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# The effects of energy costs on firm re-location decisions.

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Abstract
Energy costs are partly driven by environmental policy choices. In this paper, the effects of variations in energy costs – as measured by end-user electricity prices – on firm relocation decisions are investigated. Using a discrete choice model and a data base which has not previously been exploited to study this problem, we investigate the effects of variations in energy costs both for a sub-set of re-locating European firms in terms of which country they move to; and then for a larger set of firms in terms of the decision to re-locate or not in response to higher energy prices. We find that energy costs play a significant role in determining relocation destinations, and that this effect is asymmetric between firms moving into and out of a country, and between high energy intensity and low energy intensity sectors. The findings of the paper have implications for the Pollution Havens Hypothesis, since they show the extent to which the effects of climate policy on domestic energy costs can be expected to impact on firm relocation decisions both into and out of a country.

## 1. Introduction

For many years, academics and governments have been interested in the effects of environmental policy on the location decisions of firms (Ulph, 2000). One focus for this interest has been the Pollution Havens Hypothesis (PHH). This is concerned with the effects on plant location decisions and trade flows of the tightening of pollution regulation (Eskeland and Harrison, 2003; Copeland and Taylor, 2004). It remains an open empirical question whether pollution control costs are important enough to measurably influence trade and investment, both because the pollution haven hypothesis operates on different levels in different contexts, and because of limitations of data that have restricted the modeling of a firm's location decision. Yet this is a very important question, particularly for climate change policy. Policymakers concerned with addressing climate change might consider regulations that make it more costly for firms to emit greenhouse gases, so as to reduce total emissions. However, if the PHH is a valid concern, climate change regulations might only cause firms to relocate their activity to another country with less stringent regulations ("carbon leakage": Fischer and Fox, 2012; Elliott and Fullerton, 2014), whilst reducing economic activity in the initial host country.

Addressing the challenge of climate change has brought about policies and proposals that radically alter emissions from industry, especially from the electricity system. The added costs of climate policies have impacts on different parts of the electricity supply system, ranging from generation to transmission. The magnitude of these added costs resulting from climate policies such as carbon taxes, cap-and-trade schemes and mandatory renewable energy targets varies across countries, partly according to the commercial and regulatory structure of their electricity systems, and it is difficult to separate the effects of such climate policies from other electricity price drivers such as domestic regulatory regimes, competition, electricity import and export options and historic investments in alternative electricity generation sources. Therefore, in the policy making context, the assessment of carbon leakage risks has recently been embedded in a comparison of electricity prices faced by industry in their country as compared to main trade competitors (ICF, 2012).

This paper takes advantage of a unique dataset of EU firm relocations in order to add to the empirical evidence on the potential economic impact of climate policies, by considering the relationship between industrial electricity prices at the country level and the location decisions made by internationally-mobile firms. Since many factors will co-determine electricity prices in a given country, the paper cannot be considered as testing the existence of the PHH. However, it is a contribution to the PHH literature, and to on-going policy discussions about carbon leakage risks. The data, described below, lends itself to modeling firm location decisions in a discrete choice framework where firms choose where to locate among a choice set of potential destination countries. This modelling framework is based on the approach in Timmins and Murdock (2007). In order to model firm behavior in this way, we require country-level characteristics to serve as the choice attributes. We describe these attributes in the data section below. We then explore the effects of potential future changes to environmental regulation by examining the response of firms to changes in a country's energy prices. If firms react in a similar way to increased pollution costs as they would to an increase in energy prices, then variations in electricity prices can be used as a proxy for variations in climate policy stringency. Two models are investigated. The first is conditioned on firms having already decided to re-locate, so that the choice to be explained is *where* they will decide to move to. The second expands the choice process to include the decision as to whether to re-locate or stay, as well as where to move. We are particularly interested in whether there is a symmetric effect of higher energy costs on firms thinking about moving out of a country, compared to firms thinking about moving in; since any asymmetry would be important from a policy viewpoint. We are also interested in comparing the elasticity of firm response to an increase in energy costs between high- and low-energy intensity sectors.

## 2. Environmental policy, energy costs and firm location: an overview of the literature

Historically, the theoretical and empirical literature on firm competiveness and location decisions of plants contains two distinct strands: one related to the costs associated with environmental regulation (the pollution haven hypothesis), and another related to the impact of energy costs on the location of firms as part of factor proportion models, where trade is affected by relative factor endowments. In this latter context, energy prices were used in the literature as a proxy for endowment with energy resources. Moreover, a number of studies have recently been undertaken to determine the effect of increased electricity prices on industrial competitiveness in the European Union. These studies[2] have been undertaken both as part of the discussion on EU Emissions Trading Scheme allowance auctioning, as well as in relation to the impacts of setting renewable energy targets. Individual Member States such as Germany and the UK, where the cost of emissions reductions is generally included in the cost of electricity supply, have also commissioned studies to determine the competitiveness impacts of increased electricity prices on

[2] For example, Öko-Institute.V. and Ecofys (2013).

domestic manufacturing[3]. France and Germany are among the countries that provide significant exemptions from climate mitigation related costs to energy intensive industries.

*General overview of PHH literature*

According to Eskeland and Harrison (2003), "the pollution haven hypothesis is, perhaps, best seen as a corollary to the theory of comparative advantage: as pollution control costs begin to matter for some industries in some countries, other countries should gain comparative advantage in those industries, if pollution control costs are lower there (for whatever reason)." Baumol and Oates (1988), Pearson (1987), Wilson (1996), Ulph (1997), Rauscher (1994; 1997; 2000), List and Mason (2001), Verbeke and de Clercq (2002), and Conrad (2005) develop different theoretical models that illustrate the problem.

There are also links between the PHH literature and the more general and very extensive body of general trade economics linked to the Hecksher-Ohlin model. This builds on the Ricardian comparative advantage model of trade and concludes that countries are likely to export products that use abundant and lower cost factors of production, while importing products that use relatively scarce and expensive factors. The main parameters affecting trade are labour, capital and natural resource endowments. In the 1970s, Balassa and Grubel noted that the relative comparative advantage theory could not explain actual trade patterns among countries. Additional aspects were therefore introduced to the trade literature such as the shape of the production and demand functions, in particular increasing returns to scale and monopoly or monopolistic competition (Chamberlain style) on the supply side. For example, Krugman (1980)

[3] For example, ICF (2011) and Frontier Economics and EWI (2010)

focuses on agglomeration effects in light of labour mobility and builds a theoretical model that suggests that labour costs will be higher in larger domestic markets, due to the preference of industry to locate in areas with easy market access, and that countries with relatively large domestic markets will export the goods that enjoy a high demand in their country. This gave rise to the advent of "gravity" trade models, with the interaction between labour costs and market size emphasised. Venables (1996) states that "location decision depends on the interaction between production costs and ease of access to markets". Production costs can obviously be affected by environmental policies, whilst ease of access determines trade costs which depend on both transport and transactions costs. Venables develops a theoretical trade model concluding that at low trade costs, production location will be determined by production costs, whilst at high trade costs production location will be determined by market location, whereas at intermediate trade cost levels, multiple equilibria can occur depending on the level of trade costs and on the structure of the industry. Thus, the effects of tougher climate policy as it raises firm's manufacturing costs on location decisions will depend on trade costs.

