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Forecasting skill demand and supply in Europe: CGE developments

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Overview

Background:

- Focus on “green jobs” and sensitivity of skills demand and supply to economic factors
- Demand for additional detail by occupation and skill category
- Limitations of data and econometrics

Potential of a CGE approach

Demand for detail and sensitivity analysis

- Previous work on green jobs and climate change limited by lack of ability to take into account substitution possibilities and required level of detail
- Data limitations in estimating econometric parameters are a key constraint although some progress has been made using panel estimation techniques
- But need to move away from an econometric based method due to lack of time series data

Existing approach - WMLE

Forecasts generated using a modular modelling approach containing two major components:

- a multi-sector macroeconomic model of 29 European countries (E3ME), primarily developed and operated by Cambridge Econometrics; and
- Various labour market extensions (WLME), primarily developed and operated by Warwick IER (with inputs from AM and ROA)

Current modules – the Warwick Labour Market Extension (LME)

- EDMOD which determines the forecasts of employment by occupation (expansion demands;
- QUALMOD which determines provisional forecasts of employment by qualification;
- STOCKMOD which determines labour supply by qualification; and
- BALMOD which revises the provisional qualifications forecasts to conform to the labour supply projections from STOCKMOD.

Developing an alternative- the CGE MLME

The MLME relies:

- less on time series extrapolation and econometric analysis
- more on explicitly modelled economic behaviour, based on theoretical considerations.

Introduces a range of behavioural and technical parameters which offer more scope for modelling developments in the labour market (substitution possibilities, etc)

Enables the implications of ideas about how environmental policy may affect skill requirements within industries to be investigated more explicitly.

Supply side

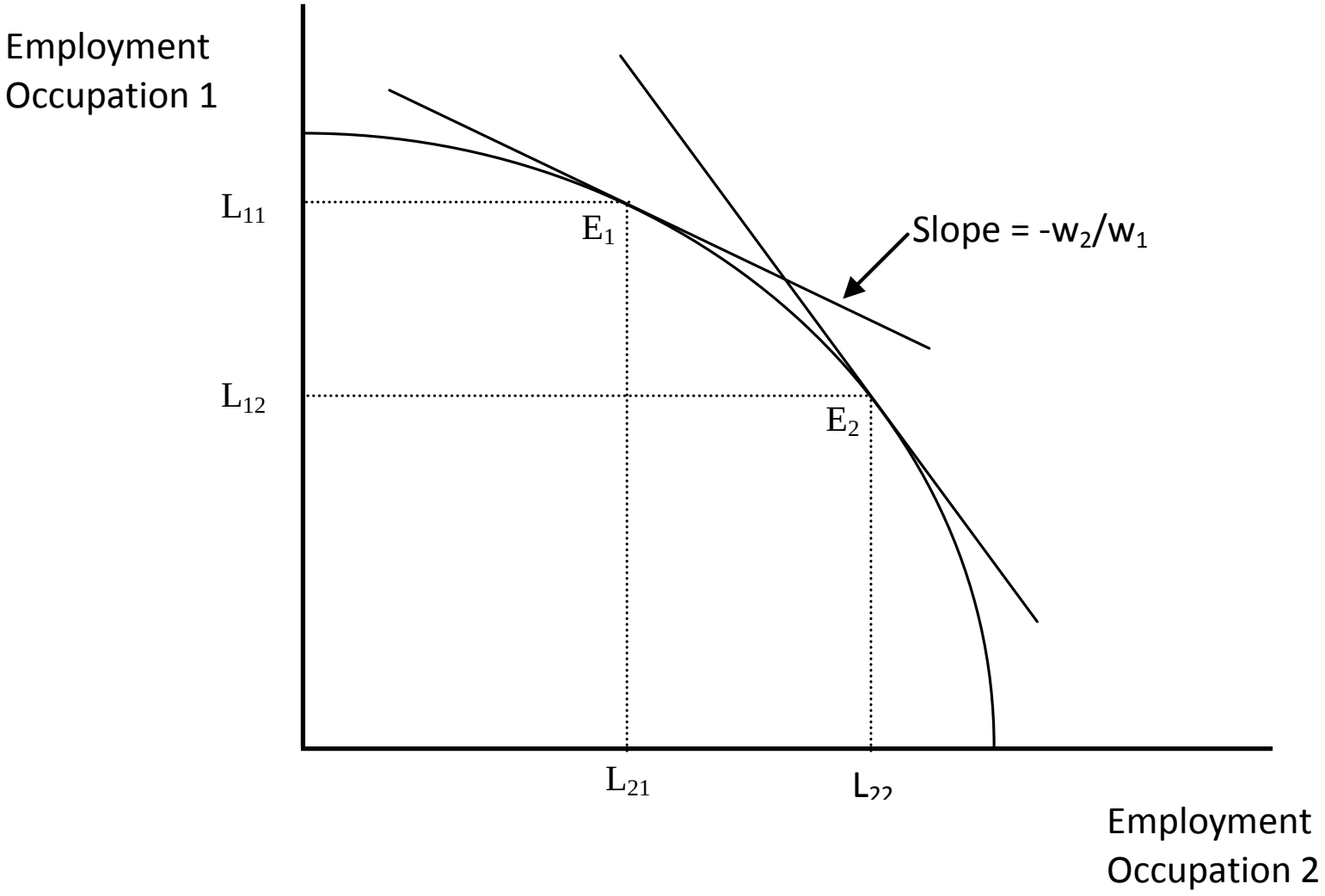
Labour x skill (3 broad qualifications) is converted into labour x occupation by a Constant Elasticity of Transformation (CET) function

