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Why is the US so Energy Intensive? Evidence from US Multinationals in the UK

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Abstract

At present the USA is - in per capita terms - the top greenhouse gas polluter among the world's major economies. This is mirrored by the high energy intensity of all sectors of the US economy including manufacturing industries. A potential explanation for the higher energy intensity is lower US energy price levels. However, common price elasticity estimates are not high enough to explain the observed differences between countries. Alternative explanations include firstly geographic or other locational differences and secondly firm specific technology differences between US firms and others. This study explores this latter possibility by comparing establishments of US firms in Britain with other comparable firms thereby ruling out locational differences. The findings are that on average US firms are not more energy intensive when operating in Britain. However, US firms that have only recently entered the UK market are found to be significantly more energy intensive at an order of magnitude corresponding to the between country US-UK gap. This difference vanishes with an increased duration of stay in the UK; however, with a considerable time lag. This suggests firstly, that barriers to knowledge diffusion are an important concern and secondly, that the long term response to a sustained price increase might be stronger than common price elasticity estimates suggest. The study also provides, for the first time, estimates of energy price elasticities for the UK on the basis of representative plant level panel data for the manufacturing sector.

Keywords: Energy efficiency, multinationals, energy demand elasticity, climate change
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1 Introduction

Many studies have discussed the productivity leadership of the US.[1] The US productivity leadership is dwarfed, however, by the US world leadership in greenhouse gas pollution (Figure 1).[2] While there are some exceptions, variations in pollution are mirrored internationally by variations in energy intensity (Figure 2). Crucially, the US is more energy intensive across all major sectors of the economy including industry (Figures 3, 4 and Table 1).

A suggested explanation for these differences can be derived from Figure 5 which shows average energy prices for industrial users for selected countries. We see that in European countries energy prices are on average around 40% higher than in the US. Hence US firms might use more energy simply because it is cheaper for them to do so. A problem with this explanation is that it does not square with estimates of industrial energy price elasticities (Roy et al., 2006; Pindyck, 1979; Griffin and Gregory, 1976). These typically suggest that industrial energy demand elasticities are smaller than one. When measuring energy intensity in value terms as in Table 1 - i.e. energy expenditure over gross output ($^{P^E E}/_{GO}$) - this would actually imply finding higher values for the UK as the decline in energy consumption would not be enough to compensate for the higher price. This motivates a number of potential alternative explanations for the US-UK energy intensity gap. Firstly, there might be factors - other than energy prices - derived from the business environment; e.g. the geographic or climatic features of the US might require more intensive usage of energy. Secondly, the higher energy intensity might be the consequence of firm specific factors. Recent work in the productivity literature suggests that productivity differences between countries can in part be explained by firm specific factors such as technology or managerial approach (Bloom and van Reenen, 2007; Bloom et al., 2007, 2008). This could also imply that energy intensity differences are the consequence of different firm specific technologies. For example, a number of recent studies (Bloom et al., 2007; Inklaar et al., 2005) suggest that higher US productivity is due to more intensive usage of Information and Telecomunication technologies (ICT). Clearly, computers need power to run which might explain why US firms are more energy intensive. Thirdly, it might be the case that commonly used energy price elasticities are underestimating the response of companies to persistent and structural energy price changes as they exist between the UK and the US.

It is important for both productivity and climate change policy making to distinguish between these different types of factors for a number of reasons. Firstly, it is important to understand if efforts of other countries to catch up with the US in terms of productivity are in direct conflict with efforts to reduce energy intensity and thereby Greenhouse Gas (GHG) pollution. This would be the case if the energy intensity gap is driven by firm specific technology differences. Secondly, for US climate change policy making it is essential to understand how industry would respond

[1] O'Mahony and de Boer (2002); Wagner and van Ark (1996);Bartelsman et al. (2008); Bloom et al. (2007).

[2] That is, among major industrialised countries. A number of small Middle Eastern countries have considerably higher per capita pollution levels.

to a persistent increase in energy prices induced by carbon taxing or trading.

This study sheds light on these issues using for the first time data on energy intensity of US multinationals (MNEs) abroad. I examine if US MNEs operating in the UK have different energy intensities from other comparable firms operating in the UK. Because the business environment is the same for all firms in the sample I can isolate the effect of firm specific factors.

I find that, on average, establishments owned by US MNEs in the UK are not more energy intensive than either domestic firms or other MNEs. However, this average result is hiding an important heterogeneity: younger US MNEs - or rather establishments of US MNEs that have only recently entered the UK - are on average more energy intensive. Moreover, the rate at which US establishments reduce their energy intensity with age is significanly higher than that of comparable establishments. This finding is robust to a wide range of robustness checks including controls for unobserved firm specific heterogeneity. I also show that this effect is stronger in establishments that are setup by US MNEs as greenfield investments rather than those acquired in takeovers.

What could rationalise this finding and what are the implications? I suggest that the observed pattern can be well understood drawing on the literature of directed technical change as well as the technology diffusion literature. Acemoglu (2002) introduces a model which endogeneises the intensity of different production factors. He shows that the short run elasticity of substitution of a specific factor is a key parameter that determines the incentives of firms to engage in R&D that improves the efficiency of this factor in response to a supply shock; e.g. in the context of labour of different skills he shows that an increase in the supply of high skilled workers can induce a skill bias in R&D that renders high skilled workers better off. For that to happen, low and high skilled workers need to be sufficiently substitutable. Below I argue in more detail that to explain the observed energy intensity differences between the UK and the US we need to assume that in the short run energy cannot easily be substituted with other factors. Thus the short run response of energy to a price increase is rather muted. However, in this case firms have after a price increase a strong incentive to find ways to reduce their dependance on energy, which means that in the long run their energy intensity declines more dramatically. In a perfectly neo-classical setting where technological knowledge spreads instantenously between countries, this in itself could not motivate persistent differences in factor intensities between firms in different countries. Hence, we need in addition, ideas from the (environmental) technology diffusion literature (Jaffe and Stavins, 1994; Jaffe Adam and Stavins Robert, 1995; Blackman, 1999). There, the basic premise is that new technology does not spread instantenously between firms. This literature centres around two key ideas. Firstly, an epidemioligical model where technology adoption depends on knowing about it. To gain knowledge about a new technology a firm has to get in touch with another firm that has already adopted the technology (or at least knows about it). This is more likely if the technology is already widely diffused and less likely if the technology has only recently entered the market. In aggregate this mechanism generates an S-shaped diffusion curve. Secondly, firm specific differences or differences in the business environment might determine if firms adopt new technologies at all and at what speed. For instance in the case of US firms it is likely that given the lower price of energy - i.e. a difference in the business environment compared to UK firms - firms have less of an incentive to adopt energy saving technology even if they know about it and they have less of an incentive to invest time or other resources into acquiring this knowledge. In equilibrium a lower number of firms in the US will adopt and know about certain types of energy saving technology or practices.

A number of points emerge from my results: First, it is clear that a knowledge diffusion story matters in the sense that US firms are not aware of all technological options when entering the UK. Otherwise we would not see that US firms have a higher energy intensity initially. Rather, they should adopt the most appropriate technology immediately. This should be particularly so if the energy intensity of a firm is - at least in part - determined by irresversible investments in fixed assets.

Second, it is easy to motivate why - once in the UK - US firms increase their rate of adoption of energy saving technology: the rate at which they meet other businesses that have already adopted has now greatly increased. Equally, because of higher energy prices they have a higher propensity to adopt and also actively search for less energy intensive solutions. Third, the process of learning and adjusting seems to be rather lengthy. I find that it takes at least 3 years until the energy intensities of US MNEs are comparable to other firms operating in the UK. Fourth, quantitatively the "energy intensity gap" between newly entering US MNEs and other firms operating in the UK is rather large and comparable in size to the aggregate gap between the UK and the US.

This last point supports the idea that the adjustment process we are observing among US MNEs in the UK might be of relevance for the potential adjustment process that would arise among US firms in the US once climate change regulation increased energy prices there to UK levels. Translating the young US MNE energy intensity gap and the US/UK energy price gap into an energy price elasticity leads to an estimate of 1.8. This can be interpreted as lower bound on the long-run energy price elasticity of the US manufacturing. It is considerably higher than conventional estimates of the long-run energy price elasticity (Roy et al., 2006; Pindyck, 1979; Griffin and Gregory, 1976).

Finally, if barriers to knowledge diffusion are an important factor for energy saving technologies, this could support the idea that even at current energy prices there is scope for reducing energy usage of US firms in the US by reducing those barriers - for example by government policies to facilitate knowledge flows.[3] This would imply that the reduction in energy intensity is associated with an increase in total factor productivity (TFP). Alternatively, it could be the case that the lower UK energy intensity is only associated with more intensive usage of factors; e.g. energy saving

[3] A motivation for this could equally be derived from the so called "strong form" of the Porter hypthesis (Porter, 1991; Porter and van der Linde, 1995; Palmer et al., 1995) and the energy efficiency paradox literature which suggests that firms do not act entirely neoclassically and systematically overlook ways to reduce pollution that also improve the bottom line. More regulation - or in our case - higher energy prices - could then trigger re-examination of the businesses with improvements along both dimensions.

machines might be more expensive, or avoiding wasting energy might require more effort and attention by workers. I examine this by looking both at changes in non energy factor intensities and TFP for US firms in the UK. This does not lead to any clear results. In my prefered specification I find that both capital intensity and TFP increase. However, the result is not significant and not very robust to slight changes in methodology. I therefore conclude that there might be a combination of both, shifts to other factors and some TFP effects so that overall there is no clear or strong signal. However, given that the evidence is not robust we cannot make any strong conclusions about the potential to reduce US energy intensity at current prices.

The rest of the paper is organised as follows. Section 2 discusses the factor bias story more formally in the context of a simple Acemoglu style model. Section 3 introduces the econometric framework, Section 4 discusses the data used, Section 5 presents estimation results, Section 6 examines implications and Section 7 concludes.

2 Theory

This section discusses the idea of biases in factor intensity between the US and UK in more formal terms. The simplest way to account for biases in factor intensities requires a CES production technology (Acemoglu, 2002).

Suppose we have an economy populated with firms[4] i that produce output Q using two factors, energy E and labour L using a CES production function:

$$Q = \left[(A_E E)^{\frac{\varepsilon-1}{\epsilon}} + (A_L L)^{\frac{\varepsilon-1}{\epsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{1}$$

where the A_j's represent factor specific efficiency parameters and ε is the elasticity of substition between labour and capital. Suppose that firms take factor prices as given. Cost minimisation subject to 1 implies that energy demand is

$$E = Q A_E^{\varepsilon-1} W_E^{-\varepsilon} \lambda^{\varepsilon}$$

where

$$\lambda = \left[\left(\frac{A_E}{W_E} \right)^{\varepsilon-1} + \left(\frac{A_L}{W_L} \right)^{\varepsilon-1} \right]^{-\frac{1}{\varepsilon-1}} \tag{2}$$

is the unit cost function.

