.1	29.2	31.1	31.6	-2.1	9.4	7.1	13.4
Non-marketed services	24.9	26.9	25.2	25.3	5.2	-3.7	1.3	-1.3
Total	100.0	100.0	100.0	100.0	-2.6	2.9	0.2	5.1

Note: Sectors are defined in SIC2003.

Source: Cambridge Econometrics, MDM revision 7146.

Table 14: Comparison of Working Futures IV with Working Futures III: Employment by Status

Working Futures III				Employment ('000s)			
	2007	2010	2017	2020	2007-10	2010-17	2007-17
Male FT	11,563	11,702	12,035	n.a.	139	333	472
Female FT	7,036	7,126	7,323	n.a.	89	198	287
Male PT	2,163	2,349	2,834	n.a.	186	485	671
Female PT	6,465	6,559	6,775	n.a.	94	216	310
Male SE	2,973	2,991	3,010	n.a.	17	20	37
Female SE	1,231	1,274	1,387	n.a.	43	113	156
Total	31,432	32,000	33,365	n.a.	568	1,365	1,933
		Shares (per cent)				(per cent)	
Male FT	36.8	36.6	36.1	n.a.	1.2	2.8	4.1
Female FT	22.4	22.3	21.9	n.a.	1.3	2.8	4.1
Male PT	6.9	7.3	8.5	n.a.	8.6	20.7	31.0
Female PT	20.6	20.5	20.3	n.a.	1.5	3.3	4.8
Male SE	9.5	9.3	9.0	n.a.	0.6	0.7	1.2
Female SE	3.9	4.0	4.2	n.a.	3.5	8.9	12.6
Total	100.0	100.0	100.0	n.a.	1.8	4.3	6.1

Working Futures IV				Employment ('000s)			
	2007	2010	2017	2020	2007-10	2010-17	2007-17	2010-20
Male FT	11,463	10,905	10,999	11,078	-558	94	-464	173
Female FT	7,172	6,711	6,930	7,126	-462	219	-242	415
Male PT	2,211	2,227	2,540	2,694	16	313	328	468
Female PT	6,284	6,262	6,482	6,685	-22	219	198	423
Male SE	2,940	2,995	3,014	3,033	55	19	75	38
Female SE	1,215	1,358	1,369	1,392	143	11	154	34
Total	31,285	30,458	31,333	32,008	-827	875	48	1,550
		Shares (per cent)				(per cent)		
Male FT	36.6	35.8	35.1	34.6	-4.9	0.9	-4.0	1.6
Female FT	22.9	22.0	22.1	22.3	-6.4	3.3	-3.4	6.2
Male PT	7.1	7.3	8.1	8.4	0.7	14.0	14.8	21.0
Female PT	20.1	20.6	20.7	20.9	-0.3	3.5	3.1	6.7
Male SE	9.4	9.8	9.6	9.5	1.9	0.6	2.5	1.3
Female SE	3.9	4.5	4.4	4.3	11.8	0.8	12.6	2.5
Total	100.0	100.0	100.0	100.0	-2.6	2.9	0.2	5.1

Table 15: *Comparison of Working Futures IV with Working Futures III: Productivity*

Working Futures III			change (per cent)	
	2007-10	2010-17	2007-17	
Primary & utilities	9.9	25.6	38.0	
Manufacturing	9.2	21.9	33.1	
Construction	2.6	11.3	14.2	
Distribution, transport etc.	7.0	16.6	24.7	
Business & other services	5.4	13.4	19.5	
Non-marketed services	4.9	11.9	17.4	
Total	6.0	14.9	21.9	
Working Futures IV			change (per cent)	
	2007-10	2010-17	2007-17	2010-20
Primary & utilities	-16.6	6.7	-11.0	13.2
Manufacturing	5.7	26.2	33.4	35.5
Construction	3.5	7.9	11.7	13.4
Distribution, transport etc.	0.7	20.9	21.7	31.1
Business & other services	-0.6	15.4	14.7	24.5
Non-marketed services	-1.9	5.2	3.2	10.9
Total	-0.6	15.8	15.1	24.1

Source: Cambridge Econometrics, MDM revision 7146.