Empirical testing of the PHH has not yielded conclusive results. For example, Copeland and Taylor (2004) undertake a review of the pre-2002 literature and conclude that some early studies found no evidence of the pollution haven effect using cross-section estimation techniques, whereas later studies find significant negative coefficients on environmental regulation in relation to plant location and to trade using panel estimators. Millimet and List (2004) found heterogenous effects of environmental regulatory burdens on plant start-up and exits for US county-level data. The PHH literature has followed developments in international trade theory, with factor endowment aspects commonly controlled for in earlier studies, and additions of agglomeration metrics in later studies such as Wagner and Timmins (2009). Firm re-location in response to variations in the costs of meeting environmental regulations can also be linked to the effects of variations in regulatory burden on Foreign Direct Investment flows between countries (Cole and Elliott, 2005; Buch et al., 2005).

*Energy Costs and Location Decisions: literature overview.*

Ben Kheder and Zugravu (2008) use electricity price data in a study of location decisions made by French firms between 1996 and 2002. Their conditional logit specification includes market potential variables such as GDP, population size and distance from other important markets, as well as labour and capital costs. Other variables include an Environmental Regulation Index built on the basis of information of international environmental agreements ratified, the energy efficiency of output and general investment friendliness indices such as corruption and the rule of law. In addition to electricity prices, the authors also include fuel and natural gas prices. The coefficients on electricity prices are not significant due to multi-collinearity between electricity and natural gas prices and fuel prices. Findings suggest that investment decisions are negatively related to fuel prices. A recent study by Ratti, Seol and Yoon (2011) uses bootstrap GMM on individual firm data from 15 European countries across 25 industries over the period 1991 – 2006. Their study identifies a negative effect of energy prices on investment in a given country, with manufacturing sectors particularly sensitive to these effects.

A forecasting exercise based on empirical evidence by Broeren, Saygin and Patel (2014) focuses on the location of chemical plants on basis of the costs of production. Energy prices, especially natural gas and other primary energy, constitute one of the main drivers for plant location along with the cost of transport and technology requirements. In the case of chlorine production, the cost of electricity is particularly important. The study concludes that by 2030 as much as 60% of basic chemicals production will be located in non-OECD countries, due to lower energy costs. In the context of non-industrialised countries, where higher energy consumption is associated with energy subsidies, the impact of energy prices on FDI has indirectly been tested as part of the extensive literature dealing with the interaction of energy consumption, FDI and economic growth. In a recent study, Omri and Kahouli (2014) use a 65 country panel for 1990 – 2011 and apply GMM by following a "growth framework," including determinants of growth such as labour force, capital stock, inflation and trade. The results of the study are separated into low-income, middle-income and high-income countries. The results suggest that for all countries, FDI leads to higher energy consumption; however, this is stronger for middle income and low income countries. In high income countries there is a bidirectional causation flow, with higher energy consumption leading to higher FDI; this is not the case in developing countries. A clear link between higher electricity consumption and economic growth would suggest the necessity of energy subsidies in order to foster growth and potentially in order to attract foreign investment to support growth. Payne (2010) produces a survey of the electricity consumption and economic growth literature. However, empirical conclusions are unclear.

Growth can also depend on energy prices indirectly via links to productivity. Miketa and Mulder (2005) explore the concept of convergence in international energy productivity in a number of sector groupings: energy intensive sectors (non-metallic minerals, iron and steel, non-ferrous metals, chemicals, and paper), energy extensive sectors (transportation equipment, machinery and wood) and a medium group consisting of food and textiles. The authors aim to identify country specific factors determining energy productivity growth rates by using data for the period 1971-1995 in 56 countries, including 32 developing countries. Their results suggest that the energy productivity depends only to a very limited extent on energy prices.

In conclusion, a number of literatures have investigated the theoretical and empirical links between environmental policy, energy costs and firm location choices. However, there are few clear messages that emerge from this body of work. Research which provides additional insight into these linkages would thus seem worthwhile. In what follows, we first describe the data used in our study, before setting out the modelling approach and results. The main research questions investigated are these: at the firm level, can we observe an effect of variations in energy prices on firms' decisions whether to stay or move? Is this effect symmetrical for those moving into versus out of a country? And how does the responsiveness of firms to energy costs vary with the energy intensity of the sector within which they operate?

## 3. Data

The present study makes use of EU-wide data to study the responsiveness of large manufacturing firms to changes in energy prices across countries. If large manufacturing firms respond in a similar way to environmental regulations as they do to increasing energy prices, this responsiveness to energy prices has implications for the pollution havens hypothesis. Eurofound's European Restructuring Monitor (ERM) conducts a comprehensive range screening of press and online news sources in the European Union (EU) to collect data on firm restructuring. An "event" is included in the dataset if it involves the destruction or creation of at least 100 jobs, or at least 10% of the workforce at sites employing more than 250 people. We focus on events from the ERM which involve the relocation of manufacturing activity from within the EU to another country, either within or outside of the EU. The sectors included in the dataset are given in Table I, and descriptive statistics of the size of the relocations are given in Table II. There are 584 such events over the course of 2002-2013. We first need to drop observations which do not tell us the specific destination country; we also treat as independent events any relocation which involved shifting manufacturing production to multiple destination countries. After cleaning this data, we are left with 634 observations of relocations. For each relocation, we observe the firm name, year of relocation, country of origin, country of destination, industry sector, and the number of jobs affected.

There are some limitations to this data. Given the criteria for inclusion in the dataset, there is a firm size bias as the dataset will include almost exclusively medium to large sized firms. In addition, variability in national coverage of restructuring events would lead to an uneven representation across the EU. Despite these limitations, this data is unique as an EU-wide dataset of large-scale restructuring and relocation events.

Other data that are crucial for our investigation are energy prices. We collect a time series of end-user electricity prices for industry from several sources. Most of the data on electricity prices come from the International Energy Agency (IEA). The IEA provides data for OECD countries and select non-OECD countries, but does not include all countries that are relevant to our study. For these countries we obtain electricity prices from Enerdata. For the few countries which do not have end-use electricity prices for industry available in either of these sources, we obtained prices from either the national power company of that country or a published research article on the electricity market of the relevant country[4].

We obtain bilateral trade data from the Eurostat COMEXT database. This is to capture the idea that for a domestic firm that is relocating, the choice among two alternative countries may be influenced by the amount of trade between the domestic country and each of the potential destinations. A high value of exports of a product category, in our case a NACE 2 category, to a country can indicate an attractive market for the exported product. A high value of imports may serve as an indication of the exporter's competitive advantage, caused by lower factor costs and agglomeration effects. The World Bank provides country-level attributes for most of our destination countries. One important measure comes from the series "Occupational Wages from Around the World" which gives some indication of labor costs across the destination countries. Labour costs are a variable very commonly used in empirical PHH and wider trade literature, e.g. Millimet and List (2004) and Buch et al (2005). The World Bank also provides a complete time series of GDP for the countries in our study. GDP, as a measure of market size, is commonly used in empirical studies based on gravity international trade model and is also used in the PHH literature, e.g. Smarzynska and Wei (2001). This is typically used in conjunction with measures of distance and "virtual" distance such as differences in language (e.g. Head and Mayer 2004).

