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Abstract

In recent years, a series of European labour market forecasts have been produced on behalf of, and have been published by, the European Centre for the Development of Vocational Training (Cedefop). These forecasts were generated using a modular modelling approach containing two major components, a multi-sector macroeconomic model (E3ME) for 29 European countries, and a labour market extension (WLME). The countries are treated as an integrated system in E3ME but the extension is applied to each country separately. Forecasts of employment by industry are determined by E3ME; forecasts of employment by occupation and qualification are determined by the extension. Both components rely mainly on time series econometric techniques to generate their forecasts. Meagher et al. (2014) describe how the WLME can be replaced with an alternative extension (MLME) which uses computable general equilibrium (CGE) modelling techniques. Compared to the WLME, the MLME relies less on time series analysis and more on explicitly modelled economic behaviour, based on theoretical considerations.

In this paper, the design of the hybrid E3ME-MLME model is advanced in two ways. Firstly, MLME is configured such that, in the absence of any shocks and assuming that the occupational labour markets clear, it reproduces the forecasts derived using WLME. In that case, the MLME forecasts can be regarded as providing enhanced information about the WLME forecasts. In particular, MLME provides forecasts of changes in relative wage rates which can be used to identify structural pressures in the markets for labour, pressures which remain only implicit in the WLME employment forecasts produced for Cedefop. Secondly, when suitably configured, MLME can be used to determine the deviations to the WLME employment forecasts which would result if some of the conditions (either explicit or implicit) under which they were derived are relaxed. In particular, MLME is used to determine how the forecasts would be different if wage rates are not sufficiently flexible to clear the occupational labour markets. The attendant surpluses and shortages revealed by MLME provide corroborative evidence on the underlying structural pressures in the Cedefop forecasts. .Results are reported for the United Kingdom, Greece and the Netherlands.

JEL codes: C53, C58, D58, E27, J23, O41

Keywords: Forecasting, CGE models, hybrid models, labour markets, structural imbalances

Contents

1. Introduction[1]

In recent years, a series of European labour market forecasts have been produced on behalf of, and have been published by, the European Centre for the Development of Vocational Training (Cedefop). These forecasts are generated using a modular modelling approach containing two major components:

- a multi-sector macroeconomic model (E3ME) for 29 European countries (E3ME), primarily developed and operated by Cambridge Econometrics, and
- a labour market extension (WLME), primarily developed and operated by the Institute for Employment Research at the University of Warwick.

The countries are treated as an integrated system in E3ME but the extension is applied to each country separately. Forecasts of employment by industry are determined by E3ME; forecasts of employment by occupation and qualification are determined by the extension.
Both components rely mainly on time series econometric techniques to generate their forecasts. An overview of the combined E3ME-WLME forecasting system, with references to further documentation, is contained in Wilson et al. (2010).

In Meagher et al. (2014), a methodology is introduced whereby WLME can be replaced with an alternative extension (MLME) which uses computable general equilibrium (CGE) modelling techniques. This extension has been developed primarily at the Centre of Policy Studies at Monash University and is referred to as the Monash labour market extension (MLME). Compared to WLME, MLME relies less on time series analysis and more on explicitly modelled economic behaviour, based on theoretical considerations.

MLME describes the operation of 27 occupational labour markets (based on the 27 2- digit ISCO occupations used in the WLME. On the demand side of these markets, labour of different occupations can be converted into effective units of industry specific labour according to Constant Elasticity Substitution (CES) functions. In principle, each of the 41 E3ME industries can employ any of 27 occupations but none of a particular occupation will be used by an industry in a forecast if none of it was used by that industry in the base period. On the supply side, labour by skill (represented by 3 broad levels of qualification as measured by ISCED) can be converted into labour by occupation according to Constant Elasticity of Transformation (CET) functions. Again, each of the 3 skills identified in WLME can, in principle, be transformed into any of the 27 occupations.

[1] A version of this paper appeared previously as Meagher et al. (2013).

The purpose of MLME is to introduce a range of behavioural and technical parameters which offer more scope for modelling developments in the labour market, especially those which impact on occupations and skills rather industries. In this paper, the design is advanced in two ways. Firstly, MLME is configured such that, in the absence of any shocks and assuming that the occupational labour markets clear, it reproduces the forecasts derived using WLME. In that case, the MLME forecasts can be regarded as providing enhanced information about the WLME forecasts. In particular, MLME provides forecasts of changes in relative wage rates which can be used to identify structural pressures in the markets for labour, pressures which remain only implicit in the WLME employment forecasts produced for Cedefop.

Secondly, when suitably configured, MLME can be used to determine the deviations to the WLME employment forecasts which would result if some of the conditions (either explicit or implicit) under which they were derived are relaxed. Here, MLME is used to determine how the forecasts would be different if wage rates are not sufficiently flexible to clear the occupational labour markets. The attendant surpluses and shortages revealed by MLME provide corroborative evidence on the underlying structural pressures in the Cedefop forecasts. .

Section 2 of the paper provides some background on the antecedents to the MLME model. Section 3 describes the how the specification of MLME must be adapted to support the preceding interpretation. Section 4 presents the enhanced forecasts for three representative countries and discusses the associated structural pressures. Section 5 contains some concluding remarks.

2. Background

The MLME model belongs to the so-called Australian school of computable general equilibrium (CGE) models, a school which has been particularly concerned with the application of large CGE models to issues of public policy. The tradition originated with the work of Johansen (1960) on the Norwegian economy, but it came to prominence in Australia in the 1970’s with the development of the ORANI model by Dixon et al. (1982). The use CGE models was largely confined to comparative static analyses until the 1990’s when the MONASH model of Dixon and Rimmer (2002) pioneered its application to forecasting and comparative dynamic analysis. A recent survey of the evolution of the Australian school can be found in Dixon and Rimmer (2010).

A typical labour market forecast can be considered to proceed in three stages. In the first stage, a forecast is conducted for the major components of GDP (i.e., household consumption, investment, government consumption, exports and imports) and for other macro aggregates such as the consumer price index. In the second stage, a model of commodity markets is used to convert the macro forecasts into forecasts of output and the demand for labour by industry. In the third stage, a model of labour markets is used to convert the demand for labour by industry and a separate forecast of the supply of labour by skill into forecasts of employment by occupation.