Table 16: *Comparison of Working Futures IV with Working Futures III by Occupation*

Working Futures III

	2007	2010	2017	2020	2007-10	2010-17	2007-17	
(SOC 2000)							Employment ('000s)	
Managers and Senior officials etc	4,858	5,111	5,731	n.a.	253	620	873	
Professional occupations	4,117	4,304	4,759	n.a.	187	456	643	
Associate professional & technical	4,500	4,691	5,154	n.a.	190	463	654	
Administrative & secretarial	3,739	3,624	3,337	n.a.	-115	-287	-401	
Skilled trades occupations	3,426	3,361	3,196	n.a.	-65	-165	-230	
Paesonal service occupations	2,498	2,627	2,941	n.a.	129	314	444	
Sales & customer care occupations	2,433	2,463	2,536	n.a.	30	72	103	
machine and transport operatives	2,304	2,270	2,184	n.a.	-34	-86	-120	
Elementary occupations	3,558	3,549	3,526	n.a.	-8	-23	-32	
Total	31,432	32,000	33,365	n.a.	568	1,365	1,933	
		Shares (per cent)			growth (per cent)			
Managers and Senior officials etc	15.5	16.0	17.2	n.a.	5.2	12.1	18.0	
Professional occupations	13.1	13.4	14.3	n.a.	4.5	10.6	15.6	
Associate professional & technical	14.3	14.7	15.4	n.a.	4.2	9.9	14.5	
Administrative & secretarial	11.9	11.3	10.0	n.a.	-3.1	-7.9	-10.7	
Skilled trades occupations	10.9	10.5	9.6	n.a.	-1.9	-4.9	-6.7	
Paesonal service occupations	7.9	8.2	8.8	n.a.	5.2	12.0	17.8	
Sales & customer care occupations	7.7	7.7	7.6	n.a.	1.3	2.9	4.2	
machine and transport operatives	7.3	7.1	6.5	n.a.	-1.5	-3.8	-5.2	
Elementary occupations	11.3	11.1	10.6	n.a.	-0.2	-0.7	-0.9	
Total	100.0	100.0	100.0	n.a.	1.8	4.3	6.1	

Working Futures IV

	2007	2010	2017	2020	2007-10	2010-17	2007-17	2010-20
(SOC 2010)							Employment ('000s)	
Managers, directors and senior officials	2,992	3,016	3,393	3,560	23	-27	401	544
Professional occupations	5,703	5,843	6,398	6,712	140	-26	694	869
Associate professional and technical	4,030	3,926	4,274	4,476	-104	-25	245	551
Administrative and secretarial	3,947	3,698	3,407	3,312	-249	-24	-541	-387
Skilled trades occupations	3,729	3,526	3,359	3,295	-203	-23	-369	-230
Caring, leisure and other service	2,585	2,719	2,893	3,032	134	-22	309	313
Sales and customer service	2,635	2,608	2,577	2,610	-27	-21	-58	2
Process, plant and machine operatives	2,139	1,950	1,797	1,737	-189	-20	-342	-213
Elementary occupations	3,525	3,173	3,235	3,274	-353	-19	-291	101
Total	31,285	30,458	31,333	32,008	-827	-18	48	1,550
		Shares (per cent)			growth (per cent)			
Managers, directors and senior officials	9.6	9.9	10.8	11.1	0.8	-0.9	13.4	18.0
Professional occupations	18.2	19.2	20.4	21.0	2.5	-0.4	12.2	14.9
Associate professional and technical	12.9	12.9	13.6	14.0	-2.6	-0.6	6.1	14.0
Administrative and secretarial	12.6	12.1	10.9	10.3	-6.3	-0.6	-13.7	-10.5
Skilled trades occupations	11.9	11.6	10.7	10.3	-5.5	-0.7	-9.9	-6.5
Caring, leisure and other service	8.3	8.9	9.2	9.5	5.2	-0.8	12.0	11.5
Sales and customer service	8.4	8.6	8.2	8.2	-1.0	-0.8	-2.2	0.1
Process, plant and machine operatives	6.8	6.4	5.7	5.4	-8.8	-1.0	-16.0	-10.9
Elementary occupations	11.3	10.4	10.3	10.2	-10.0	-0.6	-8.2	3.2
Total	100.0	100.0	100.0	100.0	-2.6	-0.1	0.2	5.1