Notice that because we are only dealing with two factors of production, the own price elasticity is equal to the elasticity of substitution:

[4] Unless specifically needed, I suppress firm indices in the following to simplify the notation.

$$\frac{\partial \ln E}{\partial \ln W_E} = -\varepsilon$$

An analogous equation applies for L. The relative factor shares for energy and labour consequently become

$$\frac{S_E}{S_L} = \left(\frac{A_E W_L}{A_L W_E}\right)^{\varepsilon-1}$$

This illustrates that in order to observe a reduction in factor share through differences in factor prices alone, requires that $\varepsilon > 1$. Notice, however, that when $\varepsilon < 1$, a lower factor share can equally be caused by an increase in specific efficiency of energy A_E. To understand if this can help explaining the US/UK energy intensity gap, let's examine the incentives of firms to improve efficiency. Suppose that firms can engage in two different types of search (or research) activities which can improve the efficincy of either factor; i.e. assume that there is a search technology that with probability

$$\rho_J = \rho\left(R_j, {}^{A_j^F}\!/_{A_j}\right) \tag{3}$$

leads to a finding that increases productivity of factor j by a factor $\gamma > 1$, where R_j is the amount of resources devoted to this search and $\rho(\cdot)$ is a concave function. A_j^F measures the economy wide technology frontier; i.e. the level of efficiency in the plant with the highest efficiency.

To examine firms' incentives to engage in this search, we first have to derive their profits. Suppose that firm's output demand is determined by monopolistic competition with the following demand function:

$$Q = P^{-\eta}$$

where $\eta > 1$ is the elasticity of demand and P is the price. Profits are then determined by

$$\Pi = \max_Q Q^{1-\frac{1}{\eta}} - Q\lambda$$

Using the envelope theorem we can show that the marginal impact of a change in specific efficiency of factor j becomes

$$\frac{\partial \Pi}{\partial A_j} = -Q\frac{\partial \lambda}{\partial A_j}$$

Further from equation 2 we see that

$$\frac{\partial \lambda}{\partial A_j} = -\lambda^{\varepsilon} W_j^{1-\varepsilon} A_j^{\varepsilon-2}$$

This implies that the marginal return to improvements in factor j becomes higher when the price of factor W_j increases; provided factor j is not too substitutable; i.e. $\varepsilon < 1$. [5]

This would explain why efficiency in the US is lower ($A_{E,US} < A_{E,UK}$), because firms there would invest less resources in a search for energy efficiency improvements. Further, if such technological knowledge does not diffuse instantenously between countries these differences persist. Finally, because of the spillover effect within the same economy in 3, UK establishments of US firms are able to catch up. The appendix contains a more complete characterisation of the firm's dynamic optimisation problem.

3 Econometric Framework

We are interested in studying differences in energy intensity between different types of firms. Conceptually this is a question of factor bias, an issue which has received considerable attention recently in the labour literature, in the context of biases between labour of different skill levels. For the current study I adapt the most general framework that has emerged from this literature[6], which is the translog factor demand framework. This suggests that a firm's technology can be described by a "dual" cost function of the following kind:

$$C_{it} = \sum_x \beta_x lnP_{it}^X + \sum_x \sum_z \beta_{xz} lnP_{it}^X lnP_{it}^Z + \sum_x lnP_{it}^X b_{it}^E + a_{it} + \beta_b b_{it}^E \qquad (4)$$

where $x, z \in \{K, L, E, M\}$ index different production factors and lnP_{it}^Xrepresents the log of factor prices. b_{it}^E is a shock that allows production technonology to vary in intensity between different firms and at different points in time.

Total factor productivity becomes

$$TFP_{it} = a_{it} + \beta_b b_{it}^E$$

where β_b measures the correlation between the bias shock and total factor productivity.

Demand for a production factor X in firm i at time t can be derived - using Shephard's Lemma - in terms of the expenditure on that factor as a share of costs as

[5] If on the other hand $\varepsilon > 1$, the market size effect (Acemoglu, 2002) reverses this mechanism; i.e. the increase in price would reduce spending on energy so much that, it reduces any incentive to devote search resources.

[6] See for example Caroli and Van Reenen (2001).

$$S_{it}^{X}=\beta_X+\sum_{Z\in\{K,L,E,M\}}\ln P_{it}^{Z}\beta_{XZ}+\beta_{XQ}\ln Q_{it}+b_{it}^{X} \tag{5}$$

where $S_{it}^{X}=\frac{P^X X_{it}}{C_{it}}$is the share of factor X in costs, P_{it}^{Z} is price of factor Z_{it}, Q_{it} is the output quantity and $b_{it}^{X}$is a firm and time specific bias term for factor X. The focus in this study is on biases in energy intensity; i.e. b_{it}^{E}. To examine if the energy intensity of US MNEs differs systematically from those of other firms I allow the bias term to vary with both the ownership status and age of the firm, where the age of a foreign MNE refers to the start of that MNEs operations in the UK

$$\begin{aligned} b_{it}^{E} &= \beta_{MNE}MNE_{it}+\beta_{US}MNE_{it}^{US}+\beta_{age}age_{it} \\ &+\beta_{MNE,age}MNE_{it}\times age_{it}+\beta_{US,age}MNE_{it}^{US}\times age_{it}+\varepsilon_{it} \end{aligned}$$

where MNE is a dummy variable that is equal to 1 if the firm is multinational and $MNE^{US}$is equal to 1 for a US multinational firm and $\varepsilon_{it}$is an error term. Consequently, the most general specification I use becomes:

$$\begin{aligned} S_{it}^{E} &= \beta_E+\textstyle\sum_{Z\in\{K,L,E,M\}}\ln P_{it}^{Z}\beta_{EZ}+\beta_{EQ}\ln Q_{it} \\ &+\beta_{MNE}MNE_{it}+\beta_{US}MNE_{it}^{US}+\beta_{age}age_{it} \\ &+\beta_{MNE,age}MNE_{it}\times age_{it}+\beta_{US,age}MNE_{it}^{US}\times age_{it}+\rho\mathbf{Z}_{it}+\varepsilon_{it} \end{aligned} \tag{6}$$

where $\mathbf{Z}_{it}$ is a vector of further control variables including sector, year $\times$ region dummies, as well as firm fixed effects. Under perfect competition it is easy to calculate the cost share because revenue will be equal to total costs $R_{it}=C_{it}$so that

$$S_{it}^{X}=\frac{P^X X_{it}}{R_{it}}$$

which avoides making any assumptions about the user cost[7] of capital to derive a total cost estimate. In most regressions reported below I assume that factor prices are the same for firms within the same region so that they would be accounted for by the region $\times$ year dummies. In some regressions I use firm specific prices for energy to derive an energy price elasticity.

Under imperfect competition $R_{it}=MC_{it}\mu_{it}$ where μ_{it} measures the firm's markup over marginal costs which is determined by the market structure and the firm's profit maximisation problem.[8] Thus changes in measured revenue share could be driven by either changes in the production technology - as suggested- or changes in

[7]That is about interest rates and depreciation.

[8]For a derivation see Martin (2008) and Klette (1999).

market power. Therefore to examine the robustness of my results being driven by technology, I also look at factor shares in variable costs; i.e. wage and intermediate costs:

$$SV_{it}^{X} = \frac{P_{it}^{X} X_{it}}{VC_{it}}$$

3.1 Total factor productivitiy (TFP)

To explore any effects on Total Factor Productivity one could try to estimate equation 4. However this would require a good knowledge of all prices, including the price for capital which is hard to obtain. Therefore, as an alternative I pursue the following (dual) production function approach: allowing for firm specific Cobb Douglas Production functions and a Dixit-Stiglitz demand market structure and taking into account the fact that revenue but not output prices are observed at the plant level - we can write[9]

$$r_{it} = S_{it}^{E} e_{it} + S_{it}^{M} m_{it} + S_{it}^{L} l_{it} + S_{it}^{K} k_{it} + \omega_{it} \tag{7}$$

where r_{it} is (the log of) plant level revenue and lower case letters refer to the log transformation of the production factors. ω_{it} is a composite of a firm specific demand and a technology shock. ω_{it} is the best measure of overall economic productivity we can get without plant specific data on output prices.

To examine if economic productivity behaves in a different way in US MNEs I specificy for ω_{it}:[10]

$$\omega_{it} = \beta_{US}^{\omega} MNE_{it}^{US} + \beta_{age}^{\omega} age_{it} + \beta_{US,age}^{\omega} MNE_{it}^{US} \times age_{it} + \varepsilon_{it} \tag{8}$$

To estimate the parameters in ω_{it} we need values for the S_{it}^{X} in equation 7. Except for capital we can obtain them directly from the plant level data. For capital note that the assumptions so far imply that

$$S_{it}^{K} = \frac{\gamma_{it}}{\mu_{it}} - S_{it}^{E} - S_{it}^{M} - S_{it}^{L} \tag{9}$$

where γ_{it} measures the scale effect of the production technology. Hence we can write equation 7 as

$$r_{it} - vi_{it} = \beta_{it} k_{it} + \omega_{it} \tag{10}$$

where $\beta_{it} = \frac{\gamma_{it}}{\mu_{it}}$ and

[9]For a more indepth discussion see Martin (2008)andKlette (1999).

[10]In the regressions below I include, in addition, controls for other MNEs. I skip those here to simplify the exposition.

$$vi_{it} = S_{it}^{E}\left(e_{it} - k_{it}\right) + S_{it}^{M}\left(m_{it} - k_{it}\right) + S_{it}^{L}\left(l_{it} - k_{it}\right)$$

To allow for the posibility that not only factor intensity but also scale or markups might vary between US MNE and others I specifiy

$$\beta_{it} = \beta_{K,US}^{\omega} MNE_{it}^{US} + \beta_{Kage}^{\omega} age_{it} + \beta_{K,US,age}^{\omega} MNE_{it}^{US} \times age_{it}$$

Finally, rather than just computing vi_{it} directly I also report results using a smoothed version, where I use predicted values for the factor shares obtained from a first stage[11] of factor share regressions such as in equation12 for all production factors:

$$\begin{aligned} S_{it}^{X} &= \beta_{US}^{X} MNE_{it}^{US} + \beta_{age}^{X} age_{it} \\ & e_{it} + \beta_{US,age}^{X} MNE_{it}^{US} \times age_{it} + \rho^{X} \mathbf{Z}_{it} + \varepsilon_{it} \end{aligned} \tag{11}$$

I drop output, thereby imposing homogeneity - consistent with the Cobb Douglas assumption - and minimising the potential for endogeneity. From equation 11 we can thus get a prediction of the cost shares and compute

$$\hat{vi}_{it} = \hat{S}_{it}^{E}\left(e_{it} - k_{it}\right) + \hat{S}_{it}^{M}\left(m_{it} - k_{it}\right) + \hat{S}_{it}^{L}\left(l_{it} - k_{it}\right)$$

Hence the full regression equation becomes

$$\begin{aligned} r_{it} - vi_{it} &= \beta_{K,US}^{\omega} MNE_{it}^{US} k_{it} + \beta_{Kage}^{\omega} age_{it} k_{it} + \beta_{K,US,age}^{\omega} MNE_{it}^{US} \times age_{it} k_{it} \\ &+ \beta_{US}^{\omega} MNE_{it}^{US} + \beta_{age}^{\omega} age_{it} + \beta_{US,age}^{\omega} MNE_{it}^{US} \times age_{it} \\ &+ \rho^{\omega} \mathbf{Z}_{it} + \varepsilon_{it} \end{aligned} \tag{12}$$

Thus, if US MNEs enjoyed an increase in productivity as their energy intensity declined we should see that $\beta_{US,age}^{\omega}$ is significantly positive.