Labour market forecasts for the Australian economy have been conducted by the Centre of Policy Studies for almost twenty years (Meagher et al., 2000). In these forecasts, the first stage has employed a version of the Murphy macroeconometric model (Powell and Murphy, 1995) and the second has employed the MONASH CGE model. For most of that period, the labour forecasts were unconstrained by supply side factors. In other words, the system produced forecasts of the demand for labour rather than forecasts of employment. However, in the lead up to the global financial crisis in September 2008, the level of unemployment fell to historically low levels in Australia, the existing specification became untenable, and labour supply constraints were introduced into the MONASH model (Meagher and Pang, 2011). Thus, in the Monash forecasting system, the stage-one forecasts are based on a time-series econometric model, and stages two and three are based on a CGE model.

In the E3ME-WLME system, the first two stages employ the time-series econometric model E3ME, while stage 3 employs the mechanical WLME labour market extension. That is, the Warwick forecasting system relies relatively heavily on time-series information to determine its forecasts, whereas the Monash system relies relatively heavily on more-detailed structural information at a particular point of time.

Recent years have seen the development of forecasting systems based on dynamic stochastic general equilibrium (DSGE) models. This kind of model combines all three stages and represents a significant advance in principle. However, in practice, its data requirements are so demanding that it has so far been able to handle only a very small number of industries. A large DSGE model might contain three industries whereas a large

CGE model would contain more than one hundred. For the time being, at least, DSGE models are mainly of theoretical interest outside stage-one forecasting..

It is worth noting that a European model more in keeping with the Monash tradition could be designed by replacing E3ME with country models from the GTAP system (Hertel, 1997) and a macro model like NIGEM (i.e., the global econometric model developed and operated by the U.K. National Institute of Social and Economic Research). This would separate the first two stages of the labour market forecasting system, and allow additional structural information (of the CGE type) to be incorporated for commodity markets as well as for labour markets. However, this strategy would require a large and expensive project, and there is much to be said for building on the intellectual capital already invested in the E3ME-WLME system in the way presented here.

3. Adapting the MLME model[2]

The complete set of equations which makes up the MLME model is set out in Meagher et al. (2012). It includes the following:

Equation T1: Demand for labour of occupation o by industry i, hours

$$d_{io*} = d^{W}_{i**} - \sigma^{S}_{i} [\, p_o - \sum_{k=1}^{OCC} SH^{W}_{ik*}\, p_k \,] \qquad \text{(all } i \in IND,\ o \in OCC)$$

where

d_{io*} is the change in demand for labour of occupation *o* by industry *i*,

d^{W}_{i**} is the change in demand for labour of all occupations by industry *i*,

p_o is the change in the hourly wage rate for occupation *o*

SH^{W}_{io*} is the share of occupation *o* in total cost of labour employed in industry *i*

σ^{S}_{i} is the elasticity of substitution between occupations in industry *i* .

[2] The treatment of technical change described in this section follows Dixon et al. (1982).

The equations in MLME are expressed in terms of percentage changes of the variables. That is, the system computes the percentage changes in the endogenous variables in some period arising from changes ("shocks") to the exogenous variables. The coefficients in the system are shares. Sets, coefficients and parameters are denoted by upper-case or Greek symbols. The convention is adopted that lower-case symbols denote percentage changes in the levels of the variables represented by the corresponding upper case symbols, that is, the notation assumes y=100 (dY/Y). The levels variables Y do not appear in the equations but they will be used in the discussion which follows.

The equation T1 maintains that, if there are no changes in the relative occupational wage rates P_o , i.e., if

$$p_o = 0 ,$$

a one per cent increase in the demand D^W_{i**} for effective units of labour in industry *i* leads to a one per cent increase in the demand D_{io*} for labour of each occupation by the industry. Here, the number of "effective" units is obtained by aggregating the occupational demands measured in hours according to a constant elasticity of substitution function. If, however, the wage rate P_o for occupation *o* rises relative to the average wage rate for the industry, i.e., if

$$p_o > \sum_{k=1}^{OCC} SH^W_{ik*} \, p_k \, .$$

the demand D_{io*} for occupation *o* will increase less rapidly than D^W_{i**}. Producers will substitute against occupation *o* in favour of other occupations. If it is difficult to substitute other occupations for occupation *o*, i.e., if the elasticity of substitution σ^S_i is small, the amount by which d^W_{i**} exceeds d_{io*} will also tend to be small. Note that the superscript W attached to the SH^W_{ik*} indicates that wage cost shares are to be used in computing the average wage rate for industry *i*, i.e.,

$$SH^W_{ik*} = P_k \, D_{ik*} \, / \sum_{o=1}^{OCC} P_o \; D_{io*} \, .$$

For current purposes, the equation is replaced by:

Equation T1: Demand for labour of occupation o by industry i, hours

$$d_{io*} = d^{W}_{i**} - \sigma^{S}_{i} [p_{o} - \sum_{k=1}^{OCC} SH^{W}_{ik*} \, p_{k}] + a^{D}_{o} - \sigma^{S}_{i} [a^{D}_{o} - \sum_{k=1}^{OCC} SH^{W}_{ik*} \, a^{D}_{k}]$$

(all $i \in IND$, $o \in OCC$)

where

a^{D}_{o} is occupation-*o*-augmenting technical change in production.

Suppose that the wage rates P_{k} and the effective demand D^{W}_{i**} are constant but technical change is taking place. If the change is *o*-augmenting at the rate of one per cent, i.e.,

$$a^{D}_{o} = -1$$

and

$$a^{D}_{k} = 0$$

for *k* ≠ *o*, then industry *i* 's demand for labour of occupation *o* falls by

$$(1 - \sigma^{S}_{i} (1 - SH^{W}_{io*}))$$

per cent, i.e. by less than one per cent. Thus the *o*-augmenting technical progress induces some substitution in favour of occupation *o* and away from occupation *k* , *k* ≠ *o*. Note that industry *i* 's demand for labour of occupation *k* , *k* ≠ *o*, falls by

$$\sigma^{S}_{i} \, SH^{W}_{io*}$$

per cent.

