ASSESSING THE IMPACT OF THE EU ETS USING FIRM LEVEL DATA

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Highlights

- This paper investigates the impact of the European Union's Emission Trading System (EU ETS) at a firm level. Using panel data on the emissions and performance of more than 2000 European firms from 2005 to 2008, we are able to analyse the effectiveness of the scheme.
- The results suggest that the shift from the first phase (2005-2007) to the second phase (2008-2012) had an impact on the emission reductions carried out by firms. The initial allocation also had a significant impact on emission reduction. This challenges the relevance for the ETS of Coase's theorem (Coase, 1960), according to which the initial allocation of permits is irrelevant for

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[2]. Those instruments – that partly serve as security valves against too-high allowance prices – inflate the cap to an unpredictable degree. Consequently, it is

initial allocation[5]. Consequently, we choose to study the changes of abatement behaviour between phases instead of using the carbon price to investigate the effectiveness of the scheme.

Another question arising in the context of the ETS is the impact of the rules of initial allocation on actual emissions. The invariant thesis of the Coase Theorem (Coase, 1960) suggests that the initial allocation of permits is irrelevant for the post-trading allocation of marketable pollution permits. Put differently, the initial allocation does not affect the reduction behaviour of regulated firms; but, it certainly matters under distributional aspects, ie who receives the income of carbon regulation. However, the Coase theorem was derived under idealised conditions (Coase, 1992). One line of theoretical reasoning against the neutrality of initial allocation originates in the theory of second best: if the trading system is imposed on an economy in which taxes exists, the initial allocation matters for the efficiency of the system (eg Goulder *et al*, 1999). Furthermore, initial allocation matters if regulated firms possess market power (eg Burtraw *et al*, 2001). If we find that the initial allocation matters for reduction behaviour, this would have significant implications for the design of emissions trading schemes, as compensation through initial allocation would no longer be emissions neutral.

Several authors have studied the effect of the EU ETS empirically. A concise overview is given in Anderson and Di Maria (2011). Our contribution is threefold. First, in contrast to other studies using country-specific firm level data (Anger and Oberndorfer, 2008) we cover the entire European Union. Second, we explicitly take into account the structural break between the EU ETS phases. This allows us *inter alia* to study the effect of changing allocation on emissions. Third, previous literature on the effect of initial allocations on reduction behaviour has been either of theoretical nature or based on numerical simulations. With our unique data we are able to estimate the effect of initial allocation empirically. This firm-level data offers several more advantages. It allows us to eliminate the impact of aggregation over firms or installations when performing estimations. Furthermore, it allows exploiting a wide heterogeneity of firms with respect to their host country, turnover, employment, profit margin, sector and initial allocation.

We find that the EU ETS induced emissions reductions in the second phase and that there were substantial differences in abatement behaviour across phases. Moreover, the initial allocation of permits and ex-post verified emissions are correlated. However, according to our findings, the EU ETS at most modestly affected profits, employment, and the added value of regulated firms.

This paper is structured as follows. In the next section we describe and qualitatively analyse the dataset. Sections 4 and 5 describe the methodological procedure and analyse the results of the estimation process. Section 6 concludes the paper.

Table 2: Regional distribution of sample companies and CITL installations

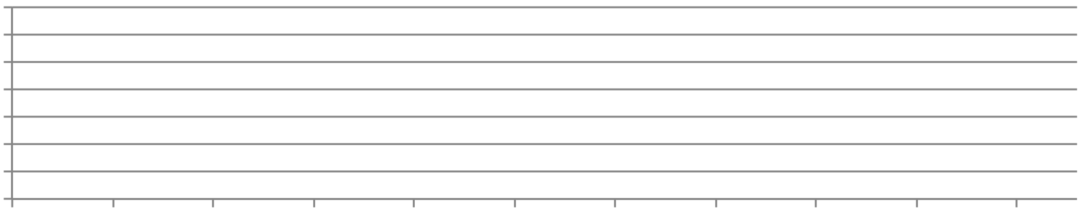
	Total CITL installations	Sample of matched firms		
Countries	# of installations	# of firms	# of installations	Country share in total sample firms (%)
Spain	1106	420	567	19.99
Germany	1971	314	644	14.95
Portugal	277	236	183	11.23
France	1118	199	291	9.47
Czech Rep.	421	120	219	5.71
Poland	930	114	205	5.43
Italy	1124	113	167	5.38
Finland	649	103	412	4.9
UK-Ireland	1247	85	163	4.05
Bulgaria- Romania	399	73	114	3.47
Sweden	798	71	116	3.47
Austria	222	68	118	3.24
Belgium-Lux	372	67	43	3.19
Slovakia	193	62	94	2.95
Netherlands	437	47	92	2.24
Denmark	403	39		