[11] When running these first stage regressions I report bootstrapped standard errors across the two stages in the tables below.

4 Data

Productivity data comes from the Annual Respondants Database (ARD). Energy data comes from the Quarterly Fuels Inquiry (QFI). Information on foreign and UK ownership is derived from the Annual Survey into Foreign Direct Investment (AFDI)[12] These are confidential business micro datasets maintained by the UK Office of National Statistics (ONS). Firms are required by law to participate in these surveys. The larger firms are required to report every year to the ARD and smaller firms are randomly sampled. Larger multiunit firms are required to report separately for different business units. In most cases (about 80% of firms) this leads us to data for "business units at a single mailing address". In the results below, I use for every firm the lowest level of aggregation that is provided through the ONS data. For simplicity I refer to these units of analysis as *plants* in the remainder. The energy data from the QFI is equally at this plant level; however for a smaller sample of about 1000 firms every year. If firms die, the ONS adds new firms to the panel. It is available for the years 1997 to 2004. The AFDI data reports foreign ownership and investments abroad at the firm level for all MNEs operating in the UK. The combined sample consists of approximately 4300 observations from 1300 plants over the years 1997 to 2004. Table 2 provides a breakdown of the sample and the underlying population of businesses by MNE type. Columns 1 to 3 report on the population of firms, whereas columns 4 to 6 refer to the combined ARD-QFI sample used in this study, which corresponds to about 0.5% of the population. Columns 2 and 5 show the distribution across all firm types (i.e including non MNEs) whereas columns 3 and 6 examine the distribution between different MNE types. We see that the combined ARD-QFI dataset heavily under samples non MNE firms. Within MNEs there is an increase in the share of UK MNEs and a reduction in the share of EU and other MNEs. However, the share of US MNEs is almost identical at 27 to 28%. The literature on MNEs has emphasised the fundamental heterogeneity between MNEs and other firms. Hence for the purposes of this study the undersampling of non MNEs firms is not worrying because non US MNE firms will form the key comparison group.

Table 3 provides descriptive statistics for the QFI-ARD sample. When looking at means in column 1, US MNEs display a slightly lower energy intensity than other types of firm. We shall see later that this pattern disappears once we control for sectoral differences. Energy prices are slightly lower for MNEs. Non US MNE are bigger than non MNEs and US MNEs are bigger than other MNEs in terms of gross output, employment as well as capital stock. US MNEs are slightly younger than other firms. Finally, in terms of value added per employee, US MNEs are slightly more productive than other firms.

Table 4 examines how the sample distributes across age classes. This reveals that the majority of firms - about 80% - are older than 20 years. The distribution across age categories is very similar between different ownership types; although US firms seem slightly more concentrated in younger age classes.

[12] For more details on these datasets see Criscuolo and Martin (2009) and Martin (2005).

Table 5 shows to what extent there are changes in ownership status over time among plants in the sample; e.g. the cell in column 1 row 2 shows that 14 UK MNE owned plants were taken over by EU MNEs over the sample period. Note that the majority of plants remain each period within their ownership class; i.e. the diagonal elements are the biggest category for all ownership types. However, there are also a number of changes between categories - e.g. more than 70 changes from other categories to US ownership. Below we will report regressions with and without the inclusion of plant fixed effects. When including fixed effects, level effects of (US) ownership are identified from these changes.

5 Results

Table 6 contains results from regressing equation 5 using energy expenditure over gross output as the dependant variable. Column 1 contains a basic OLS estimator for the pooled sample. US MNEs do not appear to be significantly different. Notice however what happens when in column 2 we restrict the sample to plants younger than 10 years. This leads to a highly significant US effect of 1.1456 percentage points; i.e. the energy share of US owned plants is 1.1456 percentage points higher than that of other MNEs. To account for this issue in the full sample I propose in column 3 to interact the age effect with firm type dummies. This interaction turns out to be significantly negative suggesting that US MNEs reduce their energy intensity by 0.041 percentage points more than other plants, when they get a year older. The non interacted MNE US effect is now significantly positive (1.129), reflecting the energy intensity gap of newly setup US establishments. Column 3 suggests that EU MNEs are not significantly different from other MNEs.[13] In column 4 we consequently group them together with other MNEs which has not much of an effect on the MNE US variables. Column 5 introduces firm level capital stocks as an additional control variable. The MNE US coefficient drops slightly but the qualitative picture is still very much the same. Column 6 drops all size controls, effectively imposing homogeneity. Again this has little effect on the US coefficients.

Columns 7 to 9 repeat the last 3 regressions including plant fixed effects. While the point estimates become somewhat smaller the pattern found in the other columns remains. The fixed effect results make clear that the result on US firms is not driven by takeovers of particularly energy intensive UK firms. Rather it seems that even if US firms take over an existing UK firm this leads to a temporary increase in energy intensity. The fact that the US level effects become smaller is consistent with expectations. The energy intensity of a plant is likely to be a great deal determined by fixed assets, such as for example the type of factory building. Such fixed assets are unlikely to change in the event of a takeover. The impact in the case of a takeover is consequently reduced to factors that change more easily. This could include the degree of monitoring of energy consumption or the extent to which energy targets are part of managers incentive structures. Below I explore these issues further by reporting results separtely for US greenfield investments.

[13] An F-test confirms this.

5.1 Timing

Figure 6 explores in more detail the timing of the adjustment process by US firms uncovered in Table 6. It plots the point estimates of age dummy variables (interacted with firm type) from a regression of energy intensity; i.e. a version of equation 5where we leave the age impact pattern completely free instead of imposing a linear form. The stars behind the age axis labels indicate if US firms are significantly different from other MNE for a particular age group. We see that, for at least ages 1 to 3 years, US firms are indeed significantly more energy intensive. The difference drops to insignificant levels at age 4. However, still at age 6 we find a significantly positive value. This would suggest that the US adjustment process takes at least 3 years but might take as much as 6.

5.2 Robustness

Tables 7 and 8 provide a range of further robustness checks. Firstly, Table 7 replicates Table 6 using energy expenditure over variable costs as dependant variable. This leads to very similar point estimates, as for energy expenditure over gross output.

Table 8 reports in column 1 a regression of equation 5 without including 3 digit sectoral dummies. We see that as a consequence, the plain MNE US effect becomes insignificant while the interaction with age remains significantly negative. This should further dispel concerns that the US effect is driven by US firms being active in particular sectors. Columns 2 and 3 explore a logistic transformation of the dependant variable; i.e. the dependant variable becomes $\ln S_{it}^{E} - \ln\left(1 - S_{it}^{E}\right)$, making the econometric model consistent with the fact that S_{it}^{E} being a share, will be bound between 0 and 1. Column 2 shows for an OLS specification and column 3 for a fixed effects specification, that this does not have have any impact on the substantial findings.

The remaining columns of Table 8explore the impact of including firm level prices as additional control variable. In columns 4 and 5 we see that the energy price enters significantly negative. The US coefficients drop in absolute value but remain significant. A key concern with the energy price variable is its likely endogeneity. Columns 6 to 7 address this by running a dynamic panel data model where energy prices as well as gross output are instrumented with twice lagged variables. In addition this version of the econometric model also includes a lagged term for the dependant variable. Column 7 includes only the contemporaneous price term, column 8 the once lagged price term and column 9 both contemporaneous and lagged price terms. This leads to the following observations: Firstly, the contemporaneous price has a significantly positive impact on energy intensity whereas the once lagged price term has a significantly negative impact. This appears plausible: when firms are first hit by a price shock they can at first not reduce their energy consumption by much and end up paying the higher price while consuming the same quantity of energy as before. However, in the next period they respond by reducing energy demand.

In section 6, I explore the implications of the estimates for energy price elasticities. Secondly, point estimates of the US effects are now back to values found earlier.

Table 10 continues the robustness checks by looking specifically at US green field investments; i.e. establishments that were US owned from the start rather than being taken over by a US firm later in life. As discussed earlier, the energy usage of a business is likely determined by aspects that can cannot be changed quickly as, for example, the type of building it is in. It therefore appears plausible that the discussed US effects are less severe or non-existent in establishments that are taken over rather than setup by US firms. A key difficulty examining this is that for most firms in the ARD/QFI sample I do not know their ownership status "at birth" simply because their birth precedes the start of my sample period. Table 9 documents that by reporting for the observations in the sample and by current ownership type the "greenfield type" - i.e. the ownership status at birth. In columns 1 and 2 of Table 10, I proceed by running regressions involving all plants in the sample that were never US or where we know that they were US owned at the start. In columns 3 and 4 on the other hand I include US plants where we either don't know or know that they were non US at the start. This shows, in line with expectations that the US effects are more pronounced in the first sample (Columns 1 and 2).

5.3 Energy quantities

The results have so far focused on energy intensity. This raises the concern that they could be driven by either output or price effects rather than genuine effects on energy usage. Equally, there might be concern about the implications for climate; i.e. a reduction in energy intensity might simply imply a shift to cheaper but not necessarily less energy or cleaner energy sources. Table 11 addresses these concerns by reporting a number of regressions for various energy quantity measures. Columns 1 and 2 start with log energy expenditure as a dependant variable to dispel concerns that the earlier results are driven by variation in gross output rather than energy. Column 1 reports OLS, column 2 a fixed effects specification. Columns 3 and 4 repeat the exercise for total kWhs of energy used; i.e. this measure aggregates energy units over different energy types. We see the familiar pattern of a negative US age effect and a positive level effect. The same is true for electricity and gas consumption in columns 5 to 8, however the values appear stronger and more significant for electricity than for gas.

5.4 Total factor productivity

Table12 examines first how non energy production intensities are behaving in US firms. This is the first step towards an analysis of TFP as discussed above. For non energy intermediates, labour and capital - where the capital share is computed as one minus the shares for the other factors - the Table reports 3 regressions of the factor share in gross output. Regression 1 is a simple OLS, regression two is a fixed effects specification and regression 3 drops output as an explanatory variable to reduce endogeneity concerns. No significant pattern emerges. The most consistent results regarding the point estimates comes from capital which suggests that US MNEs become more capital intensive with age.