In most applications of MLME, the technical change variables a^{D}_{k} are set exogenously and the model determines employment by occupation. However, if employment by occupation is set at the levels forecast by E3ME-WLME and the a^{D}_{k} made endogenous, MLME determines the technical change regime $\hat{a}^{D}_{k}$, say, implicit in those forecasts. That is, if the a^{D}_{k} are set at the levels so determined, MLME will reproduce the WLME forecasts. In the forecasts reported in the next section, a_k^D is always set equal to $\hat{a}_k^D$. Note, however, that technical change which affects the supply of labour, rather than the demand for labour, is not considered here so the specification is not unique.

4. Identifying structural pressures

Table 1 shows employment growth rates by occupation for selected countries between 2009 and 2020. The rates are those forecast by Wilson et al. (2010) for Cedefop. The table indicates a wide variety of outcomes for different occupations within a country, and for a particular occupation in different countries. For example, from row 2, employment of *Legislators and senior officials* is forecast to expand strongly in the Netherlands (rank 3) but contract strongly in Greece (rank 27) and the United Kingdom (rank 24). Similarly, from row 24, employment of *Drivers and mobile plant operators* expands in the United Kingdom (rank 7) but contracts in the Netherlands (rank 20). Within the United Kingdom, employment of *Teaching associate professionals* (row 11) is forecast to increase by 39.11 per cent over the period, an increase that is larger than that for any other occupation except *Other associate professionals* (row 12). On the other hand, employment of *Teaching professional*s (row 7) is forecast to contract by 18.05 per cent over the same period.

To see why the outcomes for the two apparently closely-related teaching occupations are expected to be so different, it is useful to decompose the employment growth into a shift component and a share component. From column 4 of Table 2, the industry *Education* (row 39) accounts for 15.791[3] percentage points (or about 87 per cent) of the contraction for *Teaching professionals*. This is because most of the occupation is employed in *Education*, the industry accounting for 87.686 per cent of its employment in the base year 2009 (see column 1). However, employment in *Education* is forecast to decrease from 2660818 persons in 2009 to 2573356 in 2020, that is, by a relatively modest 3.287 per cent. Indeed, if *Teaching professionals* were to maintain its share of employment in *Education*, the industry would contribute only 2.882 percentage points (column 2) to the contraction in its employment (the shift effect). The remaining contribution of 12.908 percentage points (column 3) arises because *Teaching professionals* loses share within *Education* (the share effect). Overall, only 1.696 percentage points (or less than 10 per cent) of the total decrease of 18.048 per cent in employment of *Teaching professionals* is due to the shift effect (i.e., to

[3] Results are often reported to a relatively large number of decimal places to facilitate the exposition and should not be taken to indicate the accuracy of the forecasts.

the occupation being over-represented in contracting industries). Most of the decrease (16.352 percentage points or more than 90 per cent)) is due to the share effect (i.e., to the occupation loosing share within industries, be they contracting or expanding).

From Table 3, the industry *Education* (row 39) also makes the largest contribution to the change in employment of *Teaching associate professionals*, accounting for 16.197 percentage points (or about 41 per cent) of its growth of 39.111 per cent. Note that the shift effect associated with *Education* remains negative (-1.215 percentage points from column 2), but this time the occupation in question increases its share of employment within *Education* and the share effect is positive (+17.412 percentage points from column 3). Overall the share effect is again dominant, accounting for 37.322 percentage points (or more than 95 per cent) of the total growth in employment. That is, the employment of *Teaching associate professionals* increases relatively rapidly because it increases its share of employment within industries, be they expanding or contracting. Furthermore, unlike *Teaching professionals*, the majority of *Teaching associate professionals* are employed outside the Education industry and, on balance, the occupation is over-represented in expanding industries. Hence the shift effect, while small, is positive overall.

The same kind of shift-share analysis can also be applied to the supply side of the labour market, as shown in Table 4. Note that the occupation *Teaching professionals* is heavily concentrated in the High-skilled group which is forecast to increase its employment by 16.179 per cent (not shown) between 2009 and 2020. Hence it receives a substantial contribution of 15.119 percentage points from the shift effect associated with that group. However, the occupation loses share within the group to such an extent that its net effect is a negative contribution of 15.170 percentage points (or about 84 per cent of the total contraction of 18.084 per cent).

The information contained in Tables 1 to 4 is generated by the E3ME model and the Warwick labour market extension (WLME). In this system, employment by occupation adjusts so as to balance the demand for labour by industry and the supply of labour by skill. However, the economic adjustment mechanism whereby the balance is achieved is not explicitly identified. In the Monash labour market extension (MLME), the demand and supply sides of the occupational labour markets are explicitly modelled. This enables additional information to be generated about the process of economic adjustment implicitly at work in the E3ME-WLME system. In particular, it provides information about the structural

Table 1. Employment Growth by Occupation, 2009 to 2020, Per Cent

Code	Occupation	Greece		Netherlands		United Kingdom	
		Growth	Rank	Growth	Rank	Growth	Rank
1	Armed Forces	-14.31	23	-40.40	27	-48.73	27
2	Legislators and senior officials	-45.35	27	24.64	3	-37.77	24
3	Corporate managers	31.68	4	-1.30	15	8.97	9
4	Managers of small enterprises	-11.89	22	16.76	6	6.64	10
5	Physical, mathematical and engineering science professionals	-0.77	17	-5.88	16	-2.09	15
6	Life science and health professionals	-0.59	16	13.39	7	29.95	3
7	Teaching professionals	1.85	14	-23.47	26	-18.05	21
8	Other professionals	-7.93	18	28.41	2	23.43	4
9	Physical and engineering science associate professionals	22.13	7	5.78	10	5.72	11
10	Life science and health associate professionals	26.83	5	1.74	14	-4.66	17
11	Teaching associate professionals	57.58	1	17.49	5	39.11	2
12	Other associate professionals	51.03	2	2.50	11	44.95	1
13	Office clerks	-10.89	20	-11.15	19	-16.08	20
14	Customer services clerks	37.70	3	21.72	4	-0.66	14
15	Personal and protective services workers	9.52	10	9.18	8	2.96	12
16	Models, salespersons and demonstrators	11.04	9	-7.17	17	14.79	6
17	Skilled agricultural and fishery workers	-15.79	24	-16.32	24	-4.79	18
18	Extraction and building trades workers	0.72	15	1.93	13	10.45	8
19	Metal, machinery and related trades workers	-11.41	21	-13.39	21	-27.22	23
20	Precision, handicraft, craft printing and related trades workers	-35.58	25	-10.79	18	-42.75	26
21	Other craft and related trades workers	-9.27	19	-14.49	23	-22.22	22
22	Stationary plant and related operators	26.51	6	8.19	9	0.03	13
23	Machine operators and assemblers	9.15	11	-18.85	25	-6.37	19
24	Drivers and mobile plant operators	4.38	13	-12.82	20	13.77	7
25	Sales and services elementary occupations	15.84	8	2.06	12	-3.67	16
26	Agricultural, fishery and related labourers	-37.01	26	-13.90	22	-41.78	25
27	Labourers in mining, construction, manufacturing and transport	5.57	12	32.22	1	18.96	5
28	All occupations	2.86		3.20		4.82	