allocation of allowances was done by member states in National Allocation Plans, which had to be approved by the European Commission. There was great variation in the plans of different countries. For example, the basis phases for calculating historic emissions were very different between member states.[7] Most of the emission allowances were allocated for free to installations based on historic emissions (so called, 'grandfathering').

During the first phase of the EU ETS the total emissions of the participating installations grew by about two percent. This was possible due to a generous cap and unexpectedly low abatement cost. In fact, the average annual cap in the first phase of the EU ETS was about three percent higher than the emissions in 2005. Consequently, the total amount of allowances distributed exceeded the verified emissions by 2.3 percent during the first phase. When market actors became aware that more allowances than needed were available, the price for allowances in the first phase crashed to below €1 per EU Allowance Unit of one tonne of CO_2 (EUA – see Figure 1).

In the second phase, the amount of allowances distributed was reduced from 2007 to 2008 by about 11 percent. This was followed by a 2 percent decline in verified emissions. Consequently, in 2008 and 2009 companies were on average short of allowances. The verified emissions exceeded the allocated allowances by 2.9 percent. In 2008, the lack of allowances led to prices of about €20 per EUA. In 2009, due to the crisis-induced demand reduction for allowances, the carbon price fell to about €15.

Figure 1 Daily Closing Price EUA spot



The trends in emissions and free allocation of allowances differ between sectors. The power sector dominates the EU ETS. It is the only sector that used more allowances than it obtained for free, in the first and the second phases. All other sectors were net sellers of allowances. Nevertheless, the power sector showed a below average decrease in emissions in the years 2005 to 2009 (-8.2 percent in the power sector vs. -11 percent in the EU ETS). Interestingly, the sectoral emission reductions for the first and the second phases are strongly negatively correlated. That is, sectors that increased carbon emissions in the good years between 2005 and 2007 reduced emissions between 2008 and 2009. When looking at the crisis year 2009, emission reductions were seen in the following sectors: mineral oil refineries, iron and steel, glass, ceramic products, pulp and paper and the remaining non-classified sectors, while coke ovens, metal ore and cement clinker increased emissions.

[7] For example Germany uses averages of the years 2000-2002 for the first phase while Slovakia uses sector specific basis periods (for steel the average of the years with the most emissions in 1990-2003).

