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Do manufacturing firms react to energy prices? Evidence from Italy

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A B S T R A C T

The reaction of energy demand to price changes is a key policy issue as it describes the economy's response to changes in market conditions or to policy interventions. The issue is even more important for the Italian economy, highly exposed to energy price changes, given its almost complete fossil fuel-related energy dependence, environmental sensitivity and highly fragmented industrial structure. Besides the policy issue, there is also an important methodological debate, concerning the best way to evaluate energy demand elasticities, looking at alternative models, data and elasticity definitions. After a discussion of the main methodological issues and the related empirical literature, this paper presents an estimation of factor and fuel demand elasticities for Italian industrial firms, by using a microeconomic panel in a two-stage translog model. Using cross-price and Morishima elasticities, we obtain information on the magnitude and asymmetry of firms' responses to price changes. Moreover, the use of a micro-dataset allows the high heterogeneity of Italian firms to be considered: the results are discussed according to technology intensity, sector and firm size. Our findings show that energy is the most elastic input for all sectors and that capital and energy are substitutes in the low technology sector and weak complements in all others. Estimated interfuel elasticities show a high degree of demand sensitivity to fuel price changes and the vast majority of cross-price elasticities exhibit substitutability. Appropriate fiscal policies can thus be identified to give an effective impulse in influencing the industrial energy mix by changing relative prices. These findings constitute an important foundation for analysing energy demand by Italian industrial firms, given that empirical literature is particularly rare on the Italian case study.

1. Introduction

Given that Europe has limited energy reserves, it has to import most of its energy, and since the price is decided by world markets, forecasting and reducing the impact of possible price increases in the near future is a central issue. The European energy strategy thus focuses on lowering energy dependency (by expanding sources of renewable energy and increasing energy efficiency) and limiting the extent to which world price increases are passed on to consumer welfare and the competitiveness of firms by means of a more efficient European market. Conversely, Europe's climate strategy aims at setting a unique price for carbon so as to implement the 'polluter pays principle' and give a signal of the real cost of releasing greenhouse gases by burning fossil fuels. The price signal is designed to induce consumers and firms to change their energy mix, favouring new products and inputs with a lower environmental impact. Pursuing both these ambitious – and apparently contradictory – goals requires considerable resources and, at the same time, a significant change in the habits and behaviour of consumers and firms which environmental and energy policies need to stimulate with all the available instruments.

When looking at firms, the reaction of agents to a price signal, whatever the reason of the price change (a result of scarcity, the market power of producer countries or deliberate, environmentally-related tax changes), is generally speaking good news as regards both such policy objectives: a 'reactive' curve – where reactivity is measured by curve elasticity – usually signifies the ability to avoid the price increase, either through greater energy efficiency, a change in the energy mix or general tax-shifting behaviour.

Some of these positive reactions may be associated with a win–win perspective: if energy efficiency improves following a price increase, it could be said that there were unexploited opportunities for saving resources that only became evident after the price shock or the price signal forced the firm to invest in innovative and energy-saving technologies. However, an increase in energy prices has a potentially negative and politically-sensitive impact: adverse effects on smaller, innovative firms, a general loss of competitiveness and delocalization (or carbon leakage) are just some of the possible downsides. Identifying who would be affected by a price increase, or how much the energy mix may change as a result of a hypothetical Pigouvian tax policy thus

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Table 1
Selected indicators of the firm panel — weighted values (average 2000–2005).

	Total observations (weighted)	(%)	Energy intensity (a)	Profitability (b)	Cost Competitiveness indicator (c)
LOT low technology	6857	36.2	0.161	0.166	1.588
MLT medium-low technology	5629	29.7	0.272	0.162	1.629
MHT medium-high technology	4251	22.5	0.062	0.151	1.501
HIT high technology	2194	11.6	0.086	0.192	1.710
<250 employees (SME)	1397	0.76	0.135	0.168	1.589
=>250 employees (LE)	4533	0.24	0.135	0.153	1.581
Panel observations (3425 firms)	18931	100.0	0.135	0.165	1.586

Notes:
(a) Energy consumption in Toe/value added in thousand Euros (median value).
(b) Gross operating surplus/value added (median value).
(c) Labour productivity over unit labour cost (median value).

appears the key starting point for any national or European strategy. Aside from the question of policy, there is also an important methodological debate, relative to the best way of evaluating energy-demand elasticities. As usual in social sciences, this matter needs to be addressed from a number of viewpoints since different methods throw up different aspects: the availability of several models and data is essential for developing a sound policy approach in this strategic field.