Notes. Columns 1 to 4 are measured in per cent.
Column 2 shows the contributions that would have been made if the occupational mix in each industry had remained constant (the shift effect).
Column 3 shows the contributions due to changes in the occupational mix (the share effect).
Column 4 shows the combined contributions.
The ranks in column 5 are

Table 2. Contributions to Employment Growth by Industry, 2009 to 2020, Teaching Professionals, United Kingdom

Code	Industry	(1) Employment Shares 2009	(2) Contributions: Shift	(3) Contributions: Share	(4) Contributions: Total	(5) Rank
1	Agriculture etc	0.235	-0.020	-0.035	-0.055	7
2	Coal	0.002	-0.001	0.000	-0.001	39
3	Oil & Gas etc	0.063	-0.033	-0.007	-0.040	8
4	Other Mining	0.000	0.000	0.000	0.000	41
5	Food, Drink & Tobacco	0.044	-0.012	-0.009	-0.021	13
6	Textiles, Clothing & Leather	0.034	-0.009	-0.007	-0.016	17
7	Wood & Paper	0.042	0.003	-0.013	-0.010	23
8	Printing & Publishing	0.036	-0.001	-0.009	-0.010	22
9	Manufactured Fuels	0.004	-0.001	-0.001	-0.002	35
10	Pharmaceuticals	0.011	-0.003	-0.002	-0.005	31
11	Chemicals nes	0.024	-0.003	-0.006	-0.009	25
12	Rubber & Plastics	0.004	-0.001	-0.001	-0.002	34
13	Non-Metallic Mineral Products	0.009	0.000	-0.002	-0.002	33
14	Basic Metals	0.025	-0.008	-0.004	-0.012	20
15	Metal Goods	0.002	0.000	0.000	-0.001	38
16	Mechanical Engineering	0.196	0.019	-0.051	-0.033	10
17	Electronics	0.011	0.003	-0.004	-0.001	37
18	Electrical Eng. & Instruments	0.020	-0.002	-0.004	-0.006	27
19	Motor Vehicles	0.015	-0.002	-0.003	-0.005	30
20	Other Transport Equipment	0.022	-0.007	-0.003	-0.010	21
21	Manufacturing nes	0.011	-0.003	-0.002	-0.005	29
22	Electricity	0.020	-0.004	-0.004	-0.008	26
23	Gas Supply	0.005	-0.001	-0.001	-0.002	32
24	Water Supply	0.002	0.000	0.000	-0.001	36
25	Construction	0.041	0.001	-0.013	-0.013	19
26	Distribution	0.078	0.002	-0.021	-0.019	15
27	Retailing	0.069	0.008	-0.023	-0.015	18
28	Hotels & Catering	0.063	-0.001	-0.015	-0.016	16
29	Land Transport etc	0.104	0.002	-0.032	-0.030	11
30	Water Transport	0.001	0.000	0.000	0.000	40
31	Air Transport	0.016	-0.001	-0.004	-0.005	28
32	Communications	0.085	0.002	-0.021	-0.019	14
33	Banking & Finance	0.090	0.004	-0.027	-0.024	12
34	Insurance	0.097	-0.016	-0.022	-0.038	9
35	Computing Services	0.045	0.003	-0.012	-0.009	24
36	Professional Services	1.892	0.405	-0.617	-0.212	5
37	Other Business Services	0.848	0.217	-0.275	-0.059	6
38	Public Administration & Defence	3.391	-0.160	-0.710	-0.870	2
39	Education	87.686	-2.882	-12.908	-15.791	1
40	Health & Social Work	1.563	0.010	-0.420	-0.410	3
41	Miscellaneous Services	3.097	0.797	-1.061	-0.264	4
42	All industries	100.000	-1.696	-16.352	-18.048	

Notes. Columns 1 to 4 are measured in per cent.
Column 2 shows the contributions that would have been made if the occupational mix in each industry had remained constant (the shift effect).
Column 3 shows the contributions due to changes in the occupational mix (the share effect).
Column 4 shows the combined contributions.
The ranks in column 5 are based on the contributions in column 4.

Table 3. Contributions to Employment Growth by Industry, 2009 to 2020, Teaching Associate Professionals, United Kingdom

