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Capital-Energy Substitution: Evidence from a Panel of Irish Manufacturing Firms¹

Stefanie A. Haller and Marie Hyland*

Using firm-level data from the Irish Census of Industrial Production for the period from 1991-2009, we look at how Irish manufacturing firms adjust their input mix in response to changing energy prices. We find that an increase in the price of energy causes the demand for energy inputs to fall, while the demand for capital, material and labour inputs rises. This indicates that the other factors of production are substitutable with energy in the Irish manufacturing sector.

We find that for Irish manufacturing firms, the demand for energy is price-responsive. Our estimates indicate that a 1% increase in the price of energy will cause the demand for it to decrease by, on average, 1.5%. The demand for other inputs experience small increases in response to rising energy prices.

In our research we focus in particular on the relationship between capital and energy inputs. The relationship between these two inputs has important implications for environmental policy – a carbon tax, or other policies designed to increase energy prices, will encourage investment in energy-saving physical capital only if capital and energy are substitutes in the production process. We find that they are but that the relationship is weak – a 1% increase in the price of energy will cause the demand for capital to increase by only 0.04%. We attribute this unresponsiveness to the fact that energy costs only represent a small proportion of total costs; on average across Irish manufacturing firms, energy costs are less than 2% of total input costs.

We further investigate whether the relationship between capital and energy differs across firms of various types and sizes. Such an effect would be important as it would indicate that certain firms may be disproportionately affected by a carbon tax, or by other factors which cause the energy price to rise. In general we find no significant differences in how various types of firms adjust their demand for capital in response to rising energy prices. There are, however, two exceptions – we find that firms that are relatively more energy-intensive increase their demand for capital more than non-energy intensive firms in response to rising energy prices. On the other hand, we find that foreign-owned firms increase their capital demand less than Irish-owned firms in response to rising energy prices. It

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has been shown that foreign-owned firms are larger, more productive and more technology-intensive, thus it is likely that these firms already embody more energy-efficient equipment.

An analysis of substitution patterns over time shows that Irish manufacturing firms have become less responsive to changing energy prices over the time period studied in our data (1991-2009). In particular we observe a sharp decline in substitution between energy and capital during the first half of the sample period in the 1990s. We attribute this to a drop in energy-intensity of the Irish industrial sector around the time driven by efficiency improvements, movements up the value chain and possibly an emerging policy focus on energy efficiency and pollution control.

Finally, using an alternative measure of substitutability we also measure the technical substitution potential between energy and capital. This measure takes account of how the price of energy affects the demand for capital, while simultaneously considering how the demand for energy itself is affected. This measure reveals a stronger technical substitution potential – a 1% increase in the price of energy causes the capital-energy input ratio to increase by 1.5%. We find no significant differences across various sizes and types of firms according to this alternative measure of substitution; however it does confirm the large drop in the substitutability between capital and energy that has taken place over time.

To summarise our findings, despite some differences in the size of the elasticities when we split the data, in all cases the substitutability between capital and energy holds. The policy implications are important - the imposition of a carbon tax, or other policies likely to increase the price of energy, are not expected to be associated with a decline in capital investment.