Other sources provide many of the country-specific attributes we use in the choice model. The CIA World Factbook provides data on tax rates and unemployment rates for each country. Head

[4] Indeed for some of the non-OECD countries, the price of electricity time series is quite incomplete, with a few countries having only 1 data point. We use linear interpolation and extrapolation to complete the dataset. Alternatively, we also calculated the annual average percent change in electricity prices from the observed data, and used this to impute the missing values for particular countries, assuming that energy prices in a country might follow global trends to some degree. The results were almost exactly identical for both methods, suggesting that the imputation of missing values does not drive our results.

and Mayer (2004) find that corporate taxation carries a negative, large coefficient in their study of location decisions of Japanese car manufacturers in Europe. The Quality of Government Institute has compiled a dataset that for each country measures indices of quality of government institutions, perceived corruption, levels of infrastructure and quality of education. These variables are commonly used in the trade literature and are included as proxies for the cost of trade. The quality of infrastructure emerges as a significant variable in the review of the PHH literature by Brunnermeier and Levinson (2004); this is also used in Wagner and Timmins (2009) and others. We use a measure of environmental stringency from the *Global Competitiveness Report, 2002-2003*, which has an index derived from a survey of the business community that serves to capture some overall level of regulation.

## 4. Modelling approach: conditional relocation

Discrete choice models are used to describe decision makers' choices between alternatives (Ben-Akiva and Lerman, 1985). The decision makers can be individuals, households, firms, or government agencies, but in order to fit into the discrete choice framework the decision maker must face a finite, exhaustive, and mutually exclusive set of choices where only one alternative is chosen on each choice occasion. The firm relocation data from the European Restructuring Monitor includes the destination choice of individual manufacturing plants, making it particularly well suited to a discrete choice framework, with firms choosing a relocation destination from among the set of countries.

Earlier work has also used the discrete choice framework to study firm location decisions. Bolduc et al. (1996) use a multinomial probit to model the choice of location by physicians for establishing their initial practice. We use multinomial logit rather than probit, and also must account for the moving cost between two countries. Another early paper of firm entry in an oligopolistic market is Bresnahan and Reiss (1991), which touched off the literature on firm entry games. Although we see the relocation decisions of manufacturing firms in the data set used here, they are all in different markets, and thus we do not model them as strategically interacting and so do not build an entry game. Closest to our modeling approach is Timmins and Murdock (2007), which models anglers' choices of fishing sites from a finite set of alternatives, taking into account the travel cost to each site for each angler. We adopt a similar estimation strategy to model firms choosing a country taking moving costs into account. We can then estimate the value (utility) of country-specific characteristics, such as the end-user price of electricity in each country, to estimate how important that is to each firm's location decision. Some papers have extended these models to dynamic settings, for example Bayer et al. (2011) who present a dynamic model of a household's neighborhood location choice. However, because we do not observe the same firm making multiple moves in the ERM relocation data, we maintain a static framework in this paper.

Due to data limitations, many studies on firm location decisions and the pollution havens hypothesis rely on aggregate data which cannot distinguish among births and deaths of plants, expansions and contractions of plant activity, and relocations. Levinson (1996) is a notable exception, which uses data from the Census of Manufacturers to estimate a conditional logit of plant relocations across U.S. states in response to state-level characteristics including environmental regulations. Levinson finds that the locations of branch plants of large firms are more sensitive to state characteristics than plants in general; however, only a few of the coefficients on measures of environmental stringency are statistically significant.

## 4.1 Empirical Model

We model firm i's decision to relocate a plant conditional on the firm deciding that it will relocate to another country in a particular year. With data on the total share of firms that decide to relocate at all, we provide a richer model that includes the decision of whether to relocate or not in the next section. The firm chooses a country j = 1,2,...J for each year t = 1, ... ,T (2002-2013). Because this choice is conditional on relocation, each firm faces J-1 alternatives, as we exclude the country of origin from the choice set. Thus at each time period, each firm i = 1,...,N faces a reduced form profit function:

$$\pi_{ijt} = \delta_j + \beta_1 Price\_elec_{jt} + \beta_2 GDP_{jt} + \beta_3 Trade_{ijt} + \theta' MC_{ij} + \epsilon_{ijt}$$

with a moving cost function

$$\theta' MC_{ij} = \theta_1 Dist_{ij} + \theta_2 Lang_{ij} + \theta_3 EU_{jt}$$

and we define the mean profit term composed of country-specific attributes, $X_j$, and an unobserved country-specific attribute $\xi_j$ as

$$\delta_j \equiv X_j' \alpha + \xi_j$$

In our current specification,

• $X_j$ are country specific attributes that do not vary with time

• $Dist_{ij}$ is a distance moving cost, measured as kilometers between countries i and j

• $Lang_{ij}$ is a dummy variable equal to 1 if firm i's country of origin has an official language in common with j

• $Trade_{ijt}$ is a measure of bilateral trade between countries i and j in year t

• $Price\_elec_{jt}$ are the end-user electricity costs for industry in country j at time t

• $EU_{jt}$ is a dummy variable for EU membership at time t

$\epsilon_{ijt}$ is an i.i.d. Type I Extreme Value distributed shock. This is so that the choice probabilities can be expressed in a closed form, which greatly facilitates estimation.

4.2 Estimation

We add the destination-specific unobserved constant $\xi_j$ in order to deal with endogeneity of our observed country characteristics, which may be correlated with the error term. By adding the $\xi_j$, the endogeneity then enters into the mean profit term $\delta_j$. Thus we have shifted endogeneity from a nonlinear model, the logit, to a linear model, where we know better how to handle endogeneity. We thus proceed with estimation in two steps.

**First stage:** Estimate the logit model, now free of endogeneity, and recover the coefficients on Price of Electricity, GDP, Trade, and Moving Costs $(\beta, \theta')$ and the mean utility terms, $\{\delta_j\}$.

**Second stage:** We estimate the linear regression of $\delta_j$ on time-invariant country attributes[5] to recover the parameters on these attributes $(\alpha = \alpha_1, \dots, \alpha_k)$. As a linear regression, we can handle endogeneity in this regression using instrumental variables. Below is an outline of the estimation procedure, analogous to the procedure in Timmins Murdock (2007). Steps 1 and 2 correspond to the first stage described here, while Step 3 will recover the second stage parameters.

**Step #1:** Contraction mapping to recover $\delta_j$ 's given an initial guess $(\beta_1^q, \beta_2^q, \beta_3^q, \theta'^q)$

Assume that $\epsilon_{ijt} \sim$ i.i.d. Type I extreme value. Then given an initial guess of parameters $(\beta_1^q, \beta_2^q, \beta_3^q, \theta'^q)$ and baseline utilities $\{\delta_j^{m,q}\}_{j=1}^{J}$ we can write the probability that firm i moves to country j:

$$P_{i,j,t}^{m,q} = P\left(\pi_{ijt} \geq \pi_{ilt} \forall l \neq j \,\middle|\, X, MC_i\right)$$

$$= \frac{\exp(\, \delta_j^{m,q} + \beta_1^q price_{elec_{jt}} + \beta_2^q GDP_{jt} + \beta_3^q Trade_{ij} + \theta_1'^q MC_{ij})}{\sum_{l=1}^{J} \exp(\, \delta_l^{m,q} + \beta_1^q price_{elec_{lt}} + \beta_2^q GDP_{lt} + \beta_3^q Trade_{il} + \theta_1'^q MC_{il})}$$

Note that in this specification which is for choice conditional on moving at time t, we have that $\sum_{j=1}^{J} P_{ijt} = 1$. These choice probabilities are used to predict the share of firms that will move to country j:

[5] These attributes, such as tax rates, will of course not really be time-invariant in reality, but for the present we treat them as such.

$$\hat{\sigma}_j^{m,q} = \frac{1}{NT}\sum_t \sum_i P_{i,j,t}^{m,q}$$

We then can use the iterative procedure proposed by Berry (1994) to get a new estimate of $\delta_j$:

$$\delta_j^{m+1,q} = \delta_j^{m,q} + ln\frac{\sigma_j}{\hat{\sigma}_j^{m,q}(\delta^{m,q})}$$

where $\sigma_j$ is the actual share of firms observed relocating to country j. We also need to make a scale normalization, so we let $\delta_1 = 0$. This step is a contraction mapping guaranteed to converge to a unique vector of mean profit terms $\{\delta_j^*\}_{j=1}^J$ given the scale normalization.

