3rd International Workshop on Empirical Methods in Energy Economics (EMEE2010)

Surrey Energy Economics Centre (SEEC)

University of Surrey, UK

24th – 25th June 2010

NOTE:

The following Poster represents *Work in Progress* for presentation and discussion at the EMEE2010 workshop. It therefore must not be referred to without the consent of the author(s).

Sponsored by:

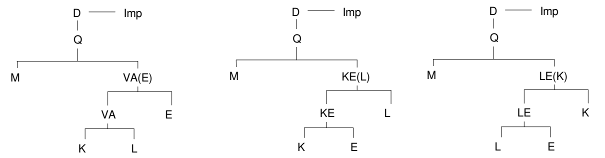
Production Functions with energy
: empirical estimates of nested elasticities for the US and UK

ESRC First Grants Initiative (ESRC grant Ref : RES-061-25-0010)

Soo Jung Ha*, Ian Lange**, Karen Turner* (*University of Strathclyde ** University of Stirling)

Introduction

•A part of the project 'An empirical general equilibrium analysis of the factors that govern the extent of energy rebound effects in the UK economy
•One of our purpose is the econometric estimation of parameter values and/or functional forms within nested CES production function in UKENVI as a research suggested the rebound effect is important
•These parameters are important for any country and here we estimated UK and US
•UKENVI, an energy-economy CGE modelling framework constructed by Allan et al (2006) has a KLEM hierarchical production function structure
•3 alternative specifications for CES production functions involving energy sector are available (capital K, labour L, and energy E)



Methods

$$e - q = (\sigma_{KL,E} - 1)a_E + \sigma_{KL,E}(p_Q - p_E)$$

$$\tilde{\theta}_{KZ} = (\sigma_{KL} - 1)a_K + \frac{\sigma_{KL} - 1}{1 - \sigma_{KL,E}}\tilde{\theta}_{ZQ} + (1 - \sigma_{KL})(p_K - p_Q)$$

$$\tilde{\theta}_{LZ} = (\sigma_{KL} - 1)a_L + \frac{\sigma_{KL} - 1}{1 - \sigma_{KL,E}}\tilde{\theta}_{ZQ} + (1 - \sigma_{KL})(p_L - p_Q)$$

$\Longrightarrow$

$$y_1 = \alpha_1 + \beta_1 x_1 + \varepsilon_1$$
$$y_2 = \alpha_2 + \beta_{21} x_{21} + \beta_{22} x_{22} + \varepsilon_2$$
$$y_3 = \alpha_3 + \beta_{31} x_{31} + \beta_{32} x_{32} + \varepsilon_3$$

$$y_1 = e - q$$
$$y_2 = p_K + k - d\ln(P_K K + P_L L)$$
$$y_3 = p_L + l - d\ln(P_K K + P_L L)$$

$$x_1 = p_Q - p_E$$
$$x_{21} = x_{31} = d\ln(P_K K + P_L L) - p_Q - q$$
$$x_{22} = p_K - p_Q$$
$$x_{32} = p_L - p_Q$$

$$\sigma_{KL,E} = \beta_1, \ \sigma_{KL} = 1 - \beta_{22}$$
$$a_E = \frac{\alpha_1}{\beta_1 - 1}, \ a_L = \frac{-\alpha_2}{\beta_{22}}, \ a_K = \frac{-\alpha_3}{\beta_{22}}$$

•The above system of equations for the case of the (KL)E nesting structure leads to the following model to be estimated (Van der Werf, 2008)
•where the lower-case letters denote percentage or growth change, for example *e = lnEt-lnEt-1 = dlnE* (the first difference of the natural logarithm of E).
•We have to impose the following cross-equation restrictions to estimate the elasticity of substitution for the inner nest: $\beta_{22} = \beta_{32} \ and \ \beta_{21} = \beta_{31} = -\beta_{22}/(1-\beta_1)$

Data

•Dale Jorgensen's KLEM projects for the U.S. (2007) and the EU (2008)
•US data : 35 sectors over the years 1961-2005
•UK data : 26 sectors over the years 1970-2005

Results by country level

•In both US and UK case, estimated elasticites of (KL)E and (LE)K are significant 1% level over the total period.

•UK estimated elasticities over 1990-2005 are smaller than the one over the total period but US ones are in the opposite direction.