Table 13 reports TFP regressions. Columns 1 and 2 report regressions of the variable factor index described in Section 3. Column 1 uses a simple OLS framework, column 2 includes firm fixed effects. In columns 3 and 4 the exercise is repeated using the 2 stage smoothing procedure described in Section 3. In neither case does a significant pattern emerge. In principle one should expect that the US energy intensity effect has a mirror image in either an increase in the intensity of another production factor, in changes in market power or returns to scale of production - these would be captured by the interaction between US variables and capital - or in TFP. However, because energy is a relatively small fraction of expenditure for most firms it is plausible that these vanish when looking at other production factors or output as a whole. This result is important, however, concerning the implications of the results for the US. More specifically, as discussed above, standard arguments about technology diffusion could motivate why even at given energy prices there might be scope for US firms to reduce energy intensity by adopting technologies and practices common for UK firms. Sufficient evidence from the UK data for this idea would be a significant increase in TFP of US firms in the UK as they reduce their energy intensity, which I don't find however. Equally, this implies that there is no evidence for any Porter hypothesis effects.

5.5 Other evidence

Is there any other evidence in support of the US energy intensity catch up story. Appendix B reports some initial evidence on the basis of a recent survey among UK managers about firm level practices related to Climate Change (Martin et al., 2009). Among a wide range of indicators and questions the survey provides information on firm level energy consumption reduction targets in percentage terms, as well as on the perceived stringency of those targets. Table 14 shows that young US firms have significantly higher targets in percentage terms while not reporting them to be more stringent than other firms.[14]This is evidence in line with the findings above: if US MNEs are catching up in terms of reducing their energy usage it is not surprising that they have higher percentage reduction targets than other firms. On the other hand, because they are lagging behind, it is fairly easy for them to meet these higher targets without experiencing that the targets are actually more stringent in practice.

6 Implications

There are a number of implications of the results presented above. Firstly, we can use the estimates with price coefficients in 8 to derive a (medium run) price elasticity of energy demand; From column 8 of Table 8 we find the combined current and lagged

[14]This is discussed in more detail in Appendix B.

effect of a 1% price increase on energy intensity to be $\beta_{PE} = 0.29\%$[15]; i.e. if prices are 1% higher then energy intensity *increases* by 0.29 percentage points. We can translate this into an energy demand price elasticity, η_{EP}, using[16]

$$\eta_{EP} = \frac{\beta_{PE}}{S^E} + S^E - 1$$

Using the average UK energy share of 1.8% from Table 1 yields $\eta_{EP} = -0.82$; i.e. a 1% increase in prices leads to an 0.82% reduction in energy demand. This is the first time such an elasticity has been computed using representative plant level micro data from the UK. Interestingly, it is virtually the same value other studies have reported for industrialised countries on the basis of sectoral data.[17]

Secondly, as argued in the introduction, elasticities of this magnitude are not sufficient to explain the observed differences in energy intensities between the UK and the US. More to the point: we see from Table 1that the US/UK gap is 0.7 percentage points. From the values underlying 5we find that US/UK energy price differences are on average 36%. Thus on the basis of the price parameters found in Table 8 we would expect a -0.1 percentage point gap; i.e. the UK being more energy intensive - in energy expenditure terms - than the US. Looking on the other hand at the energy intensity gaps between "young" US and other MNEs we see that they are of very similar orders of magnitude if not higher; e.g. in column 2 of Table 6 we find a 1.14 percentage point gap, in column 5 a somewhat lower 0.89 percentage point gap. This supports the idea that the price elasticity estimates in Table 8 and in studies such as Pindyck or Roy correspond to medium run responses to uncertain energy price fluctuations over time. The adjustment of US firms in Britain on the other hand corresponds to the more long term response to a large structural increase in prices as could be engineered by a strong and credible carbon pricing system. To ease comparison we can work out the implicit price elasticity of this adjustment as follows

$$\widetilde{\eta}_{EP} = \frac{\Delta S^E}{S^E} \frac{P^E}{\Delta P^E} - 1$$

where $\frac{\Delta S^E}{S^E}$ is the observed rate of decline in energy intensity and $\frac{P^E}{\Delta P^E}$ the inverse of the observed increase in price. Hence in our case

$$\frac{\Delta S^E}{S^E} = \frac{S^E_{UK} - S^E_{US}}{S^E_{US}} = \frac{-0.7}{2.5} = -0.28$$

and $\frac{\Delta P^E}{P^E} = 0.36$, so that $\widetilde{\eta}_{EP} = -1.78$; i.e. a 1% increase in price would lead to a 1.78% reduction in energy consumption.

[15]i.e. $1.3987 - 1.1085 = 0.2902$; recall that the dependant variable in Table 8 is in terms of %.

[16]SeePindyck (1979) and Roy et al. (2006).

[17]Pindyck (1979)reports -0.84; Griffin and Gregory (1976) -0.8.

7 Conclusion

The energy intensity of US industry is dramatically higher than that of European countries such as the UK. While a natural explanation for the perceived gaps would be lower energy prices in the US, commonly estimated energy price elasticities are not sufficiently high to explain the actual energy intensity gap. This leads to the hypothesis that US production technology might be biased towards more intensive use of energy, either because of geographical or other localised features of the US or because there are firm specific differences in technology between US and European firms. To distinguish between these latter two possibilities this study looks at the energy intensity of US firms operating abroad in the UK. The findings are firstly that, on average, plants owned by US firms in Britain are no more energy intensive than comparable other plants. However, secondly, there is evidence that US firms which have only recently entered the UK, are significantly more energy intensive and that this initial energy intensity gap vanishes after a number of years of staying in the UK. Quantitatively, the initial energy intensity gap is comparable to the between country US/UK gap.

This evidence rules out that the US/UK gap is driven by firm specific technology differences, otherwise we should see that US firms in Britain maintain an energy intensity gap in the long run. The evidence equally casts doubt on geographical differences as alternative explanation. Specifically, the strong adjustment process by US firms operating in Britain towards a reduction in energy suggests a third possibility: common estimates of energy price elasticities typically identified from time series variation within a country underestimate the response to a large structural price change as they exist between the US and the UK.

For climate change policy making this implies that a strong price signal induced by carbon pricing on the order of the US UK energy price gap would move US industry to energy intensity levels already achieved in Europe. The fact that even for US MNEs operating in the UK this process takes several years suggests that there is an issue of limited knowledge diffusion. This might imply that carbon pricing should be accompanied with policies to facilitate this diffusion, for example through government sponsored energy saving advice.[18]

References

Acemoglu, D. (2002). Directed technical change. *Review of Economic Studies*, 69(4):781–809.

Bartelsman, E. J., Haskel, J., and Martin, R. (2008). Distance to which frontier? Evidence on productivity convergence from international firm-level data. Technical Report 7032, C.E.P.R. Discussion Papers.

[18]The Carbon Trust in the UK is an example of such government sponsored advice (www.carbontrust.co.uk).

Blackman, A. (1999). The economics of technology diffusion: Implications for climate policy in developing countries. *Resources for the Future Discussion Paper*, 99-42.

Bloom, N., Genakos, C., Martin, R., and Sadun, R. (2008). Modern management: Good for the environment or just hot air? Working Paper 14394, National Bureau of Economic Research.

Bloom, N., Sadun, R., and Van Reenen, J. (2007). Americans do I.T. better: US multinationals and the productivity miracle. Technical Report 13085, National Bureau of Economic Research.

Bloom, N. and van Reenen, J. (2007). Measuring and explaining management practices across firms and countries. *Quarterly Journal of Economics*, 122(4).

Caroli, E. and Van Reenen, J. (2001). Skill bised organizational change? Evidence from a panel of British and French establishments. *Quarterly Journal of Economics*.

Criscuolo, C. and Martin, R. (2009). Multinationals and U.S. productivity leadership: Evidence from Great Britain. *The Review of Economics and Statistics*, 91(2):263–281.

Griffin, J. M. and Gregory, P. R. (1976). An intercountry translog model of energy substitution responses. *American Economic Review*, 66(5):845–57.

Inklaar, R., O'Mahony, M., and Timmer, M. (2005). ICT and Europe's productivity performance: Industry-level growth account comparisons with the United States. *Review of Income and Wealth*, 51(4):505–536.

Jaffe, A. B. and Stavins, R. N. (1994). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics*, 16(2):91–122.

Jaffe Adam, B. and Stavins Robert, N. (1995). Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technology diffusion. *Journal of Environmental Economics and Management*, 29(3):S43–S63.

Johnstone, N., editor (2007). *Environmental Policy and Corporate Behaviour*. OECD.

Klette, T. J. (1999). Market power, scale economies and productivity: Estimates from a panel of establishment data. *Journal of Industrial Economics*, XLVII(4):451–476.

Martin, R. (2005). UK plant level energy data. *DTI Economics Papers*.

Martin, R. (2008). Productivity dispersion, competition and productivity measurement*. CEP Discussion Paper 0692.

Martin, R., Muuls, M., de Preux, L., and Wagner, U. (2009). Climate change policies and management practices. Technical report.

Martin, R. and Wagner, U. (2009). Survey of firms' responses to public incentives for energy innovation, including the UK Climate Change Levy and Climate Change Agreements. Technical report.

O'Mahony, M. and de Boer, W. (2002). Britain's relative productivity performance: Has anything changed? *National Institute Economic Review*, 179(1):38–43.

Palmer, K., Oates, W. E., and Portney, W. E. (1995). Tightening environmental standards: The benefit-cost or the no-cost paradigm? *Journal of Economic Perspectives*, 9:119–132.

Pindyck, R. S. (1979). Interfuel substitution and the industrial demand for energy: An international comparison. *The Review of Economics and Statistics*, 61(2):169–179.

Porter, M. (1991). America's green strategy. *Scientific American*, 264(4).

Porter, M. and van der Linde, C. (1995). Toward a new conception of the environment-competetiveness relationship. *Journal of Economic Perspectives*, 9(4):97–118.

Roy, J., Sanstad, A. H., Sathaye, J. A., and Khaddaria, R. (2006). Substitution and price elasticity estimates using inter-country pooled data in a translog cost model. *Energy Economics*, 28(5-6):706–719.

Wagner, K. and van Ark, B. . (1996). *International Productivity Differences, Measurement and Explanations.* North-Holland.

A The Firm's Dynamic Optimisation problem

A firm's value function is as follows:

$$V\left(A_L, A_E\right) = \max_{A_L^1 A_E^1} \left\{\Pi\left[A_L, A_E\right] - R_E - R_L + \beta V\left(A_L^1, A_E^1\right)\right\}$$

where $A_j^1 = A_j + \rho\left(R_j {}^{A_j^F}/_{A_j}\right)$. Let $\rho(\cdot) = (\cdot)^\alpha$ for simplicity. This is similar to an investment problem with non-convex adjustment costs (and no depreciation). Hence firms would not invest at all, or undertake all necessary investment in the first period and enjoy the benefits of higher productivity in every period thereafter. The first order conditions consequently become

$$1 = \left(\beta + \beta^2 + ...\right) \frac{\partial \Pi\left[A_L^1, A_E^1\right]}{\partial A_j} \frac{\partial \rho}{\partial R_j} <= \frac{\beta}{1-\beta} \frac{\partial \Pi\left[A_L^1, A_E^1\right]}{\partial A_j} \rho'\left(R_j {}^{A_j^F}/_{A_j}\right) {}^{A_j^F}/_{A_j}$$

Thus the ratio between energy and labour efficiency for a frontier firm that invests in both technologies $\frac{A_E^*}{A*_L}$is determined by

$$\frac{\frac{\partial \Pi\left[A_L^*, A_E^*\right]}{\partial A_E}}{\frac{\partial \Pi\left[A_L^*, A_E^*\right]}{\partial A_L}} = \frac{W_E^{1-\varepsilon} A_E^{\varepsilon-2}}{W_L^{1-\varepsilon} A_L^{\varepsilon-2}} = \frac{\rho'\left(R_L\right)}{\rho'\left(R_E\right)}$$

Now, if energy costs go up and $\varepsilon < 1$ we need A_E to go up (or A_L) to go down to maintain the profit maximising conditions.