In principle, each of the 3 “skills” can be transformed into any of the 27 occupations

If relative wage rates change, the isorevenue line becomes more or less steep – “owners” of skills can increase incomes by offering more of their time to different occupations - the occupational mix supplied changes

Enables estimates of the supply of labour to an occupation

Skill Transformations between Occupations



Demand for occupations

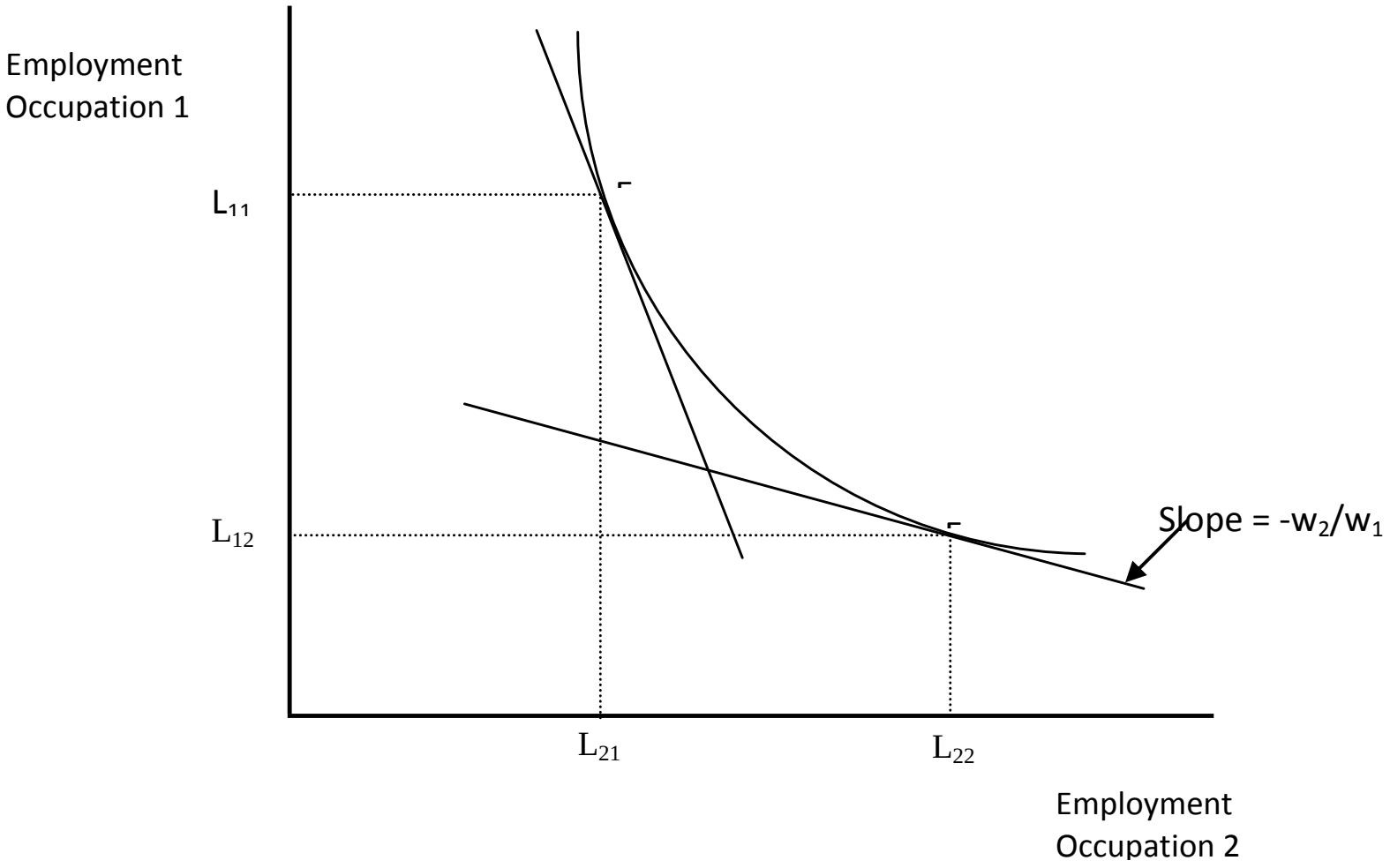
Labour in different occupations can be converted into effective units of industry specific labour according to Constant Elasticity Substitution (CES) production functions.