Table 1. Estimated elasticities by country level and different time period

	Sigma KL,E	Sigma KL	Sigma KE,L	Sigma KE	Sigma LE,K	Sigma LE
US (61-05)	0.11***	0.11***	-0.02	0.05***	0.13**	0.13****
US (90-05)	0.31***	0.32***	0.11***	0.34***	0.22***	0.36***
UK (70-05)	0.13***	0.04***	-0.08***	-0.15***	0.31***	0.18***
UK (90-05)	0.06	0.12***	0.02	0.34***	0.14***	0.16***

Results by sector

Table 2. US estimated elasticities by sector (1961-2005)

Sector (US)	Sigma KL,E	Sigma KL	Sigma KE,L	Sigma KE	Sigma EL,K	Sigma LE
Agriculture	0.19*	0.16***	0.12	0.13***	0.11	0.14***
Metal mining	-0.19	0.01	0.13	0.21***	0.35*	0.40***
Coal mining	0.18	0.22***	0.01	-0.01	0.19	0.19***
Oil and gas extraction	1.55**	1.37***	0.04	0.06	0.28**	0.28***
Non-metallic mining	0.36***	0.36***	0.31**	0.32***	0.26	0.26***
Construction	0.37***	0.36***	0.12	0.18***	0.32**	0.31***
Food and kindred products	0.14	0.08***	-0.13	-0.04	-0.05	-0.02
Tobacco	0.1	0.14***	0.06	0.11***	0.19*	0.22***
Textile mill products	0.1	0.05***	-0.01	0.03	0.24	0.16***
Apparel	0.11	0.09***	0.05	0.09***	0.50***	0.40***
Lumber and wood	0.29**	0.23***	-0.03	0.03	0.70**	0.65***
Furniture and fixtures	0.27***	0.24***	0.13*	0.15***	0.39**	0.34***
Paper and allied	0.31***	0.25***	0.05	0.08***	0.60**	0.54***
Printing, publishing and allied	0.35***	0.33***	0.22	0.23***	0.26**	0.25***
Chemicals	0.19	0.16***	0.02	0.06***	0.32*	0.27***
Petroleum and coal products	-0.36*	-0.12***	-0.23**	-0.04	0.19***	0.19***
Rubber and misc plastics	0.13	0.09***	-0.04	0	0.17	0.14***
Leather	0.40***	0.35***	0.04	0.12***	0.54***	0.51***
Stone, clay, glass	0.33***	0.28***	-0.13	-0.04	0.15	0.13***
Primary metal	0.09	0.13***	0.15	0.17***	0.34***	0.33***
Fabricated metal	0.13	0.09***	-0.14	-0.07***	0.21	0.17***
Machinery, non-electical	0.05*	0.06***	0.02	0.11***	0.26**	0.17***
Electrical machinery	0.06**	0.03	0	0.10***	0.05	0.05***
Motor vehicles	0.31***	0.35***	0.1	0.15***	0.54**	0.51***
Transportation equipment & ordnance	0.26**	0.36***	0.41	0.41***	1.12***	1.15***
Instruments	0.27***	0.20***	0.02	0.10***	0.16**	0.13***
Misc. manufacturing	0.30***	0.27***	0.05	0.10***	0.58***	0.53***
Transportation	0.29***	0.22***	-0.18	-0.07*	0.31*	0.23***
Communications	0.25***	0.16***	-0.06	0.01	0.23*	0.12***
Electric utilities	0.13	0.11***	0.08	0.05***	-0.03	-0.03
Gas utilities	0.53**	0.55***	-0.23	-0.02	0.14*	0.11***
Trade	0.27**	0.23***	-0.08*	0.01	0.07	0.04***
Finance Insurance and Real Estate	0.21	0.17***	-0.03	-0.03	0.25	0.22***
Services	0.48***	0.49***	-0.03	0.03	0.1	0.07***
Government enterprises	0.38**	0.31***	-0.27	-0.05	0.99***	0.99***

*, **, *** indicates 10%, 5%, and 1% significance, respectively, against a null of sigma=0

•Overall, 65% of all coefficients are statistically different than zero at the 10% level or smaller.

•The (KE)L structure has the least amount of coefficient statistically significantly different from zero at the 10% level or smaller.