B Results from the CEP Climate Change Management Survey

In spring 2009 a team of CEP researchers conducted a survey among UK managers concerning their practices related to Climate Change.[19] The survey is the first major study that opens the black box of what is actually happening with firms regarding Climate Change and Climate Change Policy while being able to link this qualitative information with hard performance data from other sources.[20] Aggregating the survey responses into a single index, the "CEP Climate Change Score", Martin et al. find that it is significantly and positively related to economic productivity of firms as well as negatively to the energy intensity and thus the climate impact of firms. Table 14 reports regressions of various outcome variables based on the survey responses on US ownership status. In column 1 we see that there is no significant relationship between US status and the overall Climate Change Score. In unreported results I also checked for correlations in all the sub-elements used to compute the overall score. The only case which leads to a significant relation is reported in column 5: it refers to the reduction target in percent of energy consumption that firms impose on their managers. Hence, the finding is that US firms have significantly higher reduction targets [21] than other firms. Columns 6 and 7, which report the regression from column 5 separately for younger and older firms, show that this result is driven by younger US firms. Columns 3 and 4 show that US firms do not have a significantly higher target stringency score. Column 3 is based on the whole sample, while column 4, on only the sample of firms that reported having an energy consumption target. Column 8 repeats column 5 while also including the target stringency score as well as interactions of the target stringency score with the MNE ownership variables. While not significant, the stringency variables suggest that overall there is a positive relationship between target stringency and the actual percentage level of the target. The interaction variables show that this relationship is weaker for US MNEs.

This evidence is broadly consistent with the evidence presented in the main part of this paper. If US MNEs are catching up in terms of reducing their energy usage it is not surprising that they have higher percentage reduction targets than other firms. On the other hand, because they are lagging behind it is fairly easy for them to meet these higher targets without experiencing that the targets are actually very stringent.

C Tables and Figures

[19] See Martin and Wagner (2009)for details.

[20] Johnstone (2007)reports on a similar survey by the OECD which could not be linked to independent performance data.

[21] i.e. the amount that is supposed to be reduced is higher in percentage terms.

Table 1: Energy expenditure over gross output for selected manufacturing sectors - US vs UK in 2002

Sector	ISIC (UK)	NAICS (US)	US	UK	Difference
Food	15	311	1.56%	1.43%	0.13%
Textiles	17	313,314	2.75%	2.12%	0.63%
Paper/Pulp	21	322	4.77%	3.12%	1.65%
Publishing/Printing	22	323	1.29%	0.79%	0.51%
Chemicals	24	325	7.22%	2.09%	5.12%
Rubber/Plastics	25	326	2.25%	1.34%	0.91%
Non-Metallic Mineral Products	26	327	5.22%	5.13%	0.08%
Basic Metals	27	331	7.84%	2.88%	4.96%
Fabricated Metals	28	332	1.67%	1.22%	0.45%
Machinery/Equipment	29	333	0.84%	0.74%	0.10%
Transport Equipment	34	336	0.59%	0.64%	-0.05%
All manufacturing			2.50%	1.80%	0.70%

Source: BEA, EIA, ONS

Table 2: Distribution of MNE types

	(1)	(2)	(3)	(4)	(5)	(6)
	Register			ARD/QFI sample		
		shares			shares	
Firm type	obs	of all	of MNEs	obs	of all	of MNEs
non MNE	975312	0.989		2310	0.624	
UK MNE	3919	0.004	0.349	1015	0.274	0.527
EU MNE	4256	0.004	0.379	374	0.101	0.194
US MNE	3063	0.003	0.273	537	0.145	0.279
other MNE	1719	0.002	0.153	122	0.033	0.063

Notes: The table compares the numbers of observations by MNE status in the business register (population) with those which emerge in the intersection of ARD and QFI sample.

Table 3: Descriptive statistics

		(1)	(2)	(3)	(4)	(5)
					Percentiles	
Variable	Firm type	mean	Standard deviation	25	50	75
Energy intensity	non MNE	0.017	0.019	0.006	0.010	0.021
(Energy expenditure over	non US MNE	0.017	0.020	0.005	0.010	0.022
Gross output)	US MNE	0.015	0.017	0.004	0.009	0.019
Energy Price	non MNE	0.023	0.010	0.016	0.022	0.028
(Average price per kWh)	non US MNE	0.021	0.009	0.015	0.020	0.026
	US MNE	0.021	0.008	0.016	0.020	0.026
Gross output	non MNE	40.4	114.1	7.1	16.8	35.1
(millions of £)	non US MNE	82.0	183.3	15.5	33.9	80.0
	US MNE	125.6	225.1	19.6	45.5	108.4
Employment	non MNE	305	427	98	191	357
	non US MNE	493	704	150	309	577
	US MNE	540	630	186	308	629
Capital Stock	non MNE	25.8	68.7	4.2	10.7	23.3
(millions of £)	non US MNE	50.9	110.7	10.0	20.1	46.1
	US MNE	80.7	146.2	12.0	25.3	81.7
Age	non MNE	24.33	7.54	24	27	29
	non US MNE	24.61	7.39	24	27	30
	US MNE	23.08	9.25	17	27	30
Value added per employee	non MNE	3.44	0.51	3.14	3.39	3.71
	non US MNE	3.68	0.51	3.36	3.61	3.94
	US MNE	3.85	0.56	3.48	3.77	4.16

Table 4: Observations across plant types and age categories

Age:	<5	5-10	10-15	15-20	20-25	25-30	>30
MNEEU	30	29	48	59	104	280	128
MNEUK	64	55	61	75	342	648	183
MNEUS	44	58	29	31	110	179	84
MNEother	<10	12	13	14	27	63	29
nonMNE	149	117	149	171	841	1190	393
All	297	271	300	350	1424	2360	817
MNEEU	0.04	0.04	0.07	0.09	0.15	0.41	0.19
MNEUK	0.04	0.04	0.04	0.05	0.24	0.45	0.13
MNEUS	0.08	0.11	0.05	0.06	0.21	0.33	0.16
MNEother	<10	0.07	0.08	0.08	0.16	0.38	0.17
nonMNE	0.05	0.04	0.05	0.06	0.28	0.40	0.13
All	0.05	0.05	0.05	0.06	0.24	0.41	0.14

Notes: The table reports the number of observations in the sample by different age classes. The second panel shows the distribution across age classes across different ownership types.

Table 5: MNE status changes in the sample

	MNE_{EU}	MNE_{UK}	MNE_{US}	MNE_{other}	$nonMNE$
MNE_{EU}	493	<10	<10	<10	37
MNE_{UK}	14	1071	16	<10	126
MNE_{US}	10	12	369	<10	42
MNE_{other}	<10	<10	<10	113	11
$nonMNE$	93	136	56	30	2290

Notes: '<10' indicates that a cell had less than 10 observations. ONS confidentiality rules require to blank such cells. In calculations of total figures these cells enter with a value of 10.

Table 6: Regressions of the energy expenditure share in gross output

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep.Var.	Energy intensity (Energy expenditure over gross output X 100)								
Gross output	-0.1397***	-0.1776*	-0.1383***	-0.1375***	-0.8953***		-0.6988***	-0.7423***	
(lnGO)	(0.0336)	(0.0938)	(0.0335)	(0.0333)	(0.0776)		(0.1060)	(0.1088)	
Capital Stock					0.7919***			0.2803**	
(lnK)					(0.0777)			(0.1151)	
age	-0.0127	-0.0275	-0.0061	-0.0059	-0.0022	-0.0041	0.0046	0.0020	-0.0142
	(0.0084)	(0.0245)	(0.0096)	(0.0096)	(0.0088)	(0.0094)	(0.0195)	(0.0195)	(0.0193)
MNE other	0.0597	0.4847	0.1722						
	(0.2043)	(0.4262)	(0.5454)						
MNE EU	0.0447	0.0381	0.1254						
	(0.1258)	(0.3214)	(0.3785)						
MNE	0.0383	-0.0672	0.0473	0.0986	0.1016	0.0399	-0.0301	-0.0269	-0.0230
	(0.0894)	(0.2978)	(0.2983)	(0.2487)	(0.2380)	(0.2456)	(0.1360)	(0.1359)	(0.1405)
MNE US	0.1833	1.1456***	1.1290**	1.0742**	0.8858**	1.0658**	0.4064**	0.3988*	0.4314**
	(0.1432)	(0.3756)	(0.4737)	(0.4392)	(0.4252)	(0.4428)	(0.2061)	(0.2055)	(0.2182)
age X other MNE			-0.0048						
			(0.0231)						
age X MNE EU			-0.0033						
			(0.0148)						
age X MNE			-0.0004	-0.0018	-0.0036	-0.0030	0.0011	0.0010	0.0007
			(0.0115)	(0.0095)	(0.0092)	(0.0095)	(0.0054)	(0.0054)	(0.0056)
age X MNE US			-0.0409**	-0.0395**	-0.0336**	-0.0399**	-0.0227**	-0.0225**	-0.0238**
			(0.0180)	(0.0168)	(0.0163)	(0.0170)	(0.0095)	(0.0095)	(0.0098)
Obs	4365	636	4365	4365	4365	4365	4365	4365	4365
Firms	1322	256	1322	1322	1322	1322	1322	1322	1322
Firm fixed effects	no	no	no	no	no	no	yes	yes	yes
Region X year controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
3 digit sector controls	yes	yes	yes	yes	yes	yes	no	no	no
Sample	QFI/ARD	Age<10	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD

Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. Column 2 restricts the sample to firms younger than 10 years. Column 4 is a restricted version of column 3; p-value of a test of the restriction is 0.52.