Figure 2ETS emissions by country

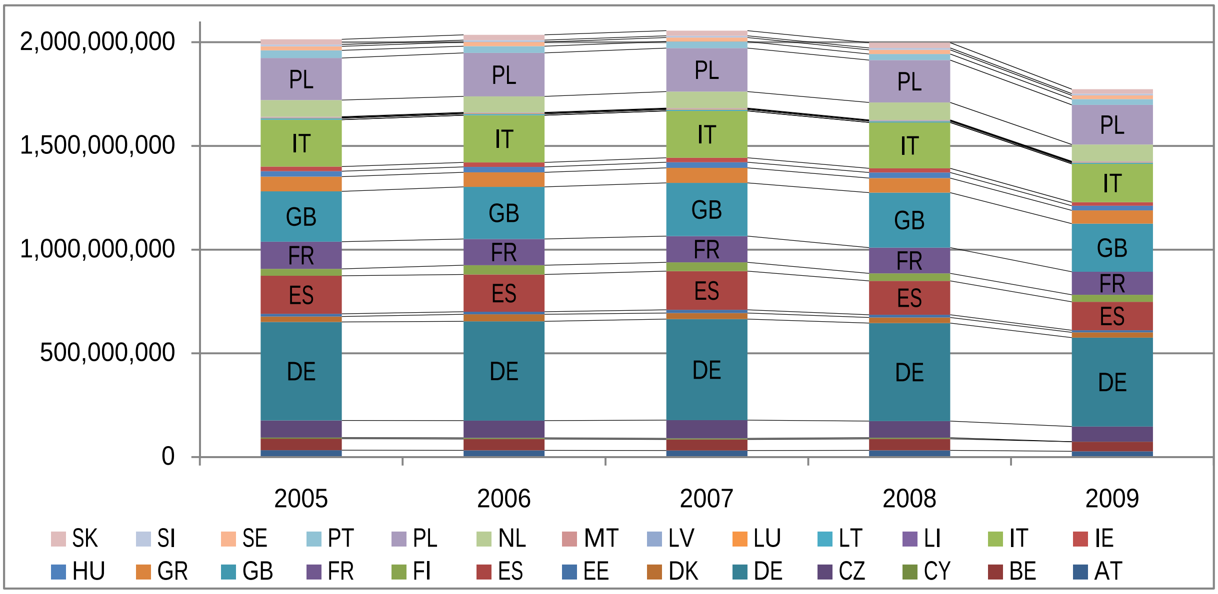


Figure 3: ETS emissions by sector

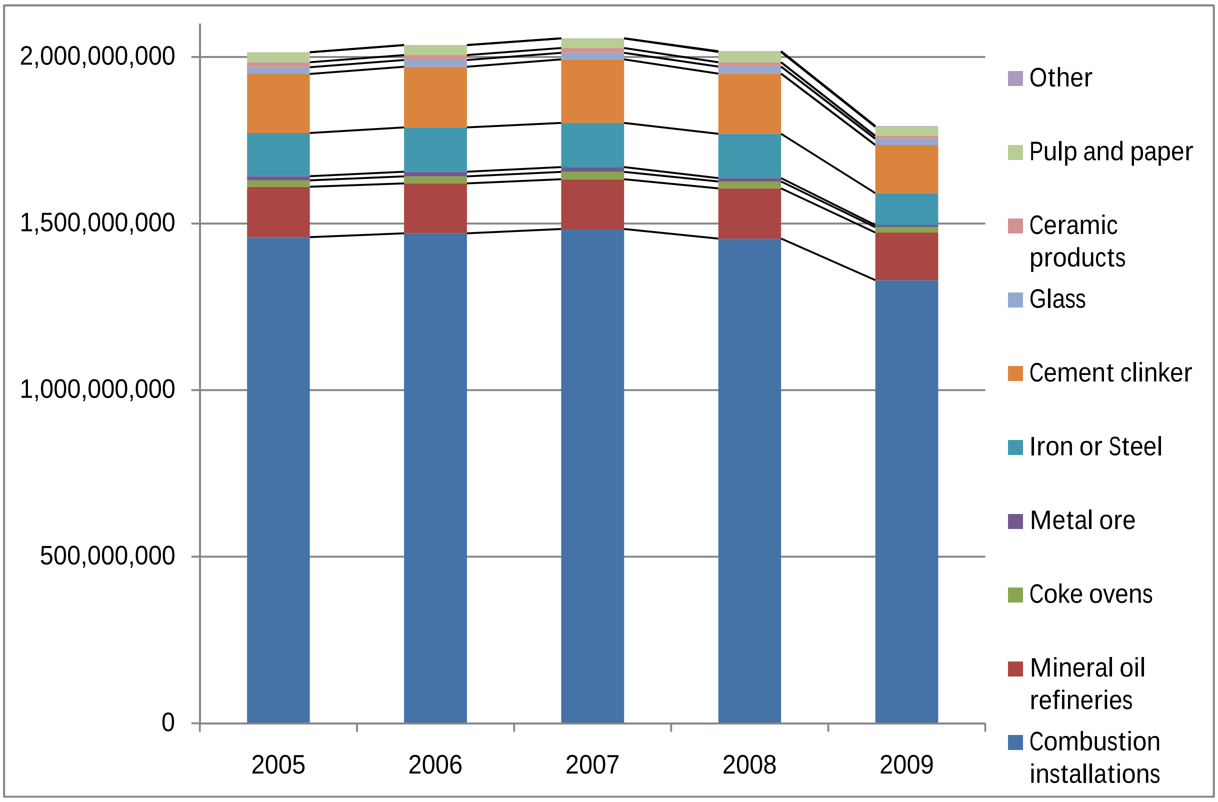


Figure 4: Excess allocation by country

Figure 5Excess allocation by sector

The CITL data suggests that emissions increased during all years of the 1st phase of the EU ETS while they abatement during the first phase, while others inflated their emissions. We contribute to this debate by estimating *ex post* the reduction in CO_2 emissions at firm level. More specifically, we study the behaviour of firms around the point of cross over from the first to the second phase of the ETS. That is, we evaluate the effectiveness of the ETS by comparing the development in the first phase to the shift from the first to the second phase. Our goal is thus to analyse if companies changed their emission reduction strategy from 2005-

4.2. Results

First, we can report a strong positive relationship between changes in turnover and changes in emissions. That is, the emissions of the installations of a company are likely to decrease if its turnover declines. This predictable interaction between the turnover data from AMADEUS and the emission data from CITL indicates that our matching of CITL-installations to AMADEUS companies has been effective. The causality of this interaction can, however, not be addressed by our analysis, i.e. it is unclear to what degree the higher cost of emissions allowances induced reductions in production, and to what degree an exogenous reduction in production led to decreasing emissions.

- Initial allocation is important for mitigation effort

Companies that obtained more allowances relative to their actual emissions show different mitigation behaviour than companies that received relatively less. We classify companies as “initially under-allocated” or “initially over-allocated” based on whether they had a higher individual allocation factor in 2005 than the medium company (1.15). According to column (2) of Table 4 under-allocated companies increased their reduction efforts between the first and the second phases. By contrast, according to column (3) of Table 4, companies that received an above-average initial allocation in the first phase did not increase their reduction effort between the phases. This indicates that firms that were short of allowances in the first phase reduced their emissions most between 2007 and 2008.