The position of the isoquant is determined by the demand for labour in the industry.

If the wage rate of occupation 2 decreases relative to that of occupation 1, the isocost line becomes flatter, and the producers in the industry can reduce their costs by substituting some of occupation 2 for occupation 1.

Hence they change the occupational mix from E_1 to E_2.

Substitution between Occupations in Industries



Advantages

Such a CGE LME can accommodate different scenarios concerning the operation of the occupational labour markets

If relative wage rates are fixed, the model determines the skill mismatches (expressed in terms of occupations) which pertain at those wage rates

If relative wage rates are flexible, the model determines the wage rate changes required to clear the labour markets and eliminate any skills mismatches

If relative wage rates are sticky, the model determines the residual mismatches after the partial wage adjustment has occurred.

Contrast to existing approach

- In CGEMOD/ MLME the focus is on balancing demand for and supply of occupations
- In WLME the emphasis is on balancing the demand for and supply of qualifications (skill)
- In CGEMOD/ MLME the focus is on total hours worked rather than jobs / numbers of people
- In order to facilitate a direct comparison both these issues need to be addressed
- WMLE has therefore been re-interpreted to focus on the demand for and supply of occupations and to include an hours worked dimension

Data requirements

Employment measured in persons cross classified by industry (41), occupation (27) and qualification (3),

Hours worked per person differentiated by industry (41) (& ideally by occupation too)

Wage rates differentiated separately by industry (41), by occupation (24) and by qualification (3),

Labour supply differentiated by qualification (3).

Wage rates differentiated by occupation and qualification, are needed for the base year only

Other data are required for every year of the forecast

Adding extra detail (more skill categories) would require some additional data

Equations in CGEMOD -1

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

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

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

Equation T2: Average demand for labour of all occupations by industry *i*, hours

$$d^{H}_{i**} = \sum_{o=1}^{OCC} SH^{DI}_{io*}\, d_{io*}$$

(all $i \in IND$)

Equation T3: Average demand for labour of occupation *o* by all industries, hours

$$d^{H}_{*o*} = \sum_{i=1}^{IND} SH^{DO}_{io*}\, d_{io*}$$

(all $o \in OCC$)

Equation T4: Supply of labour by skill *s* to occupation *o*, hours

$$s_{*os} = s^{E}_{**s} + \sigma^{T}_{s}\left[p_{*o*} - \sum_{k=1}^{OCC} SH^{W}_{*ks}\, p_{*k*}\right] - a^{S}_{*o*} - \sigma^{T}_{s}\left[a^{S}_{*o*} - \sum_{k=1}^{OCC} SH^{W}_{*ks}\, a^{S}_{*k*}\right]$$

(all $o \in OCC$, $s \in SKL$)

Equations in CGEMOD -2

Equation T5: Supply of labour by skill *s* to all occupations, hours

$$s^{H}_{**s} = \sum_{o=1}^{OCC} SH^{SS}_{*os}\, s_{*os} \qquad \text{(all } s \in SKL\text{)}$$