Table 7: Regressions of the energy expenditure share in variable costs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep.Var.	Energy intensity (Energy expenditure over variable costs X 100)								
Gross output	-0.1404***	-0.1951	-0.1393***	-0.1381***	-1.0528***		-0.6520***	-0.6956***	
(lnGO)	(0.0427)	(0.1184)	(0.0424)	(0.0423)	(0.0988)		(0.1160)	(0.1199)	
Capital Stock					0.9559***			0.2807*	
(lnK)					(0.1009)			(0.1478)	
age	-0.0147	-0.0176	-0.0063	-0.0064	-0.0019	-0.0046	-0.0138	-0.0165	-0.0309
	(0.0105)	(0.0287)	(0.0119)	(0.0119)	(0.0109)	(0.0117)	(0.0227)	(0.0227)	(0.0223)
MNE other	0.0145	0.7097	0.3156						
	(0.2334)	(0.6420)	(0.7972)						
MNE EU	-0.0064	0.1784	0.2336						
	(0.1558)	(0.4061)	(0.4822)						
MNE	0.0591	-0.1168	0.0627	0.1613	0.1672	0.1026	-0.0204	-0.0170	-0.0169
	(0.1107)	(0.3720)	(0.3697)	(0.3145)	(0.3011)	(0.3101)	(0.1484)	(0.1485)	(0.1516)
MNE US	0.1558	1.3779***	1.2509**	1.1494**	0.9211*	1.1411**	0.3727*	0.3650*	0.3990*
	(0.1748)	(0.4489)	(0.5632)	(0.5242)	(0.5101)	(0.5286)	(0.2034)	(0.2026)	(0.2110)
age X other MNE			-0.0125						
			(0.0314)						
age X MNE EU			-0.0098						
			(0.0187)						
age X MNE			-0.0002	-0.0043	-0.0066	-0.0055	0.0002	0.0002	0.0000
			(0.0143)	(0.0119)	(0.0114)	(0.0119)	(0.0060)	(0.0060)	(0.0062)
age X MNE US			-0.0473**	-0.0431**	-0.0359*	-0.0435**	-0.0233**	-0.0231**	-0.0245**
			(0.0215)	(0.0200)	(0.0196)	(0.0202)	(0.0099)	(0.0098)	(0.0099)
Obs	4365	636	4365	4365	4365	4365	4365	4365	4365
Firms	1322	256	1322	1322	1322	1322	1322	1322	1322
Firm fixed effects	no	no	no	no	no	no	yes	yes	yes
Region X year controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
3 digit sector controls	yes	yes	yes	yes	yes	yes	no	no	no
Sample	QFI/ARD	Age<10	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD

Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. Column 2 restricts the sample to firms younger than 10 years. Column 4 is a restricted version of column 3; p-value of a test of the restriction is 0.52.

Table 8: Robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model	OLS	OLS	XT	OLS	XT	ABOND	ABOND	ABOND
Dep.Var.	EE/GOX100	ln(EE/GO)-ln(1-EE/GO)	ln(EE/GO)-ln(1-EE/GO)	EE/GOX100	EE/GOX100	EE/GOX100	EE/GOX100	EE/GOX100
Gross output	-0.0952**	-0.1620***	-0.6062***	-0.0021***	-0.0074***	0.0358	0.0264	0.0232
(lnGO)	(0.0448)	(0.0202)	(0.0474)	(0.0004)	(0.0011)	(0.0799)	(0.0745)	(0.0830)
age	-0.0200**	-0.0015	-0.0204*	-0.0001	0.0001	0.0027	0.0012	0.0019
	(0.0102)	(0.0051)	(0.0107)	(0.0001)	(0.0002)	(0.0033)	(0.0032)	(0.0033)
MNE other	0.1784							
	(0.3401)							
MNE EU	0.0749							
	(0.1944)							
MNE	0.1058	0.0904	-0.1033	0.0007	-0.0001	-0.1238	-0.1583	-0.1097
	(0.1216)	(0.1271)	(0.0731)	(0.0024)	(0.0013)	(0.1150)	(0.1178)	(0.1275)
MNE US	-0.1701	0.6178***	0.1841**	0.0111**	0.0040*	0.4549***	0.4832***	0.3094
	(0.1819)	(0.2150)	(0.0889)	(0.0046)	(0.0021)	(0.1715)	(0.1707)	(0.1923)
age X MNE		-0.0022	0.0036	-0.0000	0.0000	0.0043	0.0050	0.0047
		(0.0049)	(0.0028)	(0.0001)	(0.0001)	(0.0042)	(0.0043)	(0.0046)
age X MNE US		-0.0217**	-0.0094**	-0.0004**	-0.0002**	-0.0211***	-0.0224***	-0.0153**
		(0.0085)	(0.0040)	(0.0002)	(0.0001)	(0.0072)	(0.0072)	(0.0076)
EE/GOx100(t-1)						0.8016***	0.7877***	0.8306***
						(0.0592)	(0.0581)	(0.0643)
Energy Price				-0.0082***	-0.0044***	-0.0467		1.3987**
(lnPE(t))				(0.0013)	(0.0014)	(0.2481)		(0.6994)
Lagged Energy Price							-0.3579**	-1.1085**
(lnPE(t-1))							(0.1561)	(0.4535)
Obs	4365	4365	4365	4365	4365	2629	2629	2629
Firms	1322	1322	1322	1322	1322			
Firm fixed effects	no	no	yes	no	no	no	yes	yes
Region X year controls	yes	yes	yes	yes	yes	yes	yes	yes
3 digit sector controls	yes	yes	no	yes	yes	yes	no	no
Sample	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD

Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. All regressions report robust standard errors with clustering at the firm level.

Table 9: Greenfield investments in the sample

	Greenfield type			
	EU	**US**	**other**	**unknown**
MNE_{EU}	89	63	13	448
MNE_{UK}	20	54	<10	1189
MNE_{US}	14	183	<10	258
MNE_{other}	<10	<10	<10	119
$nonMNE$	48	109	<10	2507
All	181	419	53	4521

Notes: '<10' indicates that a cell had less than 10 observations. ONS confidentiality rules require to blank such cells. In calculations of total figures these cells enter with a value of 10.

Table 10: Regressions for US greenfield investments

	(1)	(2)	(3)	(4)
Dep.Var.	ln(EE/GO)			
Gross output	-0.1095***	-0.7204***	-0.1205***	-0.6892***
(lnGO)	(0.0349)	(0.1160)	(0.0350)	(0.1153)
MNE	-0.0073	0.0057	-0.0051	0.0018
	(0.0103)	(0.0208)	(0.0102)	(0.0213)
MNE US	0.0780	-0.0451	0.1088	-0.0003
	(0.2600)	(0.1423)	(0.2588)	(0.1440)
age	1.1456**	0.4526**	0.9603	0.3703
	(0.5123)	(0.1871)	(0.6575)	(0.3296)
age XMNE US	-0.0455**	-0.0154**	-0.0314	-0.0246*
	(0.0192)	(0.0078)	(0.0249)	(0.0145)
age XMNE	-0.0019	0.0010	-0.0025	-0.0002
	(0.0099)	(0.0056)	(0.0098)	(0.0056)
Obs	3863	3863	4125	4125
F	1180	1180	1260	1260
Firm fixed effects	no	yes	no	yes
Region X year controls	yes	yes	yes	yes
3 digit sector controls	yes	no	yes	no
Sample	US in period 1 or not US	US in period 1 or not US	Note US in period 1 or not US	Not US in period 1 or not US

Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. All regressions report robust standard errors with clustering at the firm level.

Table 11: Regressions of energy quantities

Dep.Var.	(1) ln(EE)	(2) ln(EE)	(3) ln(kWh)	(4) ln(kWh)	(5) Electricity (ln(el))	(6) Electricity (ln(el))	(7) Gas (ln(gas))	(8) Gas (ln(gas))
Gross output	0.8390***	0.4403***	0.9252***	0.4611***	0.9102***	0.4542***	0.9235***	0.5045***
(lnGO)	(0.0199)	(0.0462)	(0.0241)	(0.0595)	(0.0218)	(0.0572)	(0.0346)	(0.1165)
MNE	0.0796	-0.1059	0.1109	-0.1404	0.0402	-0.1551**	0.3654	0.0410
	(0.1255)	(0.0723)	(0.1573)	(0.1110)	(0.1344)	(0.0686)	(0.2405)	(0.1464)
MNE US	0.6452***	0.1867**	0.6189***	0.1961	0.7952***	0.1375*	0.4997	0.0781
	(0.2129)	(0.0879)	(0.2393)	(0.1244)	(0.2727)	(0.0802)	(0.3833)	(0.1997)
age	0.0059*	-0.0180*	0.0095**	-0.0295	0.0019	0.0041	0.0166**	0.0072
	(0.0036)	(0.0108)	(0.0043)	(0.0188)	(0.0040)	(0.0091)	(0.0068)	(0.0200)
age X MNE	-0.0019	0.0036	-0.0027	0.0050	0.0011	0.0053**	-0.0145	-0.0015
	(0.0048)	(0.0028)	(0.0060)	(0.0043)	(0.0053)	(0.0027)	(0.0091)	(0.0057)
age XMNE US	-0.0226***	-0.0093**	-0.0206**	-0.0097*	-0.0269**	-0.0049	-0.0161	-0.0070
	(0.0084)	(0.0039)	(0.0096)	(0.0057)	(0.0106)	(0.0034)	(0.0151)	(0.0096)
Obs	4365	4365	4365	4365	4345	4345	3640	3640
Firm fixed effects	no	yes	no	yes	no	yes	no	yes
Region X year controls	yes	yes	yes	yes	yes	yes	yes	yes
3 digit sector controls	yes	no	yes	no	yes	no	yes	no
Sample	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD	QFI/ARD

Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. All regressions report robust standard errors with clustering at the firm level.

Table 12: Regressions for other factors

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep.Var.	Intermediate share (ME/GO)			Labour Share (LE/GO)			Capital Share (1-(ME+LE)/GO)		
MNE	-0.0102	-0.0012	-0.0015	-0.0033	-0.0081	-0.0074	0.0127	0.0096	0.0091
	(0.0195)	(0.0115)	(0.0116)	(0.0127)	(0.0061)	(0.0065)	(0.0134)	(0.0119)	(0.0119)
MNE US	0.0228	0.0132	0.0122	-0.0161	0.0084	0.0109	-0.0180	-0.0257	-0.0274
	(0.0290)	(0.0205)	(0.0206)	(0.0179)	(0.0112)	(0.0130)	(0.0213)	(0.0211)	(0.0217)
age	-0.0007	0.0005	0.0012	0.0010***	0.0033***	0.0014	-0.0003	-0.0038*	-0.0025
	(0.0006)	(0.0023)	(0.0022)	(0.0004)	(0.0012)	(0.0012)	(0.0004)	(0.0021)	(0.0022)
age XMNE	0.0007	0.0001	0.0002	-0.0002	0.0004*	0.0004	-0.0004	-0.0006	-0.0006
	(0.0008)	(0.0005)	(0.0005)	(0.0005)	(0.0003)	(0.0003)	(0.0005)	(0.0005)	(0.0005)
age XMNE US	-0.0007	0.0001	0.0002	0.0006	-0.0005	-0.0006	0.0005	0.0006	0.0007
	(0.0012)	(0.0009)	(0.0009)	(0.0007)	(0.0005)	(0.0005)	(0.0009)	(0.0009)	(0.0009)
Gross output	0.0337***	0.0275**		-0.0417***	-0.0692***		0.0093***	0.0487***	
(lnGO)	(0.0032)	(0.0123)		(0.0021)	(0.0070)		(0.0023)	(0.0107)	
Obs	4365	4365	4365	4365	4365	4365	4365	4365	4365
Firms									
Firm fixed effects	no	yes	yes	no	yes	yes	no	yes	yes
Region X year controls	yes	yes	yes	yes	yes	yes	yes	yes	yes
3 digit sector controls	yes	no	no	yes	no	no	yes	no	no
Sample	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI

Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. All regressions report robust standard errors with clustering at the firm level.