**Step #2:** Nest Step #1 inside a likelihood maximization algorithm.

Given a parameter vector $(\beta_1^q, \beta_2^q, \beta_3^q, \theta'^q)$ and the corresponding vector of baseline utilities that equate predicted shares to actual shares, $\{\delta_j^{*q}\}_{j=1}^J$ , we can calculate the likelihood of the observed data:

$$\mathcal{L}(\delta^{*,q}, \theta'^q \mid X, MC) = \prod_t \prod_i \prod_{j \neq j(origin)} [P_{ijt}^{*,q}]^{Y_{ijt}}$$

where $Y_{ijt} = 1$ if i moves to country j at time t. This is a product over (J-1) alternatives because we have removed the country of origin from each firms choice set (since this choice is conditional on moving). For each new set of parameters $(\beta_1^{q+1}, \beta_2^{q+1}, \beta_3^{q+1}, \theta'^{q+1})$, we calculate from step #1 new baseline utilities $\{\delta_j^{*q+1}\}_{j=1}^{J}$ and evaluate the value of the likelihood function. Continue until we find values that maximize the likelihood function, which we denote $(\beta_1^*, \beta_2^*, \beta_3^*, \theta'^*)$.

**Step #3**: Least Squares Regression

To recover the second stage parameters $\alpha$, we run ordinary least squares regressions. Standard errors provided are those resulting from asymptotic theory. We regress the mean profit term for country $i$, $\delta_j$ , on each of the country attributes that do not vary over time in our dataset. Thus each equation is given by:

$$\delta_j = X_j'\alpha + \xi_j$$

where $X_j'$ includes country-specific variables described in the data section, and expected to potentially co-determine mean profits at the country level:

- Level of environmental regulations
- Unemployment and tax rates
- Wages in Manufacturing
- Measures of infrastructure
- Measures of the quality of government institutions and corruption

The resulting parameter estimates give us the information to fully describe the choice model.

Without instruments, it is of course possible that the estimates resulting from the second stage may be susceptible to endogeneity bias, and thus be inconsistent estimates. We should be able, however, to determine the direction of the bias logically. Take country tax rates as one example. We might expect that higher taxes, which are undesirable, may be correlated with unobserved country attributes that are desirable. This would especially be the case if the country uses tax revenues to provide public goods or amenities that boost firm productivity. Then the coefficient on taxes would pick up both the effect of taxes as well as the effect of these amenities, and so the coefficient on taxes would be biased downward in magnitude.

### 4.3 Identification

Our main parameter of interest is the coefficient on electricity prices. To give a sense of the range of the electricity prices, consider end-user electricity prices for industry in 2011. Russia has some of the lowest prices at 4 US cents/kWh, while Japan is among the highest at 18 US cents/kWh; most countries are within 8 and 16 US cents/kWh. For identification of the parameter on electricity prices in our model, however, we rely on variation over time in the electricity prices. Figure 1 shows the time series of electricity prices for a small subset of countries, and gives an indication of the variation which we rely on for identification. Additionally, we assume that these price variations are exogenous, and thus uncorrelated with other factors that might influence a firm's relocation decision.

## 5 Conditional Model Results

In this section we first present the parameter estimates from the model set out in section 4. We then use these estimates to investigate how changing end-user electricity prices for industry affect the relocation decisions of manufacturing firms in the EU.

**First Stage Parameters**

The results from the first stage are given in Table III for various model specifications. These estimates look reasonable. The negative coefficient for *Distance* implies a high cost to moving; the positive coefficients on *EU* and *Language* suggest that this cost is slightly mitigated when moving to a country that is a member of the EU or that has a common official language with the firm's country of origin. Although not as large in magnitude as distance, the negative parameter on *Price_Electricity* shows that an increased price of electricity serves to discourage firms from relocating from a particular country.

These parameter estimates allow us to calculate elasticities for our parameter of interest, *Price_Electricity*. We denote by $\eta_{ijt}$ the individual elasticity of $P_{ijt}$ with respect to the price of electricity, which given our type I extreme value assumption for $\epsilon_{ijt}$, gives us the formula

$$\eta_{ijt} \equiv \frac{d \log P_{ijt}}{d \log Price_{elec}} = \beta_{price}\, Price\_elec_{jt}\, (1 - P_{ijt})$$

We aggregate these individual elasticities by taking a weighted average in order to arrive at a global elasticity, which is reported at the bottom of Table III as $\eta_{price}$ [6]. The demand for relocating to any particular country in our sample appears to be fairly inelastic with respect to the

[6] Specifically, we use the formula $\eta_{price} = \frac{\sum_{ijt} \eta_{ijt} P_{ijt}}{\sum_{ijt} P_{ijt}}$

price of electricity. That is to say, firms are not especially sensitive to the price of energy in a country when making a relocation decision. We also present the elasticity broken down by country for a subsample of countries in Table IV. There are a few countries that approximate an elasticity of 1, such as Austria and Japan with respective values of 0.92 and 1.00. China, Canada, and the United States are all around 0.5, indicating that firms relocating to there are probably being attracted by factors other than energy prices. Also for very inelastic cases such as Russia, this is likely driven by the very low energy prices we observe, so that a 10% increase in the price of electricity would still leave Russia with among the lowest prices worldwide.

Table V provides the estimates of the $\delta_j$'s (mean utilities) for each country. The vector $\{\delta_j\}_{j=1}^{J}$ is normalized to have mean zero. It was also interesting to see how these mean utility parameters vary across regions of the world, as depicted in Figure 2. China has the highest mean utility, and Asian countries on the whole are above average. Not all firms relocate to Asia, however, because of the high travel costs that are paid for moving over such a long distance. Thus, there is still a significant share of firms relocating to Western and Eastern Europe, because although the mean utilities are lower than in Asia and the Americas, distance costs are also much lower. To illustrate the importance of the distance, we can conduct a hypothetical counterfactual based on our parameter estimates. For example, we can simulate the location decisions if China were located in Eastern Europe and thus had much lower moving costs associated with it. In our sample, we see 15% of firms that relocate go to China; under the counterfactual where China is “in” Eastern Europe, the share jumps to almost 85%.

**Second Stage Parameters**

The results from the second stage are given in Table VI[7]. Keeping in mind the biases discussed above, we see that taxes and environmental regulations are estimated to negatively enter the profit function, while our measure of roads infrastructure enters positively as expected. The parameters on port and rail infrastructure have an unexpectedly- negative coefficient, and this may be an example of where the endogeneity is leading to bias; having good infrastructure is often correlated with high wages and other costs, so this estimate may be picking up those effects. Our estimate on the effect of wages should be interpreted as a combination of the estimates on our measure of wages and our measure of employee compensation as a % of expenses, which combined enter negatively into the profit function.