Code	Industry	(1) Employment Shares 2009	(2) Contributions: Shift	(3) Contributions: Share	(4) Contributions: Total	(5) Rank
1	Agriculture etc	0.074	-0.006	0.032	0.026	25
2	Coal	0.170	-0.051	0.033	-0.018	28
3	Oil & Gas etc	0.090	-0.047	0.014	-0.033	24
4	Other Mining	0.010	-0.001	0.002	0.002	39
5	Food, Drink & Tobacco	1.657	-0.437	0.313	-0.124	17
6	Textiles, Clothing & Leather	0.024	-0.006	0.005	-0.002	38
7	Wood & Paper	0.046	0.003	0.012	0.015	30
8	Printing & Publishing	0.073	-0.002	0.022	0.020	27
9	Manufactured Fuels	0.074	-0.011	0.021	0.010	32
10	Pharmaceuticals	0.172	-0.048	0.032	-0.017	29
11	Chemicals nes	0.379	-0.046	0.085	0.038	23
12	Rubber & Plastics	0.061	-0.016	0.011	-0.005	35
13	Non-Metallic Mineral Products	0.288	0.005	0.089	0.094	18
14	Basic Metals	0.020	-0.007	0.005	-0.002	37
15	Metal Goods	0.073	-0.011	0.022	0.011	31
16	Mechanical Engineering	0.137	0.013	0.050	0.063	20
17	Electronics	0.337	0.088	0.130	0.217	14
18	Electrical Eng. & Instruments	0.122	-0.013	0.035	0.023	26
19	Motor Vehicles	0.299	-0.036	0.087	0.051	22
20	Other Transport Equipment	0.173	-0.052	0.046	-0.006	34
21	Manufacturing nes	0.264	-0.060	0.060	0.000	41
22	Electricity	0.107	-0.020	0.027	0.007	33
23	Gas Supply	0.026	-0.005	0.006	0.001	40
24	Water Supply	0.200	-0.005	0.058	0.052	21
25	Construction	0.995	0.019	0.188	0.207	15
26	Distribution	1.407	0.030	0.428	0.458	13
27	Retailing	2.047	0.243	0.535	0.777	10
28	Hotels & Catering	4.164	-0.096	1.339	1.244	7
29	Land Transport etc	1.886	0.038	0.431	0.469	12
30	Water Transport	0.008	-0.001	0.002	0.002	36
31	Air Transport	0.798	-0.040	0.231	0.191	16
32	Communications	1.418	0.035	0.492	0.527	11
33	Banking & Finance	3.201	0.134	0.820	0.954	8
34	Insurance	1.053	-0.178	0.243	0.066	19
35	Computing Services	2.168	0.133	0.745	0.878	9
36	Professional Services	5.692	1.220	1.956	3.176	4
37	Other Business Services	6.788	1.737	2.560	4.297	2
38	Public Administration & Defence	13.506	-0.637	4.746	4.109	3
39	Education	36.957	-1.215	17.412	16.197	1
40	Health & Social Work	8.816	0.055	2.532	2.587	5
41	Miscellaneous Services	4.222	1.086	1.467	2.553	6
42	All industries	100.000	1.789	37.322	39.111	

Notes. Columns 1 to 4 are measured in per cent.
Column 2 shows the contributions that would have been made if the occupational mix in each industry had remained constant (the shift effect).
Column 3 shows the contributions due to changes in the occupational mix (the share effect).
Column 4 shows the combined contributions.
The ranks in column 5 are based on the contributions in column 4.

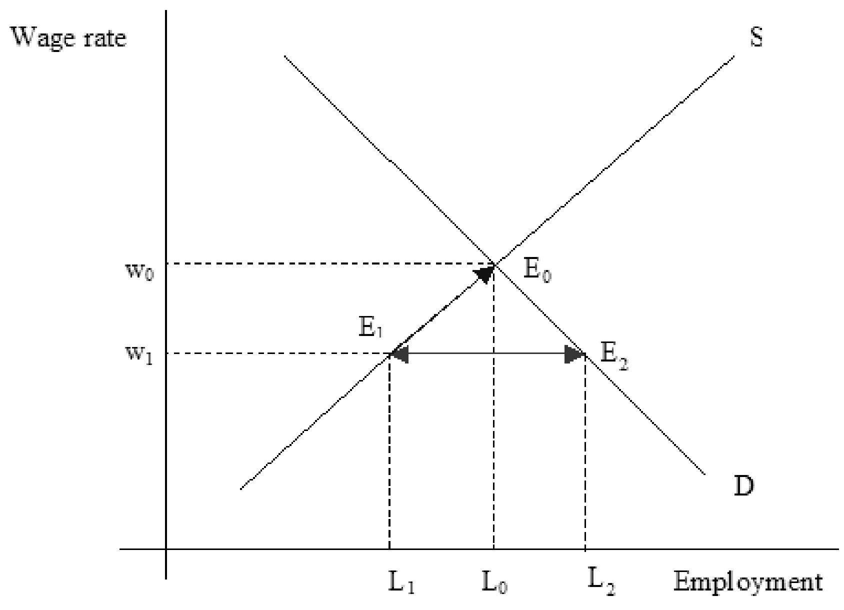
Table 4. Contributions to Employment Growth by Skill, 2009 to 2020, United Kingdom

Code	Occupation/Skill	(1) Employment Shares 2009	(2) Contributions: Shift	(3) Contributions: Share	(4) Contributions: Total	(5) Rank
7	**Teaching Professionals**					
1	Low Skilled	1.902	-0.796	-0.372	-1.169	3
2	Medium skilled	8.083	1.352	-3.061	-1.709	2
3	High skilled	90.014	14.563	-29.734	-15.170	1
4	All skills	100.000	15.119	-33.167	-18.048	
11	**Teaching Associate Professionals**					
1	Low Skilled	13.684	-5.726	1.464	-4.262	3
2	Medium skilled	43.460	7.268	12.745	20.013	2
3	High skilled	42.856	6.934	16.426	23.360	1
4	All skills	100.000	8.476	30.635	39.111	

Notes. Columns 1 to 4 are measured in per cent.
Column 2 shows the contributions that would have been made if the occupational for each skill had remained constant (the shift effect).
Column 3 shows the contributions due to changes in the occupational mix (the share effect).
Column 4 shows the combined contributions.
The ranks in column 5 are based on the contributions in column 4.

pressures that must be accommodated by the economy in order to achieve the balance described by E3ME-WLME. This is important information for organisations like Cedefop which have a responsibility for planning the allocation of training resources.

However, the economic adjustment mechanism whereby the balance is achieved is not explicitly identified. In the Monash labour market extension (MLME), the demand and supply sides of the occupational labour markets are explicitly modelled. This enables additional information to be generated about the process of economic adjustment implicitly at work in the E3ME-WLME system. In particular, it provides information about the structural pressures that must be accommodated by the economy in order to achieve the balance described by E3ME-WLME. This is important information for organisations like Cedefop which have a responsibility for planning the allocation of training resources.



Excess Demand for Labor (Skills Shortage)

As an economy develops, changes in the distribution of output and employment across industries create structural pressures in the markets for labour. In particular, surpluses (excess supplies) and shortages (excess demands) tend to develop for particular occupations and skills. Suppose there is excess demand for labour of a particular occupation at the wage rate w_1, as shown in Figure 1.

One measure of the structural pressure on the occupation is given by the percentage change 100 $(L_2-L_1)/L_1$ in the supply of labour required to establish equilibrium at the wage rate w_1. When expressed in this way, structural pressure tends to prompt a policy response, such as an increase in training or immigration, which shifts the supply curve to the right. An alternative measure is the percentage change 100 $(w_0-w_1)/w_1$ in the wage rate required to establish equilibrium at the wage rate w_0. Structural pressure is not usually expressed in this way because most analyses of skill shortages and surpluses do not consider the role of relative wage rates. Hence, the adjustment mechanism associated with the measure, namely, a movement along the supply curve from E_1 to E_0, is more usually identified with *laissez faire* than with a specific policy response. However, policies designed to improve wage flexibility would facilitate the required movement. Both types of measure are considered in this section.

