THE PATTERN OF INTER-FUEL SUBSTITUTION IN ENERGY INTENSIVE MANUFACTURING INDUSTRIES IN INDIA DURING 2000-01 – 2011-12

Shyamasree Dasgupta, Indian Institue of Technology, Mandi, India, Ph:+918017448340, Email: shyamasree@iitmandi.ac.in
Shivam Satija, Indian Institue of Technology, Mandi, India, Ph: +919805345255, Email: shivamsatija04@gmail.com
Prateek Gauba, Indian Institue of Technology, Mandi, India, Ph: +919805343714, Email: prtk0904@gmail.com

Overview

In India, an important role has been assigned to energy intensive manufacturing industries to contribute to the country's unilateral mitigation pledge. Enhanced productivity of energy as well as other inputs, deployment of efficient technology and fuel switch are considered to be promising routes for this. It is well reflected in the formulation of the energy efficiency policy Perform Achieve and Trade (PAT) under the National Action Plan on Climate Change (NAPCC) (GOI 2008). This policy is aimed to promote energy efficiency through a combination of mandates and market based mechanism by influencing the effective energy price. However, this policy treas energy as an aggregate input and therefore, does not explicitly distinguish between the type of fuels being used. Against this backdrop, we have modeled the energy demand behaviour of seven energy intensive manufacturing industries in India taking into consideration their disaggregate fule use pattern to explore their responses to changes in different fuel prices and the pattern of inter-fuel substitution. Our objective is to understand whether the response of these industries to change is different fuel prices remained asymmetric over the study period. If so, then it calls for deepening of the existing policy framework by taking into consideration different fule types. The period of analysis is 2000-01-2011-12. The industries that we have considered are non-ferrous metal, cement, chemical (without fertilizer and pesticide), fertilizer and pesticide, iron and steel, pulp and paper and textile. The fuels under consideration are are coal, electricity, petroleum products and a residual group called 'other fuel'.

Methods

The framework of analysis is based on the neoclassical theory of producers' behaviour. Given the assumption of weak separability, we have constructed an energy sub-model within input cost function where energy cost is expressed as a function of multiple fuel prices in a translog form (Hundson and Jorgenson 1974; Griffin 1977; Kar and Chakraborty 1986). Assuming contemporaneous correlation in the error we have then estimated the energy sub-model under the assumption of Zellner's Seemingly Unrelated Regression Equations (SURE) (Dasgupta and Roy 2015). The estimated parameters are interpreted to understand energy use behaviour including the trend of cost share of different energy inputs, their response to change in own prices, feasibility of inter-fuel substitution given the state of technology and behavioural response. We have used three measures of elasticity of substitution – Allen Elasticity of Substitution (AES); Morishima Elasticity of Substitution (MES) and MaFadden's shadow elasticity of substitution (SES). Annual Survey of Industries published by Central Statisitcal Organization under the Ministry of Statistics and Programme Implementaion, Governement of India and the Wholesale Price Indices published by Reserve Bank of India are the main data sources.

Results

- The average cost shares for different fuels show that other than cement and fertilizer and pesticide**,** in all industries purchased electricity accounts for the dominant share in the total fuel cost. Coal has a dominant share in the fuel cost in cement industry (54%) while the residual group "other fuel" has the biggest share in fertilizer and pesticide (58%). The dominant share of "other fuel" in fertilizer and pesticide industries is due to significant use of natural gas as feedstock.

- The Allen elasticity of substitution estimates suggest that, technologically, the feasibility of substitution between coal and electricity is high in chemical, fertilizer and pesticide, iron and steel and pulp and paper industry. AES estimates between coal and petroleum product are greater than unity for all industries other than pulp and paper. During the oil price shocks of the 1970s in India, policies were directed towards substitution of high cost petroleum by low cost, indigenous coal. It is therefore interesting to observe the prevailing substitutability between these two fuels even three decades after the oil price shocks.

- Given the estimates of Morishima elasticity, the asymmetric nature of inter-fuel substitution possibility becomes apparent. The estimates of Morishima elasticity are also highly suggestive of electricity being a good substitute of coal and petroleum product in most of the cases. The asymmetric character of Morishima elasticity of substitution has a very important policy dimension, especially related to energy price.

- The estimates of Shadow price elasticity (SES) show that coal, electricity and petroleum products are substitutes for all the industries, with the only exception in case of coal and electricity in non-ferrous metal industries.

- However, a positive technical elasticity of substitution between two fuel types can only imply that the necessary condition for inter-fuel substitution is satisfied. Our estimates show that responses of coal and electricity to their own prices are rather inelastic across industries. Such inelastic industrial energy demand with respect to its own price is not unexpected in the short run especially in case of industries with one of the possible reasons being technology lock-in or lack of fuel flexibility in existing technology (Goldar, 2010).

- The cross price elasticity estimates suggest that other than non-ferrous metal and textile industry, substitutability is observed between coal and electricity The degree of substitutability between electricity and all other fuel types varies across industries. However, in none of the cases, other than chemical industries (including fertilizer and pesticides) the elasticity is found to be high.

One has to note that underlying this price response is the assumption that the technology is given. Therefore, our finding suggests while change in fuel price in itself may not be very effective towards inter-fuel substitution in favour of electricity, but behavioural response will be conducive if technological progress shows biases towards electricity. However, one should consider the fact that electricity cannot always economically supply all industrial energy services where intense source of heat would be required.

Conclusions

Empirically, these findings have important policy implications. First, given the evident asymmetry in Morishima elasticity of substitution in Indian manufacturing industries, energy policy has to take the route of individual fuel price and both the fuel and the policy has to be chosen carefully. Other things remaining the same, the policy maker should ideally target the price which triggers higher substitution possibility between the two inputs within existing technological boundary. Second, electricity is mostly found to be substitute of both coal and petroleum. This has major implications in the context of the global conversation over carbon reduction. It is a common finding of the Integrated Assessment Models that one of the most plausible ways to achieve global emission reduction within the stipulated timeframe is to have a larger share of electricity consumption in the longer term. Our estimates suggest, in this particular set of industries technology is conducive for greater degree of electrification to substitute the use of coal and petroleum products. Finally, in general the lower values of cross price elasticity estimates suggest that change in the price of one fuel did not act as a major trigger of fuel substitution. This shows that if technology remains the same, price policies will remain insufficient to trigger behavioural response towards fuel substitution in this set of manufacturing industries in India.

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