Furthermore, firms whose initial allocation was reduced by an above-average amount between 2007 and 2008 (column (4)) significantly reduced their emissions, when controlling for changes in turnover and employment. On the other hand, firms whose allocation decreased less (column (5)) did not increase their reduction effort between the first and second phases. That

Table 5: Differential in emission growth rate 2005/06 vs. 2007/08

	Paper and paper products	Non-metallic minerals	Basic metals	Electricity heat
β_5	-0.029(0.027)	-0.087***(0.025)	-0.095*(0.049)	-0.001(0 .038)
Control variable1: changes in turnover	0.154**(0.077)	0.299***(0.058)	0.089(0.126)	0.136**(0.06)
Control variable2: changes in labor size	-0.062 (0.093)	-0.046(0.044)	0.099(0.208)	0.012(0.042)
Adj R-squared	0.13	0.27	0.71	0.21
Sample	416 firms	806 firms	159 firms	660 firms

Significance: * at 10%, ** at 5 % and *** at 1%.
Standard errors are reported in brackets
Countries dummies are not reported.

5. Did the EU ETS affect company performance?

5.1. Methodology

There are already several studies on the direct impact of the EU ETS on the participating companies. An *ex ante* report by Carbon Trust (2004) listed three determinants of the impact of

ETS on the firms' performance, we measure the difference between the state of the firms after being subject to the ETS and the hypothetical state (ie, the counterfactual) of their performance if they had not been under regulation. The counterfactual is not observable, but can be estimated (eg Heckman *et al*, 1999) by means of comparison to a control group (non-participating firms). Furthermore, to reduce the selection bias created by assigning a non participating firm to each participating firm, we use propensity score matching. This is a common way to 'correct' the estimation of participation effects while controlling for other factors that might have an influence. The basic idea is that this bias is reduced when participating and control subjects are as similar as possible. The matching procedure is explained in the next section.