Consider, then, the results reported for excess demand in Table 5. These results are generated by MLME when relative occupational wage rates are assumed to remain constant. For the occupation *Teaching associate professionals* (row 11), an excess demand equal to 51.10 per cent of base year employment would have emerged in the United Kingdom in 2020 if there had been no wage rate adjustment between 2009 and 2020. As suggested above, this kind of result is often taken as a signal that more training resources should be devoted to increasing the supply of the occupation. In this context, "more resources" means more than the amount already assumed (at least implicitly) to be committed in the WLME forecasts. More generally, if there were to be a reallocation of training resources from the occupations with excess supplies in Table 5 towards the occupations with excess demands, the employment growth rates in Table 1 could have been achieved with a more modest realignment of relative wage rates[4]. It is a question of judgment for the policy maker as to how much of the adjustment should be left to market forces (represented here by the relative wage rates) and how much should be the objective of policy.

As in Table 1, the amount of excess demand or supply in 2020 varies widely across occupations and countries. However, *Teaching associate professionals* (row 11) appears near the top of the ranking in all three countries while *Teaching professionals* (row 7) appears near the bottom. To better illustrate the relationship between the results in Tables 1 and 5, these two occupations will be considered in more detail. In the United Kingdom, employment in the former occupation was 203031 persons in the base year 2009. When markets clear, employment (and, concomitantly, both demand and supply) increases to 282439 persons in 2020. That is, employment increases by 39.111 per cent as reported in Table 1. When relative wage rates are fixed, demand increases to 323991 persons (or by 59.577 per cent) while supply increases to 220239 persons (or by 8.476 per cent). That is, there is excess demand of 103752 persons in 2020, or 51.10 per cent when expressed as a percentage of base year employment. This is the result reported in Table 5.

These results are decomposed into shift and share effects in the second panel of Table 6. As previously noted, the share effect accounts for 37.322 percentage points (or more than 95 per cent) of the increase of 39.111 per cent in demand when markets clear. This is due partly to changes in relative wage rates and partly to the technical change that was introduced to ensure that MLME reproduces the WLME forecasts. When relative wage rates

[4] This statement must be qualified to the extent that neither WLME nor MLME currently specifies the training resources devoted to particular occupations. Supply is only constrained by level of skill. Hence, the method whereby the reallocation could be achieved is not currently determined by either model. This deficiency could be corrected in more detailed future versions.

are fixed, the share effect is due entirely to technical change, and accounts for 57.788 percentage points (or almost 97 per cent) of the increase in demand of 59.577 per cent. Thus, the effect of technical change is to shift demand within industries in favour of *Teaching associate professionals* to the extent that, if it were the only influence acting on demand, demand would have increased by 57.788 per cent. Furthermore, if changes in relative wage rates were the only influence on demand in the market clearing forecast, demand for *Teaching associate professionals* would have been reduced by (57.788 - 37.322) or 20.466 per cent. That is, the effect the changes in relative wage rates implicit in the WLME forecasts is to shift demand within industries against *Teaching associate professionals.* On the supply side of the market, where it has been assumed that there is no technical change in operation, the share effect is zero when relative wage rates are fixed and the increase of 8.476 per cent is entirely accounted for by the shift effect.

The first panel of Table 6 shows the corresponding shift-share analysis for the occupation *Teaching professionals* (row 7 in Table 5). It reveals that, in the WLME forecasts,

- technical change shifts demand against the occupation within industries so as to contribute a reduction of 26.514 percentage points to the growth in demand, and

- changes in relative wages rates shift demand in favour of the occupation within industries so as to contribute an increase of (26.514 – 16.352) or 10.162 percentage points to the growth in demand .

Obviously, the results of the shift-share analysis depend crucially on the assumption that technical change affects only the demand side of the occupational labour markets. However, it does not follow that that the excess demand results in Table 5 would be significantly altered if are the technical change were distributed more evenly between demand and supply. This is because any resulting increases (decreases) in demand would tend to be offset by corresponding increases (decreases) in supply. The issue will be pursued in future work. In the meantime, the present analysis satisfies a more limited objective, namely, it demonstrates the scope offthat the additional categories introduced by the MLME model serve to elucidate the economic adjustment mechanisms underlying the WLME forecasts, and hence to enhance the value of those forecasts to makers of public policy.

Table 5. Excess Demands for Labour by Occupation, 2020, Relative Wage Rates Fixed

Code	Occupation	Greece		Netherlands		United Kingdom	
		Excess	Rank	Excess	Rank	Excess	Rank
1	Armed Forces	-46.88	25	-54.62	27	-73.09	27
2	Legislators and senior officials	-88.06	27	2.36	11	-68.45	26
3	Corporate managers	12.62	10	-18.46	22	-4.78	16
4	Managers of small enterprises	-20.57	18	12.62	6	0.67	12
5	Physical, mathematical and engineering science professionals	-35.48	22	-32.73	25	-25.13	18
6	Life science and health professionals	-44.20	23	-20.58	24	18.77	6
7	Teaching professionals	-28.89	19	-33.44	26	-44.33	22
8	Other professionals	-45.34	24	10.95	7	11.81	7
9	Physical and engineering science associate professionals	2.56	16	4.53	10	-8.32	17
10	Life science and health associate professionals	7.81	12	0.40	12	-28.50	20
11	Teaching associate professionals	90.57	1	75.71	1	51.10	2
12	Other associate professionals	49.31	3	-7.91	14	52.85	1
13	Office clerks	-28.95	20	-14.54	19	-27.99	19
14	Customer services clerks	47.38	4	33.79	3	-3.54	15
15	Personal and protective services workers	8.39	11	19.34	4	0.46	13
16	Models, salespersons and demonstrators	5.58	13	-7.60	13	21.55	4
17	Skilled agricultural and fishery workers	3.69	14	-15.27	21	0.29	14
18	Extraction and building trades workers	14.24	9	10.15	8	6.78	9
19	Metal, machinery and related trades workers	-6.78	17	-11.98	16	-44.08	23
20	Precision, handicraft, craft printing and related trades workers	-47.45	26	-11.17	15	-56.68	25
21	Other craft and related trades workers	3.22	15	-14.94	20	-33.25	21
22	Stationary plant and related operators	54.50	2	9.38	9	6.49	10
23	Machine operators and assemblers	27.12	7	-19.42	23	3.00	11
24	Drivers and mobile plant operators	17.64	8	-12.94	18	20.97	5
25	Sales and services elementary occupations	38.40	5	12.70	5	8.81	8
26	Agricultural, fishery and related labourers	-29.98	21	-11.98	17	-50.83	24
27	Labourers in mining, construction, manufacturing and transport	27.80	6	60.06	2	39.26	3
28	All occupations	0.00		0.00		0.00	

Note. Excess demands for labour are measured in persons expressed as a percentage of employment in the base year (2009). Negative excess demand signifies excess supply.