•The inner (KL)E nest of the "Oil & Gas Extraction" and the inner (LE)K nest of the "Transportation Equipment" sector are statistically larger than 1

Table 3. UK estimated elasticities by sector (1970-2005)

	Sigma KL,E	Sigma KL	Sigma KE,L	Sigma KE	Sigma LE,K	Sigma LE
Agriculture, hunting, forestry and fishing	0.17	-0.1*	-0.74***	-0.36***	-0.73***	-0.35***
Mining and quarrying	-0.23	0.08	0.42	0.44***	0.02	0.08
Food, beverages and tobacco	0.2	-0.01	-0.64***	-0.49***	0.54*	0.36***
Textiles, textile, leather and footwear	0.34**	0.19***	0.44***	0.36***	0.83***	0.82***
Wood and of wood and cork	0.16	-0.03	-0.45**	-0.49***	0.64***	0.58***
Pulp, paper, printing and publishing	0.28**	0.08***	-0.63***	-0.05	0.62***	0.52***
Coke, refined petroleum and nuclear fuel	0.68	0.79***	0.19	0.31***	0.19	0.28***
Chemicals and chemical	0.11	-0.05	-0.56***	-0.24***	0.84**	0.8***
Rubber and plastics	0.34**	0.12***	-0.28***	-0.36***	0.83***	0.79***
Other non-metallic mineral	0.21**	0.07	0.27	0.18***	0.94***	0.94***
Basic metals and fabricated metal	0.29**	0.18***	0.06	-0.01	0.58**	0.5***
machinery, NEC	0.2**	0.15***	0.74**	0.73***	0.52***	0.45***
Electrical and optical equipment	0.27	0.06	-0.43***	-0.25***	1.18***	1.18***
Transport equipment	0.27**	0.14***	0.04	-0.07	0.77***	0.75***
Manufacturing Nec, Recycling	0.19*	0.1**	-0.37**	-0.14	0.57***	0.5***
Electricity, gas and water supply	0.29	0.16**	-0.5**	-0.37***	-0.09	-0.22***
Construction	-0.01	-0.13***	-0.16*	-0.38***	0.51***	0.37***
Wholesale and retail trade	0.25	0.08***	-0.17***	-0.25***	0.37***	0.19***
Hotels and restaurants	0.15*	0.01	-0.14**	-0.32***	0.35**	0.2***
Transport and storage	0.2	0.01	-0.3***	-0.35***	1.07***	1.08***
Post and telecommunications	-0.06	-0.13***	-0.11**	-0.17	0.63**	0.48***
Financial intermediation	-0.01	-0.03	-0.22***	-0.25***	0.24**	0.1***
Real estate, renting and business activities	0.04	0	-0.11**	-0.25***	0.31**	0.16***
Public admin and defence, social security	0.16*	0.01	-0.36	-0.29***	0.38***	0.23***
Education	0.07	-0.02	-0.46**	-0.53***	0.23*	0.11***
Health and social work	0.03	0	-0.06	-0.31***	0.34**	0.2***
Other community, social and personal services	0.03	-0.03	-0.12*	-0.26***	0.56***	0.43***

*, **, *** indicates 10%, 5%, and 1% significance, respectively, against a null of sigma=0

•Overall, 71% of all coefficients are statistically different than zero at the 10% level or smaller.

•Over half of the (KE)L permutation coefficients are negative and statistically different than zero.

•The (KL)E structure has the least amount of coefficient statistically significantly different from zero at the 10% level or smaller.

•The inner and outer (LE)K nest of the "Electrical & optical equipment" and the "Transport & Storage" sector are statistically larger than 1

•If we compare the relevant sectors between UK and US (LE)K structure, the UK estimated elasticities are higher than the US ones but the US transportation equipment shows higher elasticities than the UK ones.

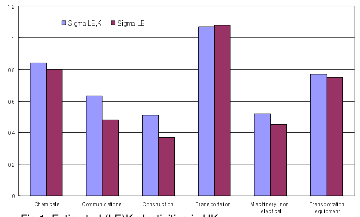


Fig 1. Estimated (LE)K elasticities in UK

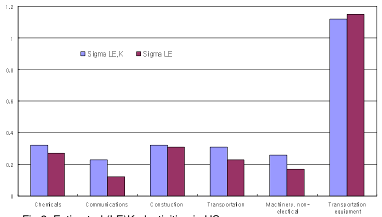


Fig 2. Estimated (LE)K elasticities in US

Conclusion

•Theoretically, it is expected that the estimates would be greater than zero thus the negative (KL)E and (KE)L results could be driven by mis-specification.

•While the estimates provided in this analysis are useful to guide CGE modellers (for example), it must be remembered that the numbers are statistical estimates. For example, our US results show that the inner (KL)E nest estimate is -0.19 for metal mining and 0.18 for coal mining. However, neither is statistically different than zero and thus both estimates are essentially zero.

•Results show that for a number of sectors (US non-metallic mining, for example), estimates for the inner and outer nests of all permutations are statistically the same. The appropriate interpretation of estimates is crucial. If one were to plug the exact estimates directly to a model (e.g. CGE) without considering their statistical nature, the resulting model outputs could be drastically different than what is implied.