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INTERFUEL SUBSTITUTION AND ENERGY USE IN THE UK MANUFACTURING SECTOR

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OVERVIEW

The growing challenge of climate change has made economists concerned about the various ways that industries can adapt to the requirements of increasingly stringent carbon emission targets. Interfuel substitution is seen as a promising venue, as industrial consumers are expected to have greater incentives than residential or small commercial users to switch to non-fossil fuels (e.g. electricity from renewable energy sources), as relative fuel prices change. A large number of econometric studies (see Barker, Ekins, and Johnstone 1995 for a survey) attempted to quantify the potential for switching between electricity and other fuels among industrial customers. These studies found that electricity is generally a poor substitute for other energy inputs (such as coal, oil, and gas).

Most of the existing literature on interfuel substitution is based on aggregate data, which makes existing estimates subject to a large measurement error. One of the few studies of interfuel substitution based on disaggregated data is Bjørner and Jensen (2002), who estimated empirical models of interfuel substitution between electricity, district heating, and two other inputs, using a micro panel dataset for Danish industrial companies. Their estimated cross-price elasticities of substitution for electricity were lower than in the studies based on macroeconomic data. Bjørner and Jensen (2002) interpreted this difference as an effect of `derived demand' (or aggregation bias). Second, studies based on aggregate data across fuel use do not capture idiosyncratic properties of different fuels in the manufacturing processes. Jones (1995, p. 459) found that "excluding fuels used for non-energy purposes yields larger estimates of the price elasticities for coal and oil and indicates generally greater potential for interfuel substitution than when using aggregate data." None of the existing studies estimated the elasticities of fuel demand differentiated by fuel use for energy purposes in industrial processes. This is, however, very important because different manufacturing processes (e.g. lighting, cooling, or chemical processes) are bound for use with specific fuels (typically, electricity).

This study provides more reliable estimates of own-price and cross-price elasticities of fuel demand by excluding the consumption of fuels used in industrial processes with limited technological substitution possibilities based on the data disaggregated at both industry and the fuel use levels.

METHODS

The econometric specification employed in this study is the dynamic version of the linear logit model suggested by Considine and Mount (1984) and extended by Considine (1990). The model is consistently estimated using a two-step iterative procedure suggested by Considine (1990). In the first step, the actual fuel cost shares observed in each period are used in lieu of the equilibrium cost shares to estimate the parameters and produce an initial set of predicted shares for each observation. These initial predicted shares are then inserted into the model for reestimation of parameters, yielding a new set of predicted shares. This process continues until the parameter estimates converge. The nonlinear iterative seemingly unrelated estimation procedure is employed to estimate the model.

RESULTS

This study applies econometric models of inter-fuel substitution to energy inputs aggregated by their energy use, and separately for thermal heating processes (which account for about 70 percent of total energy consumption), where interfuel substitution is technologically feasible. The results from 12 UK manufacturing sectors disaggregated at 4-digit SIC level between 1990 and 2005 indicate that compared to aggregate data, the own-price fuel demand elasticities for all fuels and cross-price elasticities for fossil fuels are considerably higher for thermal heating processes. Nonetheless, electricity is found to be a poor substitute to the fuels based on both aggregate data and separately for the heating process.

This study also finds that an increase in real fuel prices resulted in higher substitution elasticities based on aggregate data, and lower substitution elasticities for the heating process. These results suggest that an increase in energy prices had a limited effect on fuels' choice in the direct manufacturing process, with major substitution coming from change in fuel demand for idiosyncratic energy-using processes, such as the machine drive, electrochemical processes, and conventional electricity generation. The results of counterfactual decomposition of change in the estimated elasticities indicate that technological change was the major determinant of the differences in observed elasticities before and after the energy price increase. On the contrary, the effect of the change in economic environment (i.e. altered relative fuel prices) was limited.

CONCLUSIONS

These results have important implications for energy and climate policies. Rising fossil fuel costs will have a larger effect on substitution from carbon-intensive coal and petroleum products to less carbon-intensive natural gas, but have a small effect for substitution from fossil fuels to electricity in the manufacturing sector. Raising fuel prices will also result in higher substitutability across fuels through adjustment in idiosyncratic energy-using manufacturing processes.

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