Equation T6: Supply of labour by all skills to occupation *o*, hours

$$s^{H}_{*o*} = \sum_{s=1}^{SKL} SH^{SO}_{*os}\, s_{*os} \qquad \text{(all } o \in OCC\text{)}$$

Equation T7: Market clearing for labour of occupation *o*, hours

$$d^{H}_{*o*} = s^{H}_{*o*} \qquad \text{(all } o \in OCC\text{)}$$

Equation T8: Average hourly wage rate

$$p_{***} = \sum_{o=1}^{OCC} SH^{DI}_{*o*}\, p_{*o*}$$

Equation T9: Flexible handling of labour supply by workers with skill *s*, hours

$$s^{H}_{**s} = \bar{s}^{H}_{**s} + f\_\, s^{H}_{***} \qquad \text{(all } s \in SKL\text{)}$$

Variables in CGEMOD -1

d_{io*}	Demand for labour of occupation *o* by industry *i*, hours	(all $i \in IND$, $o \in OCC$)
d^{E}_{i**}	Demand for labour of all occupations by industry *i*, effective units	(all $i \in IND$)
d^{H}_{i**}	Demand for labour of all occupations by industry *i*, hours	(all $i \in IND$)
d^{H}_{*o*}	Demand for labour of occupation *o* by all industries, hours	(all $o \in OCC$)
s_{*os}	Supply of labour to occupation *o* by all skills, hours	(all $o \in OCC$, $s \in SKL$)
s^{E}_{**s}	Supply of labour to all occupations by all skill *s*, effective units	(all $s \in SKL$)
s^{H}_{**s}	Supply of labour to all occupations by skill *s*, hours	(all $s \in SKL$)
s^{H}_{*o*}	Supply of labour to occupation *o* by all skills, hours	(all $o \in OCC$)

Variables in CGEMOD -2

p_{*o*}	Hourly wage rate for occupation *o*	(all *o* $\in$ O*CC*)
p_{***}	Average hourly wage rate	
$\overline{s}^{H}_{**s}$	Exogenous supply of labour to occupation *o* by all skills, hours	(all *o* $\in$ O*CC*)
$f\_\, s^{H}_{***}$	Wage shift variable	
a^{D}_{*o*}	Occupation-*o*-augmenting technical change in production	(all *o* $\in$ O*CC*)
a^{S}_{*o*}	Occupation-o-increasing technical change in labour supply	(all *o* $\in$ O*CC*)

Coefficients & parameters of CGEMOD

σ_i^S	Elasticity of substitution between occupations in industry *i*	(all $i \in IND$)
σ_s^T	Elasticity of transformation between occupations for skill *s*	(all $s \in SKL$)
SH_{io*}^W	Share of occupation *o* in cost of labour in industry *i*	(all $i \in IND$, $o \in OCC$)
SH_{io*}^{DI}	Share of occupation *o* in demand by industry *i*	(all $i \in IND$, $o \in OCC$)
SH_{io*}^{DO}	Share of industry *i* in demand for occupation *o*	(all $i \in IND$, $o \in OCC$)
SH_{*os}^W	Share of occupation *o* in income from skill *s*	(all $o \in OCC$, $s \in SKL$)
SH_{*os}^{SS}	Share of occupation *o* in supply of skill *s*	(all $o \in OCC$, $s \in SKL$)
SH_{*os}^{SO}	Share of skill *s* in supply of occupation *o*	(all $o \in OCC$, $s \in SKL$)
SH_{*o*}^{DI}	Share of occupation *o* in total demand	($o \in OCC$)

Assumptions

For the exogenous variables for CGEMOD:

the d^H_{i**} and p_{***} are taken from E3ME;

the $\overline{s}^H_{**s}$ are taken from STOCKMOD; and

all the technical change variables are set to zero.

Elasticities of substitution are all set to 0.35; and

Elasticities of transformation to 0.50.

NB E3ME and STOCKMOD forecasts must first be converted from persons to hours

The choice of d^H_{i**} and $\overline{s}^H_{**s}$ implies that the wage shift variable *f_* s^H_{***} *is* endogenously determined as zero

E3ME-WLME

The E3ME-WLME system determines:

- Industry-by-occupation-by-skill employment (000s);
- Number of hours worked by industry.