Table 13: Regressions for TFP

	(1)	(2)	(3)	(4)
	Total Factor Productivity (TFP)			
Model	OLS	XT	Smooth OLS	Smooth XT
MNE	-0.4239	-0.1236	-0.4456	0.0005
	(0.4148)	(0.2404)	(0.4442)	(0.1355)
MNE US	0.2528	0.5831	0.1554	-0.2914
	(0.6106)	(0.4585)	(0.7340)	(0.2872)
age	-0.0053	0.0356**	-0.0071	0.0152*
	(0.0103)	(0.0176)	(0.0126)	(0.0091)
age XMNE	0.0159	0.0049	0.0167	-0.0007
	(0.0163)	(0.0100)	(0.0158)	(0.0058)
age XMNE US	-0.0374	-0.0268	-0.0370	0.0053
	(0.0273)	(0.0200)	(0.0319)	(0.0101)
lnk	0.8524***	0.9097***	0.8482***	0.8771***
	(0.0271)	(0.0460)	(0.0358)	(0.0254)
lnkXMNE	0.0432	0.0106	0.0458	-0.0015
	(0.0408)	(0.0238)	(0.0435)	(0.0122)
lnkXageXMNE	-0.0017	-0.0004	-0.0018	0.0002
	(0.0016)	(0.0010)	(0.0015)	(0.0005)
lnkXage	0.0009	-0.0014	0.0011	0.0005
	(0.0010)	(0.0016)	(0.0013)	(0.0009)
lnkXMNE US	-0.0354	-0.0564	-0.0258	0.0315
	(0.0580)	(0.0449)	(0.0687)	(0.0284)
lnkXageXMNE US	0.0040	0.0025	0.0040	-0.0008
	(0.0026)	(0.0020)	(0.0031)	(0.0010)
Obs	4365	4365	4365	4365
Firms	1322	1322	1322	1322
Firm fixed effects	no	yes	yes	no
Region X year controls	yes	yes	yes	yes
3 digit sector controls	yes	no	no	yes
Sample	ARD/QFI	ARD/QFI	ARD/QFI	ARD/QFI

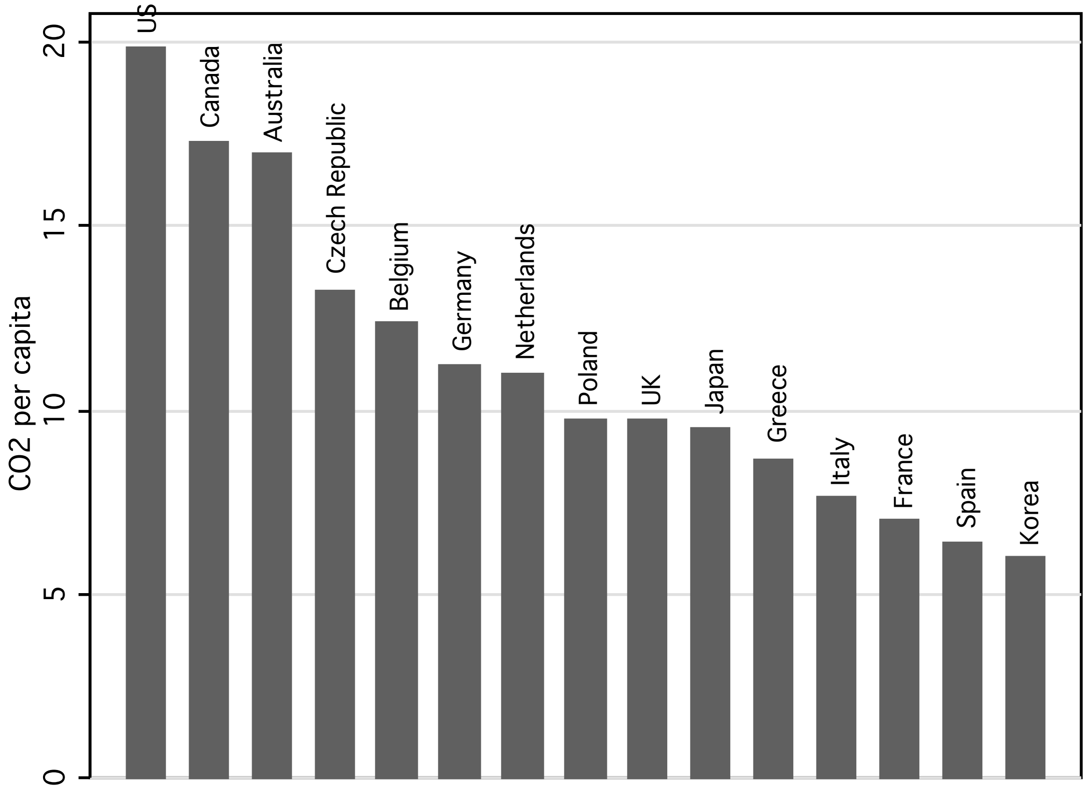
Notes: Standard errors in parenthesis. Stars indicate significance levels: *,**,*** = 10%,5%,1%. All regressions report robust standard errors with clustering at the firm level.

Table 14: Regressions on the CEP Climate Change Management Survey responses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Climate Change Score	Energy consumption Target Stringency Score	Energy consumption Target Stringency Score	Energy consumption Target Stringency Score	Reduction target Score	Reduction target Score	Reduction target Score	Reduction target Score
MNE	0.102	0.144	0.144	-0.052	0.041	2.094	0.198	0.275
	(0.089)	(0.261)	(0.261)	(0.165)	(0.436)	(2.607)	(0.345)	(0.548)
MNE US	0.015	0.131	0.131	0.361	0.793**	1.505**	-0.238	1.604*
	(0.120)	(0.274)	(0.274)	(0.222)	(0.363)	(0.700)	(0.481)	(0.818)
Target Stringency z-Score								0.680
								(0.590)
MNE X Target Stringency z-Score								-0.344
								(0.570)
MNE US X Target Stringency z-Score								-1.042
								(0.737)
age	0.001	0.001	0.001	-0.001	0.000	-0.049	0.005	0.001
	(0.001)	(0.003)	(0.003)	(0.003)	(0.004)	(0.071)	(0.011)	(0.004)
obs	183	183	183	108	108	55	54	108
MNE	0.087	0.293	0.293	-0.047	-0.017	1.614	0.183	-0.001
	(0.090)	(0.268)	(0.268)	(0.189)	(0.448)	(2.369)	(0.374)	(0.525)
MNE US	0.040	0.051	0.051	0.377	1.118***	1.573*	0.009	2.103**
	(0.139)	(0.317)	(0.317)	(0.266)	(0.401)	(0.830)	(0.541)	(0.880)
Target Stringency z-Score								0.401
								(0.585)
MNE X Target Stringency z-Score								-0.027
								(0.554)
MNE US X Target Stringency z-Score								-1.214
								(0.727)
lnk	0.075**	0.062	0.062	0.021	0.148	0.304	0.139	0.170
	(0.033)	(0.078)	(0.078)	(0.053)	(0.101)	(0.369)	(0.140)	(0.110)
age	0.002*	0.001	0.001	-0.003	-0.000	-0.008	0.003	0.000
	(0.001)	(0.003)	(0.003)	(0.003)	(0.005)	(0.082)	(0.012)	(0.005)
obs	164	164	164	97	97	46	52	97
3 digit sector controls	yes	yes	yes	yes	yes	yes	yes	yes
Sample	all	all	all	firms reporting energy quantity target	firms reporting energy quantity target	quantity target & age<=20	quantity target & age>20	firms reporting energy quantity target

Notes: The table reports regressions using outcome variables from the CEP Climate Change Management Survey (CCCMS). Panels 1 and 2 differ only in that Panel 2 includes firm level capital stock as additional control. “Climate Change Score” is an index averaging across all survey responses that allow an ordinal interpretation in terms of their mitigating effect on climate change; e.g. the degree of stringency of energy consumption targets. “Target Stringency Score” is based on the managers assessment how difficult it is to meet any given target. The lowest score is given when no targets exist. “Reduction target score” is a score based on the actual reduction target in percent.

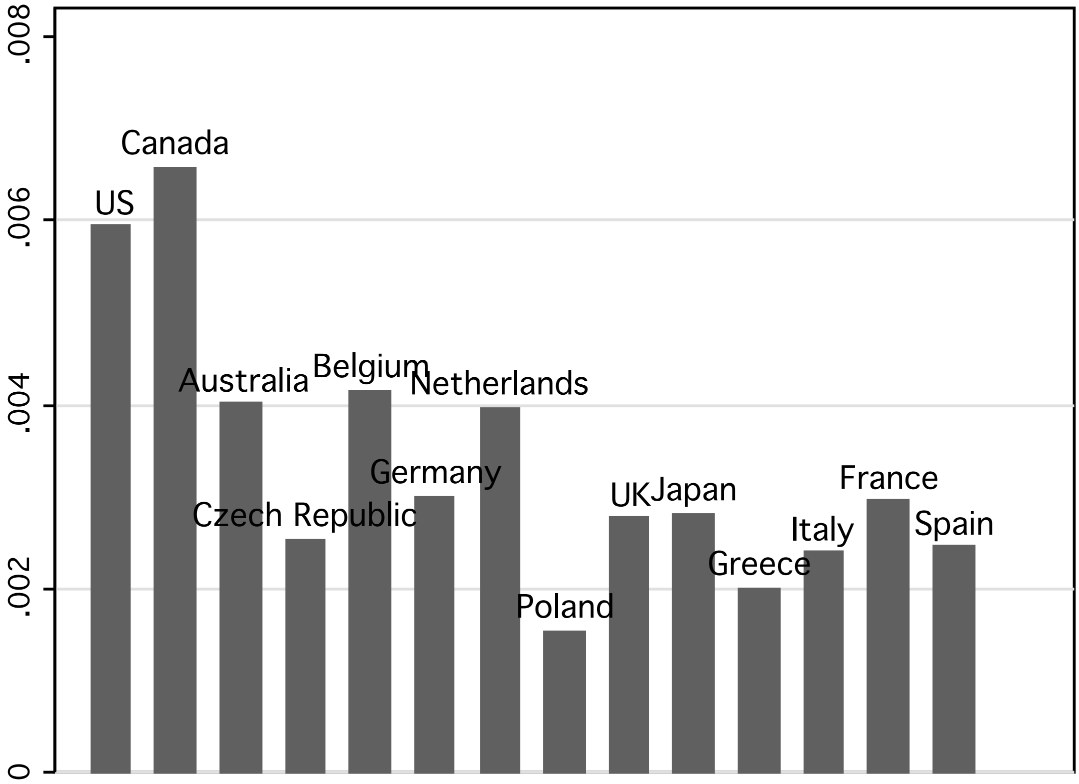
Figure 1: CO2 pollution per capita for various OECD countries



Notes: Tonnes of carbon dioxide per capita, average 2000-2003.

