Input and fuel substitution: Evidence from a panel of Irish manufacturing firms

Stefanie Haller [*], Marie Hyland [†], Liam Murphy

June 30, 2013

1 Overview

The oil price shock in 1973 first gave the debate on whether energy and in particular capital, but also other factors of production, are complements or substitutes centre stage. An increase in energy prices only leads to an increase in the demand for new, presumably less energy-intensive, physical capital if capital and energy are substitutes. Thus, whether energy and capital are substitutes or complements has important implications for firms', industries' and ultimately countries' responses to increases in energy prices or to policies that increase energy prices.

We contribute to this literature by examining elasticities of substitution between different factors of production, and between different types of fuel, in a panel of Irish manufacturing firms. Our data covers the period 1991-2009.

Although numerous authors have conducted research into this important topic, most of the literature to date has used aggregate data. The seminal paper is that of Berndt and Wood (1975), who estimated a translog cost function on time-series data from the US; their results found that capital and energy are substitutes, but that energy and labour are complements. Griffin and Gregory (1976) used a panel of aggregate, county-level data and also found that capital and energy are substitutes. (Nguyen and Streitwieser, 1999, 2008) used US micro data for 1991 and found that energy and capital are substitutes, while Arnberg and Bjørner (2007), using a panel of Danish manufacturing firms, found complementarity between energy and capital.

2 Methods

We employ a translog cost function as applied by Berndt and Wood (1975) to obtain elasticities of substitution between factors of production. We examine substitution between four factors of production: energy, capital, labour and materials.

The factor share equations are estimated simultaneously using iterative seemingly unrelated regression, (SUR, also referred to as iterative Zellner procedure). The estimates from this approach are consistent and asymptotically efficient.

Our data is a census of Irish manufacturing firms. We have information on this population of firms for nearly 20 years from 1991 to 2009. This allows us to examine the patterns of substitution over time, by firm size and other firm characteristics.

[*]University College Dublin

[†]Economic and Social Research Institute and Trinity College Dublin. Contact details: marie.hyland@esri.ie, +353-1-8632109

3 Preliminary Results

We are still in the process of carrying out the estimation, so the results to date are preliminary. Thus far the following points have emerged from our analysis:

- Based on the estimated cross-price elasticities of demand, capital and energy are weak substitutes: the demand for capital is less responsive to a change in the energy price than energy demand is to a change in the price of capital.
- The Morishima elasticities, which Nguyen and Streitwieser (2008) argue are the preferred elasticities to examine, show that energy and capital are more substitutable than the cross-price elasticities would suggest.
- Regarding own-price elasticities, energy demand is the most elastic of the four inputs, while labour is the least elastic.
- We estimate the elasticities for different sizes and types of firms, and find that the substitution between factor inputs does not vary much by firm type or size

4 Conclusions

We estimate a translog cost function in which we model firm heterogeneity directly by including additional firm characteristics in our equations. Rather than basing our results on a single measure of elasticity, we compute both the price elasticity of demand and Morishima elasticities of substitutions (MES). We believe that both have merit depending on the policy inference in question; Koetse et al. (2008) note that policy makers considering, ex-ante, the likely effect of a carbon tax on the demand for capital will be interested in the cross-price elasticities, whereas engineers may be more interested in the technological substitution potential between energy and capital, as given by the MES.

We find that all factors of production are substitutes in Irish manufacturing. The substitutability between capital and energy, as measured by the cross-price elasticity, indicates a weak substitutability. While, the Morishima elasticity of substitution shows a stronger technical-substitution potential.

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