## 6 Nested Logit Relocation Model: the decision to move and where to move

The previous section modeled firm location choice conditional on having already decided to relocate. However, for a policy maker the more interesting question is to what degree climate change policies affect a firm's decision to relocate or not, as well as the choice of destination for firms that do decide to move their production activity. In this section, we approximate the total number of manufacturing firms in the EU in order to expand our model to include the participation decision. This allows for a more complete picture of plant relocation and is useful for giving a more meaningful examination of the effects of climate change policies which drive up energy costs.

First, we need to approximate the share of firms that relocate by using an estimate of the total

[7] Standard errors for the first stage parameters are obtained from the hessian matrix. Second stage standard errors are obtained via asymptotic theory for linear regression.

number of medium and large manufacturing firms in the EU. Eurostat includes manufacturing firm counts for the EU by size class, however the most disaggregate size class includes all manufacturing firms with >10 employees, while the ERM data only captures relocations from medium to large firms. We thus look at the distribution of manufacturing firm size in Sweden, which has a detailed survey of manufacturing firms available (Johansson 1997), and use this distribution to approximate the share of medium and large manufacturing firms in the entire EU from the Eurostat firm counts. These numbers suggest a very small share of firms relocate; for robustness, we check various sizes of the outside share.

With an approximation of the total numbers of firms (and thus also the share that relocate), we can extend the model where firms have two stages of decision making. First, firms decide whether to move or not. After deciding to move, a firm then decides to which destination country to move to. The current setup will be a static framework, so firms are not making decisions taking into account expectations of future states. Rather, here firms are modeled as exogenously having the opportunity to move at each time period t, where if a firm decides to relocate from country i to country j it receives:

$$\pi_{ijt} = \delta_j + \beta_1 Price\_elec_{jt} + \beta_2 GDP_{jt} + \beta_3 Trade_{ijt} + \theta' MC_{ij} + \epsilon_{ijt}$$

with a moving cost

$$\theta' MC_{ij} = \theta_1 Dist_{ij} + \theta_2 Lang_{ij} + \theta_3 EU_{jt}$$

While if a firm decides to stay, it receives the mean utility for its country of origin, $\delta_{origin}$ and does not pay the moving cost, so it receives:

$$\pi_{i0t} = \delta_{origin} + \beta_1 Price\_elec_{origin,t} + \beta_2 GDP_{origin,t} + \epsilon_{ijt}$$

We model the firm decision as first deciding whether to relocate or not, and then only after a decision to relocate, the firm choose a country of destination. This model requires that we impose a nesting structure, so that the country of origin is in one (degenerate) nest, and all the other countries are in another nest. The error term $\epsilon_{ijt}$ is distributed type 1 extreme value, but rather than being independent across all choice, there is now correlation among alternatives in the same nest; this allows us to still calculate the choice probabilities, $P_{ijt}$ to a closed form[8]. Estimation of the parameters follows using essentially the same method as before, with the additional estimation of the moving cost constant $\theta_1$ and a nesting parameter, $\lambda_{move}$ which provides a more complete picture in any counterfactual scenarios one might want to examine by approximating the stickiness firms face in deciding whether to move.

## 7 Nested Logit Model Results

[8] The choice probabilities in the nested logit require another parameter that measures the importance of the nest, which we denote $\lambda_k$ for nest $B_k$. If we denote the profit $\pi_{ijt} = V_{ijt} + \epsilon_{ijt}$, the choice probabilities for choosing an alternative i which is in nest $B_k$ then take the form $P_{ijt} = \frac{e^{\frac{V_{ijt}}{\lambda_k}}\left(\sum_{j\in B_k} e^{\frac{V_{ijt}}{\lambda_k}}\right)^{\lambda_k - 1}}{\sum_{l=1}^{K}\left(\sum_{j\in B_l} e^{\frac{V_{ijt}}{\lambda_l}}\right)^{\lambda_l}}$. Note that if the estimated nesting parameter $\lambda_k$ is one, the choice probabilities and the model reduce to the standard logit that we used before. As the nesting parameter goes to zero, this indicates the importance in the nesting of alternatives, and signals that the more flexible nested logit captures a more realistic substitution pattern.

**First Stage Parameters**

The results for the nested logit relocation model are analogous to those of the previous section, with the addition that as we now model the decision to relocate or stay, we can estimate a moving cost constant, $\theta_1$, which is incurred only when a firm decides to relocate, and a nesting parameter $\lambda_{move}$. We also calculate elasticities separately for domestic and foreign firms. We use a similar formula to calculate individual elasticities $\eta_{ijt}$ as before[9], and denote by $I_j$ (resp. $I_j^c$) the set of all firms originating in country j (resp. outside of country j). Then we can define the country j level elasticities $\eta_{domestic}^j$ and $\eta_{foreign}^j$ as:

$$\eta_{domestic}^j = \frac{d\log(\sum_{i\in I_j} P_{ijt})}{d\log Price\_elec} = \frac{\sum_{i\in I_j} P_{ijt}\eta_{ijt}}{\sum_{i\in I_j} P_{ijt}}$$

$$\eta_{foreign}^j = \frac{d\log(\sum_{i\in I_j^c} P_{ijt})}{d\log Price\_elec} = \frac{\sum_{i\in I_j^c} P_{ijt}\eta_{ijt}}{\sum_{i\in I_j^c} P_{ijt}}$$

By taking a weighted sum of each $\eta_{domestic}^j$ across all the countries j, we arrive at an aggregate elasticity:

$$\eta_{domestic} = \frac{\sum_{i\in I_1} P_{i1t}\eta_{i1t} + \sum_{i\in I_2} P_{i2t}\eta_{i2t} + \dots + \sum_{i\in I_J} P_{iJt}\eta_{iJt}}{\sum_{i\in I_1} P_{i1t} + \sum_{i\in I_2} P_{i2t} + \dots + \sum_{i\in I_J} P_{iJt}}$$

and use an analogous definition for $\eta_{foreign}$.

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[9] Elasticities in the nested logit are given by $\left[\left(1 - P_{ijt}\right) + \left(\frac{1-\lambda_{move}}{\lambda_{move}}\right)\left(1 - P_{ijt|B_k}\right)\right]\beta_{price}\, Price\_elec_{jt}$ . Note again that with $\lambda_{move}$ equal to 1, the elasticities would be exactly the same as the standard logit case used before.

These results are reported in Table VII[10]. The elasticity for domestic firms $\eta_{domestic}$ is very low, indicating that domestic firms are not responsive to increases in their domestic energy prices. This is due to having such a large share of firms in each domestic country that do not relocate in a multinomial logit specification. On the other side, this unconditional model allows us to also study the responsiveness of foreign firms to domestic energy prices, to give a sense of how much a country might be able to attract foreign firms by having lower energy prices. This responsiveness is indicated by $\eta_{foreign}$, which corresponds to the results from the Conditional Relocation Model from the previous section. Our estimates range from 0.58 to 0.76, suggesting there is more responsiveness in attracting foreign firms through lower energy costs, but still this responsiveness is modest.

Table VIII includes robustness checks on the outside share. With N firms making a location decision each period, N= 800, 1000, and 1500 correspond to an outside share of .93, .94, and .96 respectively. Although the point estimates do vary, the elasticities remain with a reasonable range, with for example the elasticity on foreign firms remaining high but below unity (.71-.89).

