



Paper on Energy Economics

Estimating factor substitution elasticities in Swiss manufacturing

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1 Overview

This paper analyzes the widely discussed issue of substitutability in factor demand of the manufacturing sector. As most studies so far are based on aggregate data at the sectoral level, they are not able to account for heterogeneity between the different companies. They also fail to exploit information of factor substitution within a company over time. As a consequence, it has been argued by Solow (1987) that when applying macro level data, it is not possible to capture the substitution among capital and energy.

We estimate sector- and firm-specific substitution elasticities using Swiss panel data on the company level from 1997 to 2008 for three levels of energy intensity. From a theoretical point of view, it is not far to seek that different importance of energy in the production process might correlate with the ability or the ease of substitution. As previous studies as well as our results indicate, substitution among energy and other factors is generally weak. For the fraction of high energy intensity, the issue of weak substitutability is likely to be even more severe, because of the significance of energy in the production process. On this level of disaggregation, one can control for firm specific features and thus discover the true factor substitution within the firm.

Given the plans of the Swiss government concerning the nuclear phase-out, it is of paramount importance to explore the possibilities of Swiss manufacturing firms to substitute their factor inputs. To our knowledge, only three previous studies employ data on a company level to estimate the factor substitution among capital, labor, energy and material to date. Besides Woodland (1993) and Nguyen and Streitwieser (1999), both applying cross-section data, the most recent work is done by Arnberg and Bjørner (2007), where panel data on Danish firms from 1995 until 1997 are used. In this context, it is worth mentioning that while the two cross-section data based studies found energy and capital to be substitutes, Arnberg and Bjørner (2007) discover complementary patterns while panel data are applied and substitutional patterns when the time dimension is ignored. Our work provides further insights to this still relatively limited literature on within-firm substitution of factor inputs.

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2 Methods

Our functional specification is a translog function as introduced by Christensen et al. (1973) where we consider capital, labor, energy and material as input factors.

The model set-up accounts for company fixed effects and the estimation method consists of a simultaneous equation framework to meet the requirements for several parameter restrictions imposed by the translog function.

Besides the technical model framework, we estimate several specifications and incorporate firm and sector specific control variables on the one hand and deterministic terms on the other hand.

3 Results

In general the results are more in favor of substitutability rather than complementarity among the input factors. However, the high energy intensity subset might face one serious problem in substitution as there is evidence for complementarity between energy and capital at least in the short run. While substitutability among material and other factors is estimated highest in all subsets, in the case of energy substitution seems weak.

4 Conclusion

The policy implications from this analysis are that both the low and medium energy intensity firms should not face severe problems in dealing with raising energy prices. In general, the elasticity pattern probably changes if the time dimension of the panel data is ignored. In the long term, substitution possibilities might evolve a much broader magnitude as fundamental adjustment in the production process cannot be applied immediately.

Nonetheless, in cases where energy is of paramount importance in the production process complementarity between energy and capital imply both a decreasing amount of energy as well as of capital to hold the output on a constant level. For this fraction even long-term substitution possibilities of energy might be nonexistent. As Arnberg and Bjørner (2007) follow, capital and energy should be seen as a package in the production process and technological innovations affecting prices for one factor must be considered in an extended production horizon.

Keywords: Substitution elasticities · Switzerland · Factor demand · Micro-panel data · Translog

JEL classifications: C33, D24, Q41

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