Source: Cambridge Econometrics, MDM revision 7146 and IER estimates.

Table 15 compares productivity by broad sector. Official data show now that output per job fell by 0.6 per cent over 2007-10. In WF III the forecast was for an increase of 6 per cent over the same period. Part of this difference is explained by the change in productivity in the non-marketed services. While in WF IV productivity fell by almost 2 per cent, reflecting the faster increase in employment than in output, in WF III the forecast was for an increase in productivity of about 5 per cent. Productivity in market services also performed worse in WF IV, as business retained employment but reduced working hours in the recession.

Over 2010-17 UK productivity as a whole is expected to rise slightly faster in WF IV than was forecast in WF III. However, manufacturing and private services productivity is expected to show the best gains. Productivity in primary & utilities, construction and Non-market services is expected to grow somewhat less rapidly than in WF III.

Comparing the productivity forecast over the decade (i.e. WF IV 2010-20, WF III 2007-17) the main differences are:

- productivity in the UK is expected to increase by 24 per cent in WF IV, which is 2 percentage points faster than the forecast from WF III;

- growth in manufacturing productivity is slightly faster (2 percentage points) in WF IV;

- growth in productivity in distribution & transport is strong at 31 per cent in WF IV, 6 percentage points faster than in WF III;

- productivity in Non-market services and primary & utilities is much lower in WF IV than in WF III.

16.2   Comparison with previous forecasts for Occupations

The analogous comparison for occupations is shown in Table 16. The comparison of the occupational projections is also complicated by changes in classification. The switch from SOC2000 to SOC2010 resulted in significant changes in how jobs were classified. The main changes affect the shares employed in managerial occupations (the much tighter definitions in SOC2010 reducing the share) and nursing being largely reclassified as professional (as opposed to associate professionals).

The new estimate of the total number of managers in 2007 is now around 2 million lower than in the previous *Working Futures* projections. Professional occupations are the main area where such jobs have been reallocated in the new SOC. The associate professional group also benefits to some degree, but this is more than offset by the switch of nurses to the professional group. The employment shares of the other occupational groups are broadly similar in the old and new results (although note that these are based on two different occupational classifications, SOC2000 and SOC2010).

The other key factor which is different between the two sets of projections is of course the impact of the recession. In WF II an increase of employment of over half a million was expected between 2007 and 2010. The latest results show a decline of more than ¾ of a million jobs. All occupations have shared in the job losses, although for those such a managers and professional sit has been in the form of less than expected growth while for many other occupations job losses have been greater than expected.

Experience suggests that occupational patterns do recover from such 'shocks' and that longer term trends are generally re-established relatively quickly. Sharp recessions often hasten the structural changes going on the economy, resulting in the more rapid decline of struggling sectors and declining occupations and the birth of new ones. The increasingly inter-connected nature of the global economy may help to hasten this process. Analysis of previous recessions suggest that, while the impact on employment levels can be quite severe as the downturn accelerates, the effect on patterns of labour demand by sector and skill are much less marked, and that the underlying trends in such shares are quite robust.

This is the case here. Despite the changes in classification, at the major group level, the occupational trends over the period since the early 1980s are indeed very similar to those presented in previous *Working Futures* projections.