**Second Stage Parameters**

The results from the second stage are given in Table IX. While we cannot measure a statistically significant effect for functioning of government or our measure of environmental stringency, we do find some significant effects. The most significant effect is for roads infrastructure, and it has

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[10] We also estimated the unconditional relocation model without the nesting structure. Because the nesting parameter $\lambda_{move}$ is different than 1, suggesting a standard logit is mis-specified, we present only the nested model logit. Elasticities were very similar under both models, the main difference was that the nested logit estimated smaller moving costs, while the i.i.d. structure of the error term in the standard logit drove the moving cost estimate to be larger in magnitude.

the expected sign that a better road infrastructure makes a country more attractive to relocating firms. Also as expected, we find that higher employee compensation as a % of expenses and tax rates make countries less desirable. Unexpected results are the negative coefficients on the measure of ports and rail infrastructure; these may be again subject to endogeneity bias.

## 8 Firm Heterogeneity

It seems likely that, at the margin, there are firms that are more responsive to the cost burdens imposed by environmental regulations. For example, some heavily polluting manufacturing plants may be more likely to relocate in response to new regulations, and they may face a tradeoff between upgrading to cleaner technology or relocating, and large differences in national regulatory environments can have a big influence on these decisions. Moreover, heterogeneity among industries in levels of pollution and moving costs may result in a heterogeneous response to increases in energy costs across specific industries. Similarly, one can speculate that firms which operate in more energy-intensive sectors are more likely to respond to increases in energy costs than those in less energy-intensive sectors. While our data are not particularly well-suited to investigate firm heterogeneity in great detail, we can make use of 2 digit sector codes to create a set of high energy intensive industries and a set of low energy intensive industries[11]. That is, we use energy intensity information to partition our data set.

[11] This categorization is derived based on the DECC Annual Industrial Energy Consumption Tables for the UK. This source has total annual electricity consumption information per sector expressed in ‘000 MWh/year, which was divided by the number of enterprises in the sector in the UK as reported in Eurostat. This is a crude statistic as electricity consumption varies considerably within the two digit level sector classification used here; therefore we create two groupings, one includes energy intensive industries and another - the remainder of sectors. Energy intensive industries include pharmaceuticals, paper, electronics, chemicals, basic metals, tobacco products and coke and refined petroleum products.

We account for firm heterogeneity in energy intensity by adding an interaction of the electricity price with an indicator for being an energy intensive sector. The profit function from the previous sections then takes the form:

$$\pi_{ijt} = \delta_j + (\beta_1 + \gamma \times INTENSE_i)Price\_elec_{jt} + \beta_2 GDP_{jt} + \beta_3 Trade_{ijt} + \theta' MC_{ij} + \epsilon_{ijt}$$

where $INTENSE_i$ is an indicator for firm i belonging to an energy intensive sector, so that we now estimate an extra parameter $\gamma$ which reflects the importance of the electricity price for firms in energy intensive sectors, beyond the effect for firms that are not in energy intensive sectors.

The results are presented in Table X. With only 166 firms in energy intensive sectors, we are not quite able to find statistically significant estimates for the interaction effect. The point estimate is, however, large and in the expected direction, indicating that energy intensive sectors are more responsive to energy prices. Indeed this is reflected in the corresponding elasticities, where low energy intensive firms have an elasticity around 0.4, while the energy intensive sectors firms have an elasticity of 0.8. A larger dataset or one with more detailed firm characteristics such as sector beyond the two digit NACE code would be required to investigate this question more precisely.

## 9. Conclusions

In this study we are able to statistically measure a relationship between energy costs and location choice for manufacturing plants which have the possibility of moving into, or out of, or within, European Union countries. The magnitude of the effects that we measure on investment decisions are relatively modest. A country j can try to attract a relocating foreign firm by lowering production costs, but the responsiveness of the foreign firm will be only modest with an estimated elasticity of $\eta_{foreign} \approx 0.7$. On the other hand, a country might fear that imposing environmental regulation will cause domestic firms to leave. However, we found very little responsiveness of domestic firms to increasing energy costs, with an elasticity of $\eta_{domestic} \approx .005$. This marked asymmetry is partly a consequence of the multinomial logit specification and the resulting expression for elasticities; since most domestic firms remain at home, $P_{ijt}$ is high for domestic firms, and therefore the elasticity $\beta_{price} Price\_elec(1 - P_{ijt})$ will be small, while the opposite occurs for the foreign firms. But the asymmetry is also consistent with our assumed firm decision process. If most domestic firms are not considering relocation, it would take a large change in input prices in order for them to even consider incurring the fixed costs of a relocation. By contrast, from the perspective of home country i, there are many foreign firms (the domestic firms in all other countries), and if even a small number are considering relocation from each country, in sum this group of relocating firms may be sizeable. Having decided it is worthwhile to incur the fixed moving costs, they may be more sensitive to small changes in energy prices in home country *I* in choosing *where* to relocate.

We also found that the responsiveness of firms to higher energy costs in terms of the probability of them re-locating was about twice as large for high energy users than for low energy users. This suggests one reason why governments might want to find means of reducing the financial burden of climate policies on high-energy use sectors: although, of course, these are the very sectors that typically offer the greatest potential for achieving national emission reductions.

We are not able to determine whether countries are setting environmental standards below socially efficient levels in order to attract and maintain firms, as this would require some measure of the social cost of pollution. Particularly in the case of climate change, these costs are hard to estimate. But our results indicate that countries should not expect many domestic firms to leave as a result of regulations that lead to increases in the costs of production for manufacturing firms. It may be modestly more difficult to attract foreign firms when domestic climate policy is strengthened in a way which increases end-user energy prices. If this is a significant concern of policy-makers, then this would place more importance on a coordinated regulatory frameworks across countries.

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**Table I. Sample of Sectors Observed**

| | Number of Firms |
|---|---|
| Manufacture of computer and electronics | 90 |
| Manufacture of electrical equipment | 113 |
| Manufacture of motor vehicles | 102 |
| Manufacture of food products | 37 |
| Manufacture of chemicals | 31 |
| Manufacture of rubber and plastics | 31 |
| Manufacture of fabricated metal products | 22 |

**Table II. Size of Relocation Events**

| | Obs | Mean | Std Dev | Min | Max |
|---|---|---|---|---|---|
| Jobs Affected | 634 | 294.3 | 323.9 | 30 | 3200 |

**Table III. First Stage Parameter Estimates**

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Distance (100 thous. km) | -60.8107** | -56.2302** | -56.1763** | -56.2443** |
| | (7.6512) | (7.798) | (7.8211) | (7.834) |
| EU membership | | -0.0562 | -0.0541 | -0.0478 |
| | | (0.2511) | (0.2522) | (0.2556) |
| Electricity Price (US cents/kWh) | -6.8226** | -7.1134** | -7.1076** | -7.0035** |
| | (3.2938) | (3.307) | (3.3081) | (0.0553) |
| GDP | | | 0.0251 | 0.0553 |
| | | | (0.2748) | (0.3406) |
| Language | | 0.5373** | 0.5374** | 0.5367** |
| | | (0.1718) | (0.1718) | (0.1718) |
| Trade | | | | -0.0683 |
| | | | | (0.455) |
| $\eta_{price}$ | 0.6358 | 0.6623 | 0.6617 | 0.6521 |
| N | 634 | 634 | 634 | 634 |

Note : Significance results are $p \leq .05$ is ** and $.05 < p \leq .1$ is *.

