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An investigation of issues relating to where energy should enter the production function

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ABSTRACT

This paper examines the impact of imposing different separability assumptions in the specifications of the standard hierarchical KLEM production function in a computable general equilibrium (CGE) model. The appropriate means of introducing energy to production functions has been a source of debate for a number of years. However, while modellers often subject results to parametric sensitivy analysis regarding the values associated with elasticities of substitution between inputs, it is rarely the case that the structure of the production function is subjected to testing. However, the chosen structure reflects the modeller's view about elasticity between different inputs and will have implications for model results wherever there are changes in relative prices. We illustrate our argument by introducing a simple demand shock to a CGE model of the Scottish economy (targeted at the energy supply sector) under different assumptions regarding the structure of the KLEM production function and separability assumptions therein.

1. Introduction

The appropriate specification of nested production functions in computable general equilibrium (CGE) models, and associated use of 'separability assumptions', are historically a source of debate in the literature (see, for example, Despotakis and Fisher, 1988; Hertel and Mount, 1985; Li and Rose, 1995; Naqvi, 1998). In particular, the debate focussed on the specification of KLEM functions, which incorporate and distinguish capital, labour, energy and material inputs, with specific focus on how energy should combine with other inputs. Energy CGE models have become increasingly commonly used, for example in the energy efficiency and rebound literature (Gløsmrod and Wei, 2005; Grepperud and Rasmussen, 2004; Turner, 2009; Wissema and Dellink, 2007). However, while parametric sensitivity analyses of CGE model results may be conducted, these tend not to include consideration of alternative structures in the production function. This paper aims to reawaken the debate regarding the importance of separability assumptions by focussing on the impact of varying the structure of the production function itself; that is the manner in which energy is introduced as an input to production.

The empirical analysis in this paper (using a CGE model of the Scottish economy as an illustrative case) focuses on introducing a very simple change in economic activity that would be expected to have a short-run impact on relative input, especially energy, prices in the KLEM production function. We then examine the sensitivity of key results to alternative nestings of the KLEM production function, with particular attention to the point at which energy enters. Moreover, the simulation is designed to produce changes in prices that are transitory so as to allow us to confirm that the particular nesting of the production function only matters where relative prices change.

The specific simulation involves introducing a disturbance to export demand for the outputs of the (relatively energy intensive) Scottish energy supply sectors. A simple demand disturbance is used because, in the absence of any lasting constraints on supply, the CGE simulations should produce input–output type results over the long-run, with prices returning to their pre-shock levels (McGregor et al., 1996). We further simplify by assuming the nominal price of labour is determined exogenously (e.g. a national bargaining scenario in the regional model). This makes the supply of labour completely elastic while capital supply is completely inelastic in the short run. This implies that the source of all price changes is variation in the capital rental rate up to the point where capital stocks are fully adjusted in response to the shock.

Thus, with no long-run change in relative input prices, the impact on macroeconomic variables should be the same regardless of the nesting of the production function. The model confirms these results. However, the short-run impact is sensitive to the particular nesting of the production function. More generally, we would only expect differing price elasticities between inputs, either directly imposed or

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