Compared with earlier projections, much slower growth over the period 2007-2017 is now indicated for: managers; associate professional occupations; and sales occupations. Somewhat more rapid declines than previously expected are now projected for: administrative, clerical & secretarial occupations; skilled trades; sales occupations; process, plant and machine operatives; and elementary occupations.

Comparing the changes expected over the decade 2010-2020 with those projected previously for 2007-2017, the overall shifts in occupational employment structure are fairly similar. Employment growth is expected to favour managers, professional and associate professionals, plus a few generally less skilled occupations such as caring, leisure and other service occupations. Job losses hit hardest for: administrative and secretarial; skilled trades; and process, plant and machine operatives. Sales occupations are expected to see some job losses now, while there is a modest growth in some elementary occupations (linked to the expansion of some parts of the service sector).

16.3 Comparison with previous results by Country and Region

Background

This section compares the current set of projections with the *Working Futures* projections for the period 2007 to 2017, focussing on the regions and nations of the UK. The actual values change between projections for a whole host of reasons, including: choice of different periods; revisions to historical data and models; and the changing economic circumstances between the times at which the projections were made. However, it is possible to compare the broad patterns of projected change between the two sets of projections.

The projections for 2010 to 2020 are for a slightly faster annual average rate of growth in GVA and a slightly slower rate of growth in employment than was projected for 2007 to 2017. This is mainly accounted for by the fact that the latest projections encompass the recovery from the deep recession of 2008-9. The broad trends of employment change across

industries, regions and time demonstrate considerable similarity for the two projections. The key similarities and differences in the projected regional trends are discussed below.

16.4   Comparison of overall prospects by region and nation

The spatial pattern of annual average rates of change in GVA is very similar in both sets of projections. In each case, GVA is projected to increase in all regions and nations, with the highest rate of increase being projected for London. Rates of growth are much lower in the midlands and northern England than in southern England. The growth rate of Wales is slightly lower and that of Scotland slightly higher in the latest projections than was projected for Working Futures 3. Wales is the only nation or region in which GVA is projected to grow more slowly.

In both sets of projections, employment growth is projected to be fastest in southern England. Total employment is projected to grow at the same or at a slightly slower rate in nearly all regions and nations. However, no employment growth is projected for 2010-20 in the North East, compared with an annual average rate of employment change of 0.3 per cent in the previous set of projections.

The labour market residuals for the Working Futures 4 projections are only about half as large as those for the previous set of projections. The very large residuals in the North West, West Midlands and Scotland in the projections for 2007-17 are not present in the current set of results.

16.5   Comparison by broad sector

The 2010-20 projections by broad sector exhibit marked differences to the projections of *Working Futures 2007-17.* GVA was projected to increase in all sectors between 2007 and 2017. However, the projections for 2010-20 are for no growth in the primary sector and utilities, faster growth in manufacturing, construction and business and other services and much slower growth in Non-market services. *Working Futures 2007-17* projected rapid declines in employment in the primary sector and utilities and in manufacturing and relatively slow growth in construction and the service sector industries, with business and other services gaining employment most quickly. The projected rate of decline in employment between 2010 and 2020 in the primary sector and utilities is slower and the growth of employment in trade, accommodation and transport and business and other services is slower. The largest differences are in the higher predicted rate of employment growth in construction and the decline in employment in Non-market services.

Regional differences in rates of employment change between the projections for 2007-17 and 2010-20 are clearly influenced by the effect of the 2008/9 recession and the recovery from it. Thus, the rate of decline of manufacturing employment in the midlands and Wales is projected to be much slower for 2010-20 than for 2007-17. There is a rates of employment growth to be faster in the southern and eastern regions than in the northern and western regions and nations in both sets of projections and this is strongest in the projected pattern of employment change between 2010 and 2020 in Non-market services, with the periphery experiencing the greatest negative effects from the contraction of the public sector.