Assuming hours do not vary by occupation, industry-by-occupation-by-skill forecasts of labour demand A^D & supply measured in hours A^S are derived

These matrices provide projections for exogenous variables in CGEMOD

The assumptions are very strong - future work should explore variations in hours worked by industry, occupation & skill

The E3ME-WLME system also determines skill supply (***Stockmod***)

CGEMOD

CGEMOD also determines industry x occupation & occupation x skill employment forecasts in terns of hours.

Need to convert to persons for comparison with E3ME-WLME

By construction, employment x industry (in hours) is identical, but the mix of occupations in industries differs

Similarly, employment by skill (in hours) is identical but the mix of occupations within skill groups differs

It follows that, if the matrices A^D and A^S are used to convert the CGEMOD forecasts from hour to persons, the demand for labour of a particular occupation (measured in persons) will not equal supply.

If labour markets are to clear when measured in persons the hours worked matrices must change

Comparing the two LMEs

Comparison of the forecasts by occupation suggests the differences are significant;

These differences are in part due to the technical change variables in CGEMOD being set at zero;

Further work needs to be dome to explore sensitivity to these and related assumptions about the elasticities of substitution and transformation.

WLME demand

The *industry shift effect* (ISE) shows how demand for occupations (jobs) changes if the mix of occupations in each industry is fixed (determined by the E3ME model);

The *occupational share effect* (OSE) shows how the mix of occupations (jobs) in each industry changes (EDMOD)

The *average hours effect* (AHE) describes how the average hours worked per employed person in each occupation changes over time.

(The AHE, does not usually form part of WLME - it is required to interface MLME with E3ME. It allows the occupational forecasts produced by WLME and MLME to be compared in either persons or hours)

WLME supply

The skill shift effect (SSE) shows how supply of labour (persons) changes if there is no change in the mix of occupations within each of the three skill groups (determined in STOCKMOD)

The *occupational share effect* (OSE) shows how the mix of occupations (persons) within each skill group changes - OSE is interpreted analogously on demand & supply sides of a labour market:

- In WLME, the supply side OSE is determined by the requirement that all occupational labour markets must clear (or be in “balance”);
- Balance is achieved by application of the iterative RAS method.

SSE & OSE together set the supply of labour by occupation (persons)

The *average hours effect* (AHE) shows how hours worked changes over time - (no distinction between the demand & supply sides of the (postulated) occupational labour markets in WLME, therefore if in balance in jobs/persons, it is also in balance measured in hours.

Interpretation

The demand side in WLME is determined without reference to the supply side. - the adjustment required to achieve balance falls on the supply side of the labour market - only the supply-side OSE values diverge from trend

It is possible to impose supply-side OSE values which reflect trends - in that case, WLME would determine the excess demands for, or supplies of, labour implied by the trend OSE's (the model would determine the "skills gaps" that would develop in the labour markets if existing trends were to persist. (cf analysis of initial RAS values and imbalance indicators)

There is no necessity for balance to be achieved entirely by supply-side adjustment within the WLME framework. In principle, it would be possible to achieve balance at any set of occupational employment levels intermediate between the two sets implied by the trend OSE's. The RAS method could be applied on both the demand & supply sides rather than just on supply.

MLE demand

The *industry shift effect* (ISE) shows how demand for occupations (hours) changes if the mix of occupations in each industry is fixed (determined by the E3ME model, supplemented by the industry-by-occupation hours worked matrix A^D

The *occupational share effect* (OSE) shows how the mix of occupations (measured in hours) within each industry changes over time (given occupational wage rates, the demand-side OSE values are determined by technology (CES production functions) & cost-minimising behaviour of producers)

ISE & OSE determine the demand for labour x occupation (in hours)

The *average hours effect* (AHE) shows how the average hours worked in each occupation changes (determined by the module HTOPMOD)

MLE supply

The skill shift effect (SSE) shows how the supply of labour (in hours) changes if there is no change in the mix of occupations within the three skill groups (determined by the STOCKMOD module, supplemented with an occupation-by-skill hours worked matrix

The *occupational share effect* (OSE) shows how the mix of occupations (measured in hours) in each skill group changes (determined by technology (CET transformation function) & the income-maximising behaviour of workers)

A^S

SSE and OSE determine the supply of labour by occupation (in hours).

