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PAPER TITLE

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

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ABSTRACT

Overview

Modelling frameworks such as computable general equilibrium (CGE) rely on a number of assumptions that can have both qualitative and quantitative impacts on their output. The energy CGE modelling literature identifies the elasticity of substitution between inputs in the production function and the structure in which these inputs interact as key among these assumptions. Many models structure the decision process as firms choosing capital (K) and labour (L) first, and then choosing energy (E) to combine with a capital-labor composite. However, the imposed structure of the production function, and elasticity values therein, may greatly impact on model results. For this reason, we attempt to econometrically estimate the appropriate structure and parameter values for nested production functions for different production activities/sectors in the UK and US. Here, the elasticities of substitution across three permutations of a 2-level CES production function ([KL]E, [KE]L, and [LE]K) are estimated for about 30 sectors in each of the US and UK, followed by a discussion of the meaning and appropriate interpretation of the estimates and their statistical inference for CGE models.

Berndt and Wood (1975) were the first to estimate the elasticites of substitution with energy in a production function using US manufacturing data from 1947-1971. Van der Werf (2008) derives estimates of the elasticites of substitution across the three permutations of a 2-level CES production function. However the estimates are either for 12 countries or 7 sectors. Our analysis makes a new contribution to the literature by using larger datsets across two countries (the UK and US) to obtain estimates by country and sector and considering the use of these estimates to inform the calibration process of a wider set of models, such as CGE.

Empirical Methodology

Following the methodology of van der Werf (2008), sector level data for the US and UK are used to estimate 2-level CES production functions with capital, labor, and energy by sector. The estimating equations are derived from an assumption of cost minimization with the choice of the three inputs. All three permutations are estimated and compared. The US data contains 35 sectors over the years 1961-2005 while the UK data contains 26 sectors over the years 1970-2005. A number of sectors overlap, allowing for a comparison of elasticities by sector and country. Data are obtained from Dale Jorgensen's KLEM projects.

Results

The results show significant variation in the estimates of the elasticity of substitution between sectors and within sectors by input structure. Generally we find that the [LE] K permutation explains the least amount of variation

in the data. Further, about 75% of the estimates are statistically different than zero. About 5% of the estimates are negative and statistically different than zero. A negative elasticity implies that the two inputs are complements rather than substitutes. About 30% of the estimates are larger than one.

We identify and discuss two key issues and their implications for the US and UK cases. These are:

1. Whether elasticities greater or less than 1, at one or both nests
2. Which nest (inner or outer) has the larger elasticity

In the case of the first, an elasticity of less than 1 for energy implies that the share of energy in the input mix would fall if the relative price of energy decreased (see, for example, Saunders, 1992; Turner, 2009). This would be important, for example, if one were examining rebound effects from energy efficiency in CGE framework. In the case of the second, preliminary CGE testing (see Guerra, Lecca, Swales and Turner, 2010) suggests that the relative size of elasticities at the inner and outer nests will significantly impact both on the change in energy use/input mix and on the wider economic effects of any given change in activity.

We also discuss how, even if elasticities are the same across sectors, different input mixes will impact on model results. However, our results suggest that different types of sectors and activities will not have the same elasticities. Thus there is a need to examine issues (1) and (2) across groups of sectors (e.g. that have common characteristics such as energy intensity), and compare results for key sectors in the UK and US. We also attempt to identify sectors where outer and/or inner nests essentially same and consider whether this means that the structure of the nested production function is irrelevant.

Summary and Conclusion

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. Statistically, it is difficult to say more than a particular estimate is different than zero. For example, our US results show that the inner (KL), E nest estimate is 0.18 for metal mining and -0.18 for coal mining. However, neither is statistically different than zero and thus both estimates are essentially zero. Moreover, we find that for a number of sectors (agriculture 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.

Key References

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