In order to assess the impact of the ETS across the two phases, we estimate the following equation:

$$y_{it} = \beta_0 + \beta_1 D_{t,it} + \beta_2 D_{P,it} + \beta_3 x_{it} + \beta_4 \gamma Z_t + \varepsilon_{it}, \quad t = 2004, 2005 \text{ or } 2008 \qquad (3)$$

Where:

- y_{it} is the outcome variable in log value which can be added value, profit margin or employment
- $D_{t,it}$ is a dummy variable which equals 1 after the launching of the ETS (2005 or 2008) and 0 otherwise (2004)
- $D_{P,it}$ is a dummy variable which equals 1 if the firm is under EU ETS phase P (2005 or 2008)
- x_{it} is a set of dependent variables for each outcome variable: labour and fixed capital for added value, lagged value of employment value for employment and lagged value of turnover and employment for profit margin
- γZ_t is a set of sectoral and country dummies
- ε_{it} the error term decomposed into a firm specific effect μ_i and a time variant effect u_{it}

By taking the first differences of (3), we have:

$$\Delta y_i = \beta_1 + \beta_2 D_{P,i} + \beta_3 \Delta x_i + \beta_4 \gamma Z_t + \Delta u_i \qquad (4)$$

The relative allocation of emissions may have an impact on the firm's behavior, and results can be different from a sector to another as we have seen in section 4. Therefore we perform additional regressions on subsamples.

compared with the BAU. However, if one applies Kyoto measures, ETS is the most competitive scheme even in sectors which do not take part in emissions trading.

5.3.Results

According to Table 7, being subject to the ETS had no impact on a company's added value, employment and profit margin in 2005 or 2008. This is slightly counterintuitive, as obtaining the right to either use or sell free allowances should increase the degree of freedom of a company's profit maximization strategy and thus potentially increase profits. Furthermore, the pass-through of the opportunity cost of emission allowances should increase the prices of carbon-intensive products. Thus, participating companies could expect higher profits (so-called windfall profits, eg *Sijm et al*, 2006).

We also perform different analyses on the subsamples of under- and over-allocated firms, but there is still overall no significance for the parameter estimating the impact of the ETS (see Appendix 3 for the regressions within sectors which do not lead overall to any significant results). At the 10 percent level, however, some interesting results can be reported. *First*, over-allocated firms obviously benefited from their participation in the ETS by increasing their profit margin in the first and the second phases. *Second*, the profit margins of under-allocated firms decreased between 2004 and 2008. *Third*, certain sectors (eg non-metallic minerals, see Appendix 3) are disproportionately affected. However, the overall conclusion is that participating companies did not experience any significant loss of competitiveness.

Some caveats apply to our results. First of all, the matching procedure should have been done within the sectors of interest for our study. This was not possible because we wanted to avoid including in our control group participating firms that we were not able to identify in the Amadeus data. Consequently, we compare companies from all non-regulated sectors to companies from regulated sectors. Thus, our results might just capture sectoral dynamics. Second, the five-year panel does not allow us to introduce as many control variables as we would have needed, especially for the employment equation. Finally, economic firm data was obtained from Amadeus which is known to have a different way of measuring firm characteristics (employee size, turnover) than national statistics.

Table 7: Effect of the ETS on companies' performance

Dependent variable	Added value		Employment		Profit margin	
Period	(1)= 2004-2005	(2)= 2004-2008	(1)= 2004-2005	(2)= 2004-2008	(1)= 2004-2005	(2)= 2004-2008
$|_6$	-0 .09 (0.08)	-0.11 (0.08)	- 0.002 (0.002)	-0 .009 **(0.004)	-0.53 (0.45)	-0.51 *(0.37)
Changes in fixed capital	0.08***(0.01)	0.06***(0.01)				
Changes in employment	0.11***(0.01)	0.10***(0.02)	0.50***(0.002)	0.52***(0.02)	-0.59*(0.32)	-0.52(0.32)
Changes in turnover			0.04***(0.02)	0.05***(0.02)	3.91***(0.21)	3.67***(0.21)
Adj R-squared	0.78	0.83	0.75	0.73	0.58	0.62
Sample	4202 firms	4202 firms	4202 firms	4202 firms	4202 firms	4202 firms
Underallocated firms (AF<1)						
Dependent variable	Added value		Employment		Profit margin	
	(1)	(2)	(1)	(2)	(1)	(2)
$|_6$	-0.04 (0.04)	-0.05 (0.06)	-0.003(0.003)	-0.013 (0.095)	-0.22 (0.31)	-1.95 *(1.11)
Changes in fixed capital	0.08***(0.01)	0.11***(0.01)				
Changes in employment	0.16***(0.02)	0.17***(0.02)	0.49***(0.002)	0.50***(0.002)	-0.42(0.43)	-0.34(0.43)
Changes in turnover			0.04***0.003)	0.03***(0.003)	2.61***(0.27)	2.54(0.27)
Adj R-squared	0.75	0.77	0.69	0.67	0.51	0.52
Sample	1436 firms	1538 firms	1538firms	1538 firms	1538 firms	1538 firms