Table 6. Contributions to Growth, 2009 to 2020, United Kingdom, Per Cent

Code	Category	(1)	(2)	(3)
		Contributions		
		Shift	Share	Total
7	**Teaching Professionals**			
	Market clearing -			
	Demand	-1.696	-16.352	-18.048
	Supply	15.119	-33.167	-18.048
	Fixed relative wage rates -			
	Demand	-1.696	-26.514	-28.211
	Supply	15.119	0.000	15.119
11	**Teaching Associate Professionals**			
	Market clearing -			
	Demand	1.789	37.322	39.111
	Supply	8.476	30.635	39.111
	Fixed relative wage rates -			
	Demand	1.789	57.788	59.577
	Supply	8.476	0.000	8.476

The estimates of structural pressure obtained using the wage rate measure are shown in Table 7. The rankings conform quite closely to those in Table 5 and the two measures are in basic agreement. Note that they should not be expected to conform exactly as, in terms of the diagram, the excess demands in Table 5 reflect differences between points like E_1 and E_2, whereas the wage rate changes in Table 7 reflect differences between points like E_1 and E_0.

The changes in the occupational wage rates associated with Table 7 can also be used to determine the changes in the average wage rates paid by different industries for their workforce. That is, when markets clear, the structural pressures are manifest in cost increases which vary across industries. From Table 9, the industries in the United Kingdom which are most adversely affected are *Retailing* (row 27), *Banking and finance* (row 33) and *Land transport* (row 29). The overall size of the increase reflects the change in the aggregate wage rate determined by the E3ME model. Thus, from row 42 of Table 9, wage rates in the United Kingdom are expected to increase on average by 3.88 per cent per annum between 2009 and 2020. The structural pressures described in Table 8 determine which industries will have wage rate increases above the average and which below. The dispersion of the increases depends on the values assigned to the elaticities of substitution in production, and to the elasticities of transformation in the supply of labour to different occupations. The easier it is to substitute and/or transform, the smaller will be the change in relative wage rates required to clear the markets, and the smaller will be the dispersion of wage rate increases across industries. A systematic consideration of the appropriate values for the elasticities will be undertaken in future work.

The effect of structural pressure on the average wage rates received by workers with different skills can be determined in a similar manner. The results are shown in Table 9.

The analysis presented in this section indicates that, in order to form a judgement about training needs, a position must be adopted with respect to wage rate adjustment. If wage rates are assumed to remain constant (the skills mismatch approach), the entire adjustment must be borne by the training response. If labour markets are assumed to clear, the entire adjustment must be borne by wage rates in the short term. In the longer term, the change in the wage rates itself is likely to induce a training response, at least from workers. In principle, policy should be directed at achieving a system of wage differentials which reflects the working conditions attached to different jobs such as differences in work intensity, the work environment, the risk of injury or social prestige. However, the correct system of so-called "compensating wage differentials" is unknown and, by default, the existing system is usually accorded the status of desirability. Deviations from existing differentials are habitually met with complaints of "skills shortage" from the business community, and with demands that the government provide more training to restore the status quo. In Australia, the sacrosanct nature of existing differentials has long been enshrined in the notion of "comparative wage justice", although the influence of this idea has been on the decline in recent years. The popularity of the skills mismatch approach as a prescription for government training policy reflects this kind of thinking. Indeed, more often than not, the role of wage rate adjustment is simply ignored in discussions of training policy.

Table 7. Wage Rate Changes Required to Clear Occupational Labour Markets in 2020

Code	Occupation	Greece		Netherlands		United Kingdom	
		Change	Rank	Change	Rank	Change	Rank
1	Armed Forces	-4.29	23	-6.50	27	-9.93	27
2	Legislators and senior officials	-13.10	27	2.24	13	-7.83	26
3	Corporate managers	2.57	14	0.32	23	2.54	16
4	Managers of small enterprises	0.22	18	4.69	7	3.61	13
5	Physical, mathematical and engineering science professionals	-3.36	21	-1.93	25	-0.31	18
6	Life science and health professionals	-4.40	24	-0.07	24	4.78	7
7	Teaching professionals	-3.51	22	-3.49	26	-3.32	23
8	Other professionals	-4.52	25	3.10	10	4.28	9
9	Physical and engineering science associate professionals	2.26	16	3.30	9	1.84	17
10	Life science and health associate professionals	2.20	17	3.06	11	-0.52	19
11	Teaching associate professionals	8.82	2	10.84	1	7.71	3
12	Other associate professionals	5.97	9	1.70	19	8.24	1
13	Office clerks	-1.22	20	1.04	21	-0.62	20
14	Customer services clerks	7.01	6	7.24	3	3.07	15
15	Personal and protective services workers	3.65	12	5.46	4	3.51	14
16	Models, salespersons and demonstrators	3.63	13	2.91	12	6.70	4
17	Skilled agricultural and fishery workers	4.97	10	1.39	20	3.70	12
18	Extraction and building trades workers	6.51	7	5.06	6	4.59	8
19	Metal, machinery and related trades workers	2.56	15	1.86	16	-3.20	22
20	Precision, handicraft, craft printing and related trades workers	-4.78	26	1.73	18	-6.61	25
21	Other craft and related trades workers	4.26	11	1.78	17	-1.35	21
22	Stationary plant and related operators	10.29	1	4.39	8	4.19	10
23	Machine operators and assemblers	7.34	5	0.82	22	3.82	11
24	Drivers and mobile plant operators	6.26	8	2.01	15	6.30	5
25	Sales and services elementary occupations	7.59	4	5.35	5	4.83	6
26	Agricultural, fishery and related labourers	-0.92	19	2.09	14	-5.43	24
27	Labourers in mining, construction, manufacturing and transport	7.78	3	10.34	2	8.22	2
28	All occupations	2.89		3.29		3.88	

Note. The wage rate changes are the average annual changes between 2009 and 2020 expressed in per cent.