16.6   Comparison by occupation

The pattern of projected employment changes for SOC Major Groups 1 to 5 is broadly similar for both 2007-17 and 2010 to 2020. However, the largest differences for 2010-20 relative to 2007-17 are in the much slower projected growth of caring, leisure and other service occupations, the switch of sales and customer service occupations from growth to decline, the much faster decline of process, plant and machine operative occupations. Overall, the difference in occupational employment projections can be summarised as an acceleration of the trend towards the polarisation of employment into growing employment in high and low-skilled occupations and a 'hollowing out' of employment in the middle range of skilled manual employment and more routine non-manual occupations.

There is less regional and national variation in rates of employment change by occupation projected for 2010-20 than was projected for 2007-17. The key spatial differences in the pattern of occupational employment change are the faster rates of loss of associate professional and process, plant and machine operative occupations in northern England and the nations beyond England.

16.7   Comparison by gender and employment status

The most striking differences between the two sets of projections are in the much slower rates of female employment growth projected for 2010-20 than for 2007-17. The largest difference is in the rate of growth of female self-employment. Male part-time employment is also projected to grow more slowly than in the 2007-17 set of projections. However, there is little difference in the spatial pattern of employment change by gender or full-time / part-time status. Self-employment is projected to grow more slowly during 2010-20 than for 2007-17 in southern England, but more quickly in northern England and the non-English nations.

17   General caveats on the employment estimates

17.1   *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 in the *Sectoral Report*, 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. Table 17 shows that in a number of industries total employment in 2010 is well below 250,000. 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 (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, 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.

17.2   *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 dimension s 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 Economic and Labour Market Review (ELMR) and similar publications.[33] 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 2011). 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. So our 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 SOC 2010;

- 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.

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[33] ONS ceased publishing the ELMT as separate document in May 2011, focusing instead on making data available via its main website which delivers statistics and articles online.

Table 17: Output and employment shares in the 22 industries

| | Employment | | Output |
	thousands	% of total	% of total
Primary sector & utilities	*767*	*2.5*	*3.4*
Agriculture	453	1.5	0.6
Mining & quarrying	57	0.2	0.4
Electricity & gas	99	0.3	1.5
Water & sewerage	158	0.5	0.9
Manufacturing	*2,518*	*8.3*	*11.9*
Food drink & tobacco	401	1.3	2.1
Engineering	397	1.3	2.3
Rest of manufacturing	1,719	5.6	7.5
Construction	*2,092*	*6.9*	*6.8*
Trade, accomod. & transport	*7,977*	*26.2*	*20.5*
Whol. & retail trade	4,661	15.3	12.5
Transport & storage	1,424	4.7	4.9
Accommod. & food	1,892	6.2	3.2
Business & other services	*8,909*	*29.2*	*37.0*
Media	323	1.1	1.8
IT	773	2.5	5.6
Finance & insurance	1,092	3.6	8.9
Real estate	436	1.4	2.2
Professional services	2,280	7.5	9.2
Support services	2,353	7.7	5.4
Arts & entertainment	856	2.8	2.1
Other services	796	2.6	1.9
Non-marketed services	*8,195*	*26.9*	*20.5*
Public admin. & defence	1,544	5.1	5.6
Education	2,703	8.9	6.5
Health & social work	3,948	13.0	8.3
All Sectors	30,458	100.0	100.0

Source: Cambridge Econometrics, MDM revision 7146.

Notes: a) Broad sectors are indicated by italics.

        b) Both the sectors and the broad sectors are defined in the Technical Report.

        c) Total employment and employment in non-marketed services includes H. M

        c) Output excludes unallocated and ownership of dwellings.

          Shares therefore differ from those in Table 3.1 of the Main Report.

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
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	Multi-sectoral Dynamic Macroeconomic 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
RAS	Iterative procedure (see Section 11)
RD	Replacement Demand
RMDM	Regional Multi-sectoral Dynamic Model
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
WF I	Working Futures 2002-2012
WF II	Working Futures 2004-2014
WF III	Working Futures 2007-2017
WF IV	Working Futures 2010-2020
UKCES	UK Commission for Employment and Skills

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