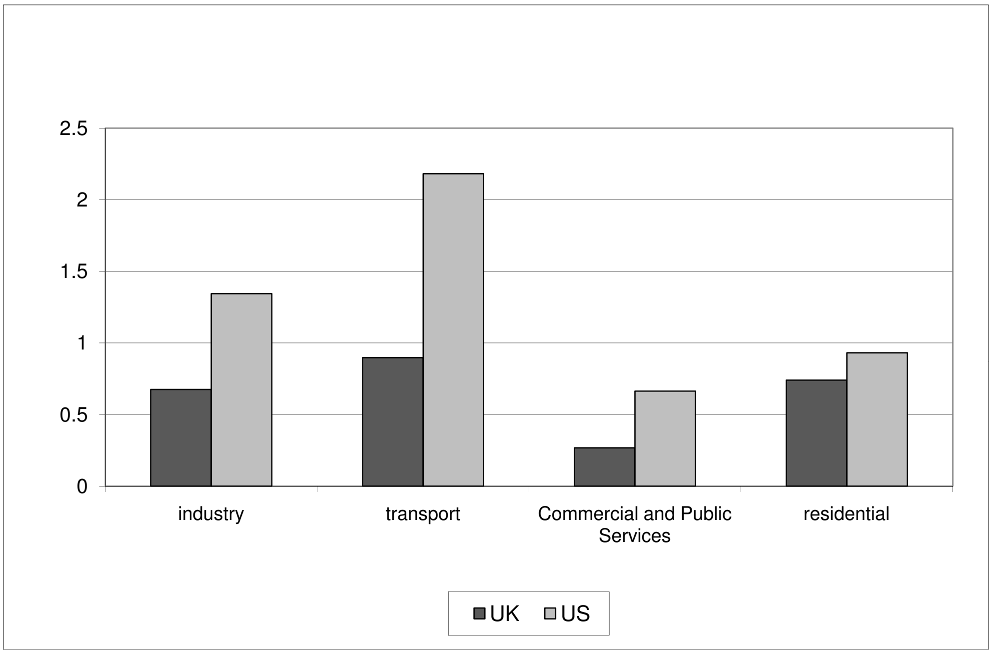
Source: IEA

Figure 2: Energy use per capita for various OECD countries



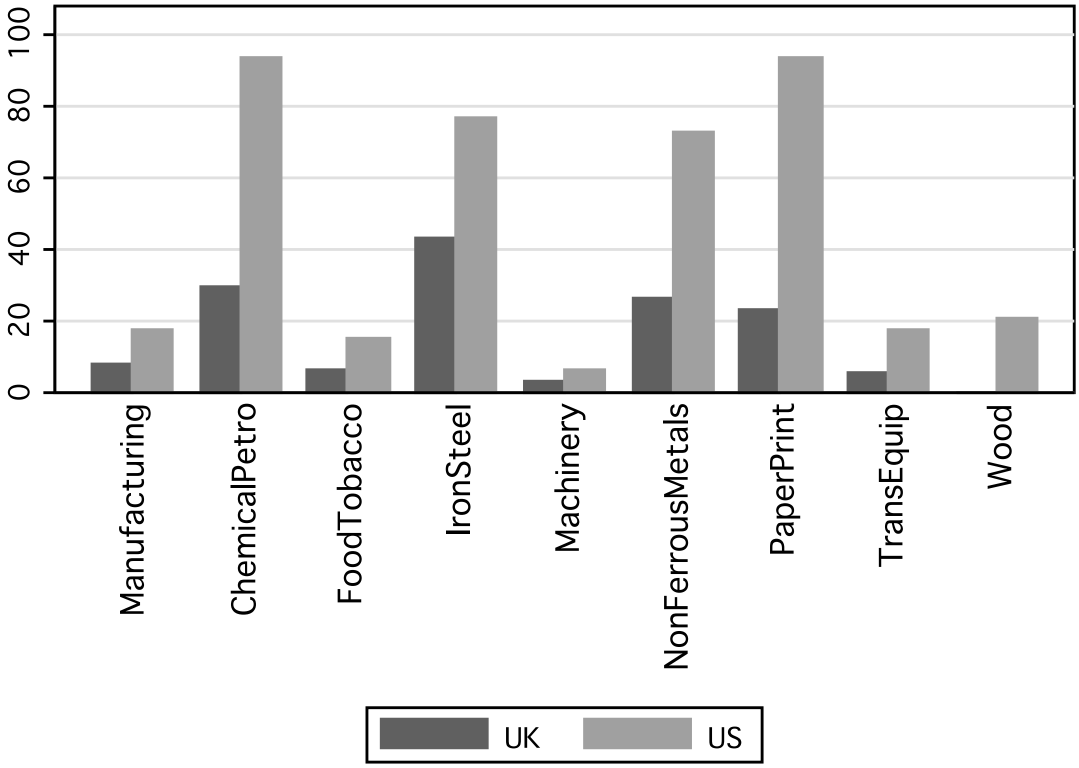
Notes: Tonnes oil equivalence units, average 2000-2003.
Source: IEA

Figure 3: Energy use per capita across major demand categories - UK and US



Notes: Tonnes oil equivalence units, average 2000-2003.
Source: Authors calculations based on IEA and OECD data.

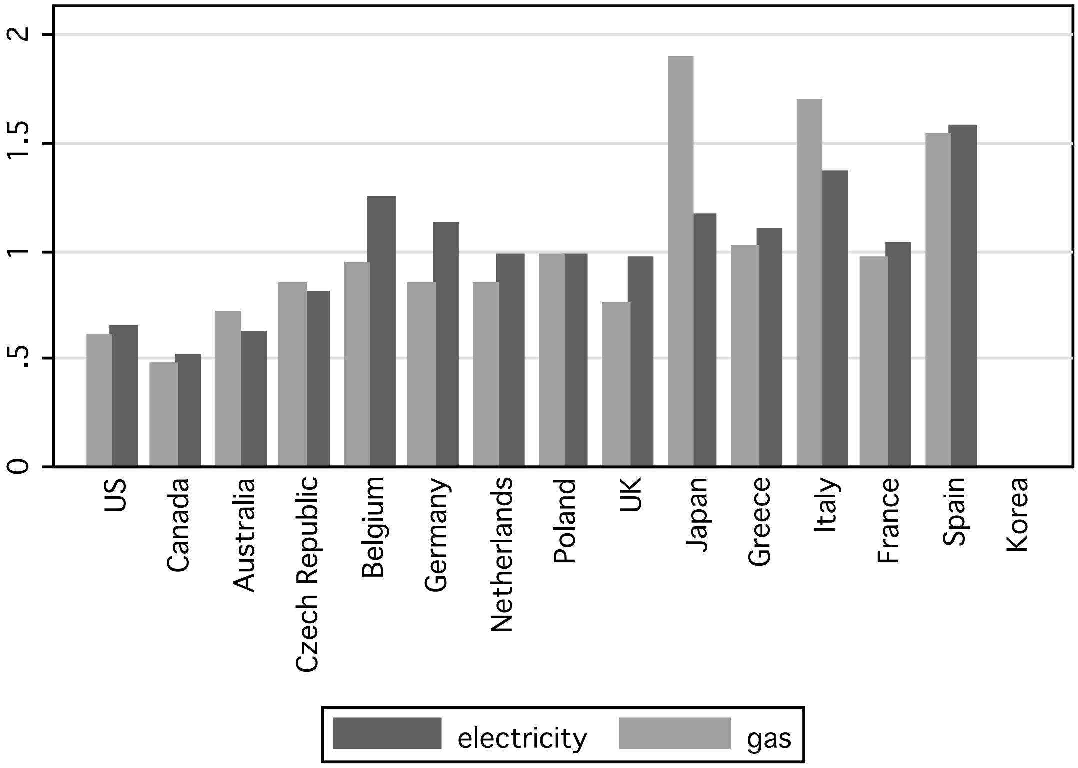
Figure 4: Energy per employment across various manufacturing sectors - UK and US



Notes: Tonnes oil equivalence units per employee, average 2000-2003.

Source: Authors calculations based on IEA and OECD data.

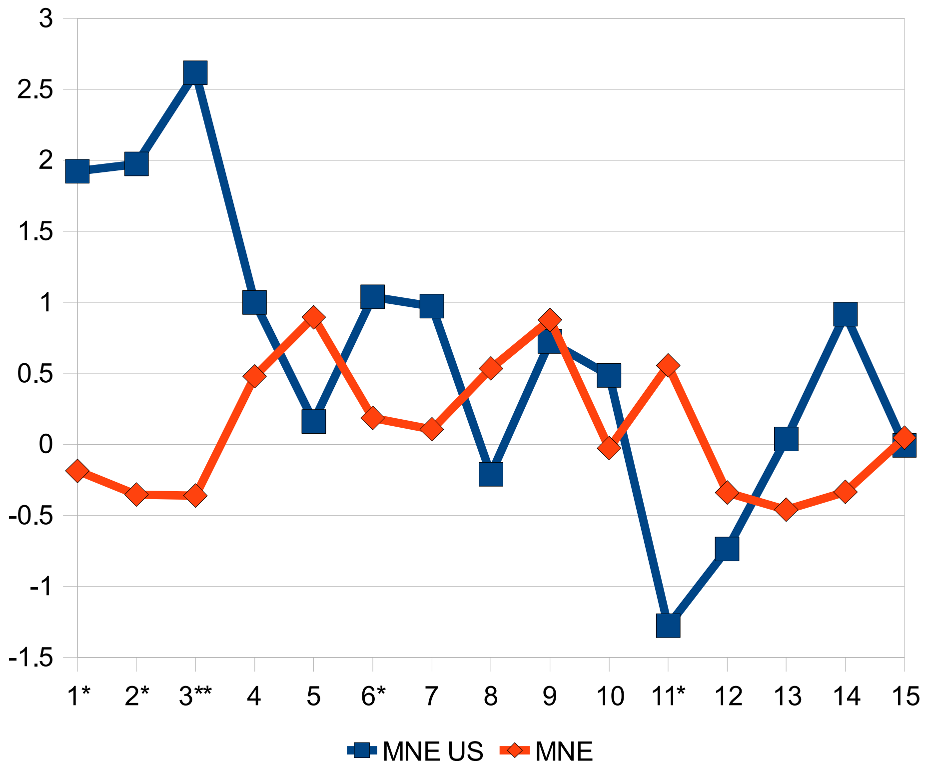
Figure 5: Energy prices across major OECD countries



Notes: PPP US dollar price over mean of price across countries, average 2000-2003.

Source: Authors calculations based on IEA data.

Figure 6: Expenditure share of MNEs and US MNEs relative to domestic plants



Notes: Results from a regression of energy expenditure over gross output with annual age dummies interacted with MNE and US MNE dummies. Stars indicate the significance of the difference between US and other MNEs.

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