**Table IV. Demand elasticity with respect to electricity prices for a selection of modelled countries**

| | $\eta_{price}$ |
|---|---|
| Austria | 0.9272 |
| Brazil | 0.7297 |
| Canada | 0.4593 |
| China | 0.5315 |
| Croatia | 0.5933 |
| Czech Republic | 0.6942 |
| Denmark | 0.7188 |
| France | 0.5554 |
| Germany | 0.7107 |
| India | 0.7969 |
| Japan | 1.0024 |
| Poland | 0.5508 |
| Russia | 0.2873 |
| United Kingdom | 0.7367 |
| United States | 0.4207 |

**Table V. First Stage Mean utilities for conditional model.**

| | Mean Utility | | Mean Utility |
|---|---|---|---|
| Argentina | 2.9257 | Macedonia | -3.203 |
| Austria | -1.4202 | Malaysia | 4.1775 |
| Belarus | -2.2426 | Malta | -2.7065 |
| Belgium | -1.7932 | Mexico | 4.0843 |
| Bosnia Herzegovina | -2.1985 | Moldova | -3.216 |
| Brazil | 2.4574 | Morocco | -0.4045 |
| Bulgaria | -1.4326 | Netherlands | -0.8231 |
| Canada | -1.096 | Norway | -3.2921 |
| China | 4.9309 | Poland | 1.5112 |
| Costa Rica | 1.0887 | Portugal | -0.2909 |
| Croatia | -2.4194 | Romania | 0.8615 |
| Czech Rep | 1.1512 | Russia | 0.8781 |
| Denmark | -1.455 | Serbia | -1.7158 |
| Egypt | -2.399 | Singapore | 3.3443 |
| Estonia | -0.5836 | South Korea | 1.8626 |
| Finland | -2.0798 | Slovakia | 0.2204 |
| France | -0.2649 | Slovenia | -1.0754 |
| Germany | 0.6539 | South Africa | 1.7862 |
| Hong Kong | 1.62 | Spain | 0.0391 |
| Hungary | 0.8492 | Sweden | -0.4922 |
| Iceland | -2.8883 | Switzerland | -3.4292 |
| India | 3.2297 | Thailand | 3.2572 |
| Indonesia | 3.7395 | Tunisia | -0.3236 |
| Ireland | -1.6681 | Turkey | -0.0925 |
| Italy | 1.0091 | United Kingdom | -0.3137 |
| Japan | 1.5255 | Ukraine | -2.1316 |
| Latvia | -2.9859 | United States | 2.819 |
| Lithuania | -2.0269 | Vietnam | 2.4466 |

**Table VI. Second Stage Estimates for conditional model**

| | Est | St Error |
|---|---|---|
| Constant | 7.3506** | (0.4248) |
| Env Stringency | -0.2351** | (0.1054) |
| Unemployment | -0.0827** | (0.0086) |
| Taxes | -0.1118** | (0.0069) |
| Wages | 0.0003** | (0.0001) |
| Function Government | -0.021 | (0.0251) |
| Ports | -0.7846** | (0.1035) |
| Rail Infrastructure | -0.3633** | (0.0873) |
| Roads | 0.9287** | (0.088) |
| Employee compensation (% expenses) | -0.0421** | (0.0082) |

Note : Significance results are $p \leq .05$ is ** and $.05 < p \leq .1$ is *.

**Table VII. First Stage Parameter Estimates, Nested Logit**

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Distance (100 thous. km) | -5.3021** | -6.3928** | -6.4771** | -6.7932** |
| | (2.0365) | (1.9929) | (2.0047) | (2.054) |
| EU membership | | 0.0613 | 0.0618 | 0.0701 |
| | | (0.0429) | (0.0431) | (0.0465) |
| Electricity Price (US cents/kWh) | -0.5032** | -0.8481** | -0.8759** | -0.8802** |
| | (0.2741) | (0.3808) | (0.3908) | (0.3934) |
| GDP | | | -0.0141 | 0.0053 |
| | | | (0.0324) | (0.0414) |
| Language | | 0.066** | 0.0666** | 0.069** |
| | | (0.027) | (0.0271) | (0.0276) |
| Trade | | | | -0.0444 |
| | | | | (0.0577) |
| $\eta_{domestic}$ | 0.0031 | 0.0052 | 0.0054 | 0.0054 |
| $\eta_{foreign}$ | 0.5821 | 0.746 | 0.7632 | 0.7355 |
| $\lambda_{move}$ | 0.0875 | 0.1152 | 0.1162 | 0.1211 |
| Moving Costs | -3.1739 | -3.3387 | -3.3426 | -3.3669 |
| N | 1000 | 1000 | 1000 | 1000 |

Note : Significance results are $p \leq .05$ is ** and $.05 < p \leq .1$ is *.

**Table VIII. Nested Logit model: Robustness Check using differing values of N**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Distance (100 thous. km) | -4.9569** | -6.0603** | -12.8038** |
| | (2.1794) | (2.0701) | (2.3983) |
| EU membership | 0.0306 | 0.0615 | 0.2662** |
| | (0.0316) | (0.0448) | (0.0857) |
| Electricity Price (US cents/kWh) | -0.6279** | -0.8237** | -1.9777** |
| | (0.3621) | (0.392) | (0.5769) |
| GDP | -0.0095 | -0.0126 | -0.0428 |
| | (0.0251) | (0.0302) | (0.0605) |
| Language | 0.0488* | 0.0624** | 0.1409** |
| | (0.0252) | (0.027) | (0.0416) |
| $\eta_{domestic}$ | 0.0048 | 0.0051 | 0.0082 |
| $\eta_{foreign}$ | 0.7171 | 0.7718 | 0.8964 |
| $\lambda_{move}$ | 0.0886 | 0.1081 | 0.2247 |
| Moving Costs | -2.9831 | -3.3153 | -4.3116 |
| N | 800 | 1000 | 1500 |

Note : Significance results are $p \leq .05$ is ** and $.05 < p \leq .1$ is *.

**Table IX. Second stage estimates from nested logit model**

| | Est | St Error |
|---|---|---|
| Constant | 0.851** | (0.0424) |
| Env Stringency | -0.0123 | (0.0103) |
| Unemployment | -0.0104** | (0.0009) |
| Taxes | -0.0135** | (0.0007) |
| Function Government | -0.0021 | (0.0026) |
| Ports | -0.105** | (0.0107) |
| Rail Infrastructure | -0.0367** | (0.009) |
| Roads | 0.1302** | (0.0091) |
| Employee compensation (% expenses) | -0.0066** | (0.0008) |

Note : Significance results are $p \leq .05$ is ** and $.05 < p \leq .1$ is *.

**Table X. Check for Firm Heterogeneity, conditional model**

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Distance (100 thous. km) | -60.5193** | -55.7853** | -55.8921** | -55.9389** |
| | (7.6614) | (7.8085) | (7.8299) | (7.8432) |
| EU membership | | 0.1063 | 0.1043 | 0.1074 |
| | | (0.2667) | (0.2669) | (0.2685) |
| Electricity Price × High Intensity | -4.0046 | -3.8089 | -3.8006 | -3.7978 |
| | (2.7081) | (2.7057) | (2.7034) | (2.7034) |
| Electricity Price (US cents/kWh) | -4.4872** | -5.0604** | -5.1191** | -5.0723** |
| | (2.4536) | (2.5647) | (2.5851) | (2.6265) |
| GDP | | | -0.0498 | -0.0292 |
| | | | (0.2784) | (0.3464) |
| Language | | 0.533** | 0.5328** | 0.5323** |
| | | (0.1719) | (0.1719) | (0.172) |
| Trade | | | | -0.0456 |
| | | | | (0.4546) |
| $\eta_{price}^{high}$ | 0.7796 | 0.8143 | 0.819 | 0.8145 |
| $\eta_{price}^{low}$ | 0.4371 | 0.4921 | 0.4979 | 0.4934 |
| N | 634 | 634 | 634 | 634 |

Note : Significance results are $p \leq .05$ is ** and $.05 < p \leq .1$ is *.