Table 8. Average Annual Wage Rate Changes by Industry when Labour Markets Clear, 2009 to 2020, Per Cent

Code	Occupation	Greece		Netherlands		United Kingdom	
		Change	Rank	Change	Rank	Change	Rank
1	Agriculture etc	4.82	10	3.50	16	2.79	39
2	Coal	5.65	4	3.53	15	3.88	23
3	Oil & Gas etc	5.78	3	2.72	34	2.97	36
4	Other Mining	5.02	7	3.00	27	4.11	16
5	Food, Drink & Tobacco	4.57	12	4.13	6	4.36	14
6	Textiles, Clothing & Leather	4.03	21	3.47	17	4.61	7
7	Wood & Paper	6.16	1	3.59	13	4.37	13
8	Printing & Publishing	1.44	36	3.84	11	4.79	5
9	Manufactured Fuels	4.19	18	2.90	28	2.90	38
10	Pharmaceuticals	4.47	14	3.09	26	4.01	20
11	Chemicals nes	4.47	13	3.09	25	4.01	19
12	Rubber & Plastics	4.93	9	3.97	10	4.44	10
13	Non-Metallic Mineral Products	5.14	6	3.65	12	3.89	22
14	Basic Metals	4.96	8	3.39	19	3.02	35
15	Metal Goods	3.42	25	2.87	30	3.13	33
16	Mechanical Engineering	3.47	24	2.83	32	3.29	29
17	Electronics	1.61	35	3.15	24	3.06	34
18	Electrical Eng. & Instruments	2.91	27	3.31	20	3.16	32
19	Motor Vehicles	4.04	20	2.49	35	3.23	30
20	Other Transport Equipment	3.51	23	2.87	29	2.96	37
21	Manufacturing nes	4.37	15	4.08	7	4.43	11
22	Electricity	2.32	31	2.46	37	3.57	25
23	Gas Supply	2.33	30	2.46	36	3.57	24
24	Water Supply	4.24	17	2.81	33	3.30	28
25	Construction	5.94	2	3.99	9	4.20	15
26	Distribution	2.22	32	4.45	3	4.38	12
27	Retailing	1.88	33	4.86	2	5.41	1
28	Hotels & Catering	2.62	28	5.42	1	4.03	18
29	Land Transport etc	5.19	5	4.24	5	4.90	3
30	Water Transport	3.42	26	3.42	18	3.18	31
31	Air Transport	4.14	19	4.33	4	3.97	21
32	Communications	2.42	29	3.55	14	4.06	17
33	Banking & Finance	4.00	22	2.27	38	4.98	2
34	Insurance	4.66	11	2.11	39	4.81	4
35	Computing Services	1.00	39	1.47	40	2.63	40
36	Professional Services	1.21	37	3.20	23	4.51	8
37	Other Business Services	1.15	38	3.29	21	4.44	9
38	Public Administration & Defence	1.62	34	2.84	31	3.51	27
39	Education	0.51	41	0.90	41	0.40	41
40	Health & Social Work	0.93	40	3.27	22	3.56	26
41	Miscellaneous Services	4.30	16	3.99	8	4.67	6
42	All industries	2.89		3.29		3.88	

Table 9. Average Annual Wage Rate Changes by Skill when Labour Markets Clear, 2009 to 2020, Per Cent

Code	Skill	Greece		Netherlands		United Kingdom	
		Change	Rank	Change	Rank	Change	Rank
1	Low Skilled	4.55	1	4.86	1	4.53	1
2	Medium skilled	3.41	2	3.60	2	4.24	2
3	High skilled	0.85	3	1.87	3	3.35	3
4	All skills	2.89		3.29		3.88	

5. Concluding remarks

Labour market forecasts provide valuable information to organisations like Cedefop in determining how training resources should be allocated between competing uses. In the E3ME-WLME forecasts, balance between the demand (industry driven) and supply (skill driven) sides of the labour market is achieved by mechanically manipulating employment by occupation. In this paper, "balance" has been interpreted to mean that labour markets clear. Given that interpretation, E3ME has been combined with the CGE-style labour market model MLME so as to reproduce the WLNME forecasts and to reveal the structural pressures which underlie those forecasts. This represents a significant enhancement of the value of the forecasts for purposes of training policy.

Training agencies are much concerned that the education and training system responds to emerging shortages and surpluses in the markets for occupations and skills. Their concern is that the system should deliver a workforce equipped with the skills it will require to fill the jobs of the future. Often, emerging mismatches are inferred from analyses of the current state of the markets. However, shortages and surpluses cannot usually be observed directly. Rather, they must be deduced from other labour market indicators such as changes in job vacancies, employment and unemployment, participation rates, hours worked and wages. The resulting estimates of existing and future mismatches are usually only qualitative, and are not derived in any transparent way from the market indicators on which they are based[5]. Hence they are of limited use for informing allocation decisions which, of their nature, are quantitative.

[5] For a recent major study using this approach, see Mavromaras et al.(2013).

Formal forecasting models of the type considered here would appear to offer a much better alternative. They deliver views about the future of the labour market that are:

- *comprehensive* (they cover the entire workforce),
- *coherent* (they are all consistent with one another and with a defensible overall view about the future of the economy),
- *efficient* (they bring to bear large amounts of relevant data),
- *reliable* (they are more reliable than the best available alternatives[6]), and
- *transparent* (their forecasts can be understood intuitively in terms of their theory and data, albeit not without some effort).

Finally, formal models are *progressive*, that is, they can be refined in response to past performance. Now that the efficacy of the E3ME-MLME arrangement has been established, it could be used in future work to canvas the options regarding the specification of technical change, and the values which should ideally be assigned to the elasticities of substitution and transformation. Moreover its coverage could be extended to include the remaining countries belonging to the European Union, and to modelling an integrated labour market for the Union as a whole.

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