

# ***ENERGY ENDOWMENTS AND THE INTERNATIONAL LOCATION OF MANUFACTURING PLANTS***

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## **Overview**

Over recent years, many businesses, analysts and other stakeholders have raised concerns about the effect of energy prices on international competitiveness. Particularly close attention has been paid to this issue in Europe because a significant gap in energy prices has emerged between European countries and the United States since the mid-2000s. Climate change policies such as renewable energy subsidies and the European Union Emission Trading Scheme (EU ETS) may have contributed to this energy price gap. However, according to the International Energy Agency (IEA), climate policies are far from the dominant factor in price formation. Instead, the IEA suggests that the main factor is that the US shale gas revolution has greatly increased US energy independence, while Europe in contrast is reliant on expensive imported fuels.

If energy endowments are an important source of comparative advantage, multinational firms may choose to structure their production globally to exploit international differences in energy resources. Such behaviour, which comes directly from the theory of vertical foreign direct investment (FDI), may mean that energy intensive jobs and production locates away from countries which do not keep up with other nations in their development of new domestic energy resources, resulting in relatively high equilibrium energy prices. In this paper we exploit the US energy revolution as a quasi-natural experiment to test whether multinational firms locate their production in this way. We use data on UK manufacturing firms to consider whether energy intensive firms establish new foreign affiliates in the US after the US energy endowment shock. We also analyse the within-firm, plant level adjustments of US investors in the UK to consider whether these firms shut down their energy intensive UK production in response to the endowment-driven energy price gap.

We perform our analysis using confidential, micro-level data on outward investment by UK manufacturing firms. In our empirical analysis we follow the previous literature (Arezki et al. 2017) by assuming that the US-UK natural gas price gap represents an unanticipated – and therefore exogenous – shock to the relative energy price between the US and UK. Using firm-level data on energy intensity and investment decisions allows us to incorporate the predications of the heterogeneous firms models of international trade and investment into our empirical analysis.

Our focus on the impact of the US energy revolution on UK firm behaviour is motivated by three considerations. First, the UK is highly integrated with the US economy. Across all industries, the UK has the most cumulative FDI of any country in the US, equal to \$512 Billion or 15.5 percent of the total in 2015 (US BEA, 2017). Within our sample, around 30-40% of UK multinationals typically operate one or more foreign affiliate in the US each year. More generally, the UK is one of the major outward investors of the global economy, with a total stock of outward FDI across all countries of \$1.5 Trillion in 2016 (OECD, 2018). Second, besides the energy price gap, the US and UK both share characteristics that are likely to be attractive to energy intensive industries. For example, both economies have high quality energy supply infrastructure, and both are physical capital abundant. In addition, both the UK and US are highly open economies. Third, the UK has displayed a sharp decline in its domestic endowment of natural gas. This has meant that the UK has moved from being a net exporter of natural gas to a major net importer of natural gas in the mid-2000s. The possibility that the positive US natural gas endowment shock is a source of comparative advantage may therefore be particularly pertinent in this context.

## **Methods**

Our empirical analysis consists of two stages. In the first stage, we examine the effect of the endowment-driven energy price gap between the US and UK on plant location decisions. To do this we use a difference-in-differences specification that compares the propensity for firms to invest in the US before and after the energy price gap, for energy intensive versus non-energy intensive firms. When analysing this extensive margin of adjustment, we focus on a firm fixed effects model to control for observed and unobserved firm characteristics that may also affect the likelihood that the firm invests in the US. We employ a long interval approach that compares before and after the US-UK energy price shock. We also estimate a fully non-parametric specification using annual data to consider when UK firms switch into US investment.

In the second stage of our analysis, which looks at the decision to exit plants in the UK in response to US investment, we estimate a duration model of plant survival using annual data. More specifically, we estimate a discrete time proportional hazards specification using the complementary log-log model. We then compare the hazard rate of exit for UK plants before and after the US-UK energy price gap, for energy intensive versus non-energy intensive plants. We also compare the hazard rate for US investors against a control group of firms that do not invest in the US.

To perform our analysis we use confidential plant and firm level data provided by the UK Office for National Statistics over the period 1998-2015.

## **Results**

From our analysis we find evidence to suggest that energy intensive UK firms are more likely to invest in the US post the US-UK energy price gap than before it emerges. In particular we find that the firm's most energy intensive line of production in the UK has a strongly significant and positive effect on the US FDI decision. The same effect is not found for the energy intensity of the firm's main line of business in the UK. This suggests that it is important to take into account within-firm heterogeneity when considering the determinants of firm-level FDI decisions. The effect is small in magnitude, with a 1 standard deviation increase in energy intensity increasing the propensity to invest in the US by about 0.7 of a percentage point due to the emergence of the energy price gap. This reflects that only a small proportion of firms are able to overcome the sunk costs involved with investing abroad, which is consistent with the results of the heterogeneous firms literature for trade and investment.

Our results are also robust to a range of robustness tests. We also do not find a positive and significant effect when estimating the same model for two placebo tests. These two placebo tests look at the pre-sample period before the US-UK energy price gap emerges, and look at the propensity for UK firms to invest in the EU. The fact that we do not find significant effects in the placebo tests supports the interpretation of our main results as the casual effect of the US-UK energy price gap.

For the second stage of our analysis, we do not find evidence to suggest that firms investing in the US are more likely to shut down their energy intensive production in the UK in response to the price gap. Relative to non-US investors, investing in the US is found to be a complement rather than substitute for energy intensive production in the UK, and this effect varies little with the price gap. This finding is robust to various empirical specifications and two alternative measures of the US-UK energy price gap (including both the natural gas price gap, and sector specific overall energy price gaps). We also find that US owned UK energy intensive plants are not more likely to shut down in response to the energy price gap.

## **Conclusions**

We investigate whether UK manufacturing firms are engaging in FDI in order to exploit the endowment-driven energy price gap between the US and the UK. We find evidence to suggest that energy intensive firms are establishing US affiliates in response to the price gap. However, there is little evidence that this is at the expense of energy intensive UK production. Investing in the US is found to be a complement rather than substitute for UK energy intensive production.

## **References**

Arezki, R., Fetzner, T. and Pisch, F. (2017) On the comparative advantage of U.S. manufacturing: Evidence from the shale gas revolution, *Journal of International Economics*, pp. 34-59.