**Figure 1 Time Series of End-User Electricity Prices for Industry**

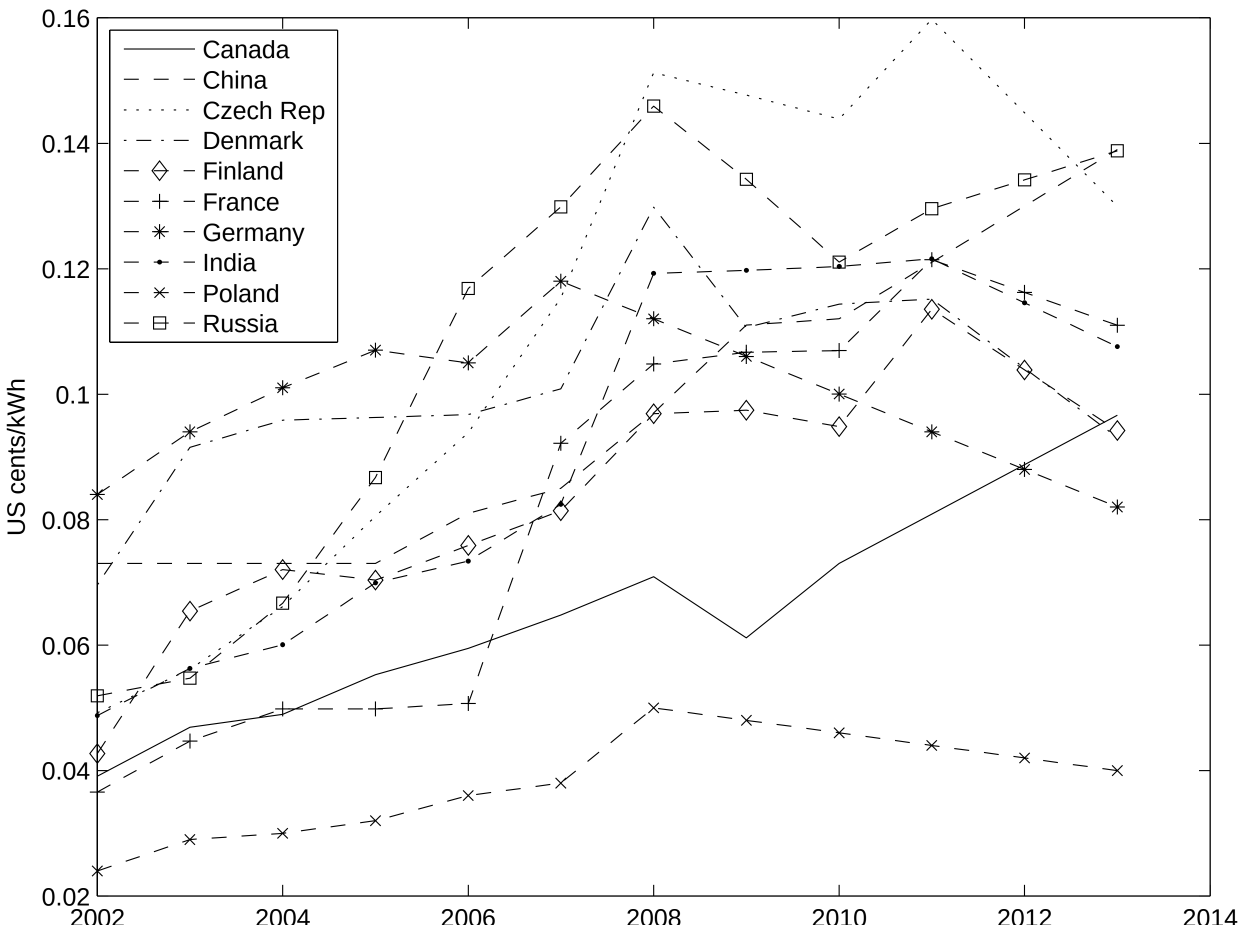

**Figure 2 Mean utilities by region**

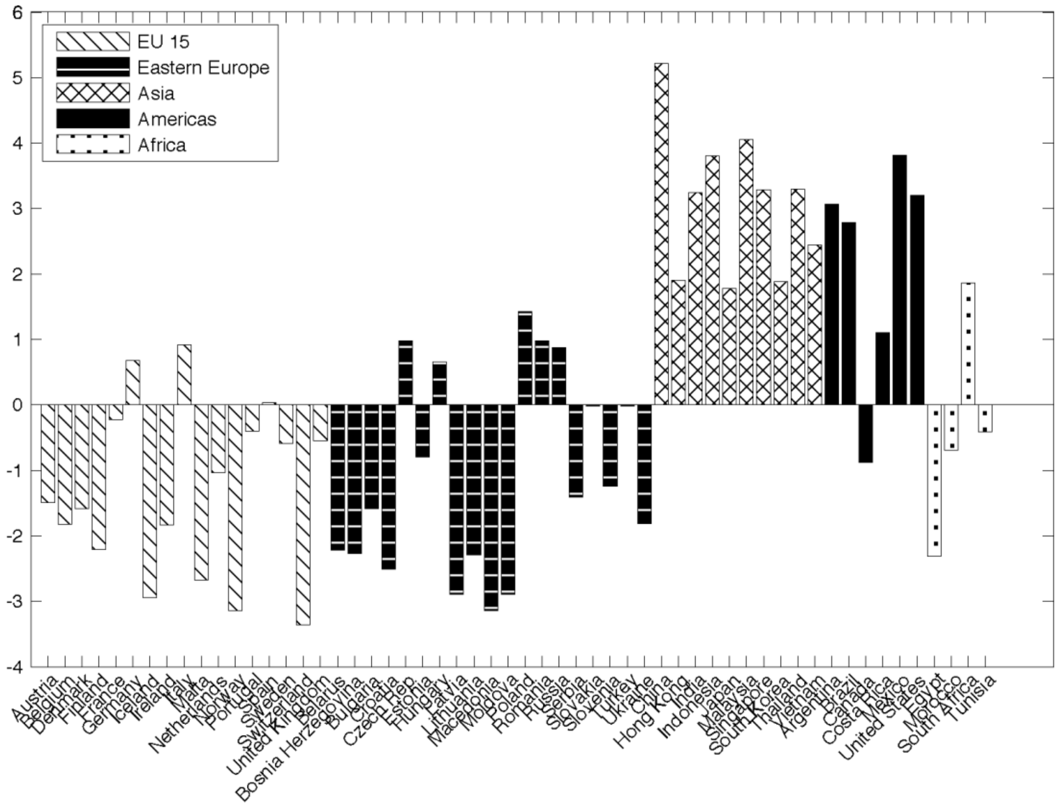

**Figure 3 Mean Utilities from Nested Logit**