The *average hours effect* (AHE) shows how the average hours worked in each occupation changes over time (determined in HTOPMOD)

Labour market adjustments

When the same set of occupational wage rates is assumed for both the demand and supply sides of the labour markets, MLME determines the skills gaps which will pertain at those wage rates

For practical purposes, only one such set of wage rates will clear all the markets (i.e., eliminate all the skills gaps)

Correspondingly, there will be only one set of equilibrium (or balanced) occupational employment levels

In an equilibrium solution, it is changes in relative wage rates, rather than the skills gaps, which reflect structural pressures in the economy and provide indicator of labour market pressure.

Comparing projections UK

Table 5. Alternative Employment Forecasts, MLME, 2020, Persons, United Kingdom

Seq. No	Occupation	(1) Type of Average Hours Adjustment: Supply Only	(2) Type of Average Hours Adjustment: Demand Only	(3) Type of Average Hours Adjustment: Equal Contributions
1	01 Armed Forces	61778	61464	61621
2	11 Legislators and senior officials	60725	61225	60975
3	12 Corporate managers	3893747	3893223	3893485
4	13 Managers of small enterprises	1157664	1171099	1164381
5	21 Physical mathematical and engineering science profs	1290689	1293005	1291847
6	22 Life science and health professionals	474760	471508	473134
7	23 Teaching professionals	1399572	1388542	1394057
8	24 Other professionals	1786497	1785760	1786129

Comparing projections UK

Table 6. Deviations in Employment Forecasts, WLME and MLME, 2020, United Kingdom

Seq. No	Occupation	(1) WLME (persons)	(2) MLME (persons)	(3) Deviations (per cent)
1	01 Armed Forces	31343	61621	96.60
2	11 Legislators and senior officials	35127	60975	73.58
3	12 Corporate managers	3912781	3893485	-0.49
4	13 Managers of small enterprises	1162210	1164381	0.19
5	21 Physical mathematical and engineering science profs	1144780	1291847	12.85
6	22 Life science and health professionals	566434	473134	-16.47
7	23 Teaching professionals	1103303	1394057	26.35
8	24 Other professionals	1918894	1786129	-6.92
9	31 Physical and engineering science associate professionals	762539	775354	1.68

Contributions to demand UK

Table 7. Contributions to Growth in Demand, 2009-20, Thousands of persons, MLME, United Kingdom

Seq. No.	Occupation	(1) Employ-ment 2009	(2) Industry Shift Effect	(3) Occupation Share Effect	(4) Employ-ment 2020
1	01 Armed Forces	61	-2	3	62
2	11 Legislators and senior officials	56	2	3	61
3	12 Corporate managers	3591	207	96	3893
4	13 Managers of small enterprises	1090	76	-2	1164
5	21 Physical mathematical and engineering science profs	1169	80	43	1292
6	22 Life science and health professionals	436	13	24	473
7	23 Teaching professionals	1346	-23	71	1394
8	24 Other professionals	1555	219	13	1786
9	31 Physical and engineering science associate professionals	721	35	19	775

Contributions to supply UK

Table 8. Contributions to Growth in Supply, MLME, 2009-20, Thousands of Persons, United Kingdom

Seq. No.	Occupation	(1) Employment 2009	(2) Skill Shift Effect	(3) Occupation Share Effect	(4) Employment 2020
1	01 Armed Forces	61	4	-4	62
2	11 Legislators and senior officials	56	7	-2	61
3	12 Corporate managers	3591	386	-83	3893
4	13 Managers of small enterprises	1090	41	34	1164
5	21 Physical mathematical and engineering science profs	1169	161	-39	1292
6	22 Life science and health professionals	436	68	-31	473
7	23 Teaching professionals	1346	204	-156	1394
8	24 Other professionals	1555	213	18	1786
9	31 Physical and engineering science associate professionals	721	74	-20	775

Conclusions

Methodology for linking a CGE LME with E3ME established

Forecasts for selected countries cf E3ME-WLME

Focus on qualitative interpretation of differences in the 2 sets

Explicit specification of technical change & economic behaviour can be substituted for time series extrapolation

Empirical feasibility established & technical and conceptual issues explored

But still to produce robust alternative forecasts – this needs better technical change assumptions but more than one specification is possible & it is not obvious which is best – more research needed!

Next steps

Refine assumptions about parameters, including technical change

Refine assumptions about where adjustment is focused (not just on supply side)

Improve treatment / analysis of occupational hours (include other relevant data on hours worked by occupation)

Roll out to all countries - develop relevant computer code and link the resulting output with the current framework and workbooks (modify standard workbooks to incorporate CGE LME outputs)

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