The research presented in this paper belongs to the econometric approach to modelling industrial energy demand as presented in a compendium of analytical methods by Greening et al. (2007). Our approach is based on a micro-panel dataset covering Italian manufacturing firms in the period 2000–2005. Most studies in the related literature on industrial energy demand have been based on time-series aggregate data or cross-section data. The contribution of this paper to the energy elasticity debate is therefore manifold. Firstly, it fills the gap in firm level studies on energy use in Italy, shedding some light on the reactivity of the manufacturing sector to changes in energy prices. In this research a unique panel database is used, including information on energy use and economic variables for very small as well as medium to large industrial enterprises, by means of which we add important information on energy-related elasticities. In addition, this paper jointly considers the issues of inter-factor and inter-fuel elasticities, assessing the room for substitution between energy, capital, labour and materials, as well as between different fuels within production processes. Given the need to differentiate various production processes, we run separate estimations according to a technology-based classification, also taking into account the heterogeneity of the size of firms. Our results show that energy is the most elastic input for all sectors and that capital and energy are substitutes in the low technology sector and weak complements in all others. Morishima elasticities between capital and energy are positive and greater than one in most sectors, and the technological substitution potential of capital for energy tends to dominate over the reverse: the share of capital increases following an increase in energy prices to adjust the characteristics of the capital stock towards more energy-saving technologies. As regards inter-fuel substitution, estimated elasticities show a high degree of demand sensitivity to fuel price changes and the vast majority of cross-price elasticities show substitutability while a large potential of substitution between natural gas and fuel oil is estimated by Morishima elasticities, particularly for medium-high and high tech firms. Appropriate fiscal policies can thus be identified to give an effective stimulus in influencing the industrial energy mix by changing relative prices.

The paper is organised as follows. After a brief overview of the most important methodological caveats and the main findings of the empirical literature (Section 1), Section 2 summarizes the translog model and the specific elasticity definitions adopted in this paper. Section 3 describes the dataset, and in Section 4 the results of estimation are discussed. The final section contains our conclusions.

1.1. Some methodological issues

All impact estimations – for which elasticities play a key role – are strongly model-dependent, not only as regards to the ability to implement policy details and to identify various aspects of policy effects and feed-back, but also in terms of the underlying crucial theoretical hypotheses and the estimation strategy adopted. Over the last two decades there have been countless studies on the impact of changes in energy prices on the economy, based economic models using different approaches and different sources of data.[1] However, the scarcity of data in this field has resulted in only those macroeconomic estimations considering energy as a composite good and microeconomic estimations concerning household energy demand being abundant, whereas the analysis of firms' demand for energy, based on microdata, is much rarer. The availability of micro-based studies is important since, as Solow (1987) states estimating factor substitution with aggregate data on inputs and output may be misleading because changes in the product mix are likely to occur when factor prices change, and thus the estimates of the elasticity of substitution based on aggregate time-series are likely to be biased downwards.[2]

However, different models and data characteristics are not the only methodological problems. Even the definition of elasticity is widely disputed in the literature, especially where the substitution or complementarity of factors and/or energy inputs – for a given level of output – is the focus of the analysis. Indeed, an absolute or a relative approach may be considered: in the first approach elasticity measures the change in quantity of one factor following a variation of the price of another factor, as in cross price elasticities and Allen–Uzawa elasticities. In the second approach the analysis focuses on how the relative usage of two factors (the level of one relative to the other) is influenced by one input price (as in Morishima elasticities) or by the relative input prices (shadow elasticities of substitution). These elasticities differ in the underlying hypotheses and their explanatory capacity: to give just one example, Allen–Uzawa elasticity, although widely used in the empirical literature, may be considered uninformative when more than two factors are used.[3] Moreover, its definition implies symmetry in the reaction of two factors (or energy inputs): according to Allen–Uzawa elasticity, the change in factor i after a change in the price of factor j is identical to the change in factor j due to a change in the price of factor i, a hypothesis clearly too limiting on empirical grounds. As we chose to include four factors and four energy inputs in the empirical analysis (for

[1] See Bardazzi and Pazienza (2014).
[2] On this issue see also Miller (1986).
[3] For a survey of the main issues relating elasticities and an empirical application of several measures (Allen-Uzawa elasticities, cross-price elasticities, Morishima and shadow elasticities) to Italian manufacturing firms see Bardazzi et al. (2012). Seminal contributions on this issue come from Blackorby and Russell (1989) and Frondel (2004, 2011).