6. Conclusion

The purpose of this study was to shed light on the effect of the EU ETS at firm level. We have used a sample of 2101 European firms covered by the ETS

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APPENDIX 1

Table 1: Distribution of emissions and allowances in thousand EUAs: Matched sample and raw CITL data

	Verified emissions 2005 (Sample)	Verified emissions 2005 (CITL)	Allocated Allowances 2005 (Sample)	Allocated Allowances 2005 (CITL)	Verified Emissions 2008 (Sample)	Verified Emissions 2008 (CITL)	Allocated allowances 2008 (Sample)	Allocated allowances 2008 (CITL)
Total								
Mean	336	160	337	166	468	168	407	155
Median	16	10	20	12	20	11	24	14
Max	32000	32000	30800	30800	72800	30900	46900	26900
Q3	84	39	103	48	114	43	120	51
Q1	2	0	4	0	4	1	6	2
Q3-Q1	81	38	99	47	110	42	114	49
Std	1479	881	1421	862	2389	865	1873	718
Germany								
Mean	471	241	484	250	618	240	491	197
Median	22	15	27	19	28	13	31	17
Max	29700	29700	28700	28700	72800	24900	46900	19600
Q3	121	56	164	68	170	55	188	62
Q1	5	5	6	6	5	2	7	3
Q3-Q1	116	51	158	62	165	53	180	59
Std	2227	1359	2220	1353	3460	1311	2283	937
Poland								
Mean	572	218	613	255	716	219	685	216
Median	26	21	32	27	25	19	28	21
Max	32000	32000	30800	30800	30900	30900	26900	26900
Q3	101	50	157	65	110	48	112	57
Q1	12	8	14	11	9	6	11	8
Q3-Q1	89	43	143	54	100	42	101	49
Std	2638	1332	2592	1375	2902	1311	2637	1177
France								
mean	235	117	261	135	342	111	354	116
Median	38	19	55	26	42	16	55	20
Max	11500	11500	12200	12200	15500	15500	15800	15800
Q3	118	51	147	66	141	45	162	52
Q1	14	8	19	12	14	5	16	8
Q3-Q1	104	43	128	54	128	39	146	44
Std	921	547	984	601	1380	513	1386	522

Table 2: Descriptive statistics by sector

Paper	Added value	Employees	Fixed Capital	Profit Margin
Median	9418	208	14958	1.7
Mean	52720	578	105853	1.2
Std	297281	2815 o		y

Table 3: Descriptive statistics by region

Spain	Added value	Employees	Fixed Capital	Profit Margin
Median	3016	45	4582	4.5
Mean	57465	366	132424	4.6
Std	273521	1956	775999	16.4
Bel-Lux				
Median	33747	272	19397	3.6
Mean	222391	982	193984	5.4
Std	747286	2608	665943	13.9
France				
Median	17071	280	14118	3.6
Mean	70777	704	67721	4.0
Std	197116	1410	218339	10.0

Table 5: Allocation factor: Matched CITL-Amadeus sample comp

outlying in the space of explanatory variables) and high Gaussian efficiency. An MM-estimator is expressed in the following way:

$$\hat{\beta}_{M} = \arg\min_{\beta} \sum_{i=1}^{n} \rho\left(\frac{r_i}{\sigma}\right)$$

where $\rho(.)$ is the convex loss function and σ is the measure of dispersion. To implement this estimation, we use an iterative reweighted least-square algorithm with weights $w_i = \rho\left(\frac{r_i}{\sigma}\right) / r_i^2$

(observations with a cook distance larger than one are assigned a weight zero) such that we now have:

$$\hat{\beta}_{M} = \arg\min_{\beta} \sum_{i=1}^{n} w_i r_i^2(\beta)$$

With this weighted least-squares estimator, the weights w_i are unknown because they are a function of β. The starting weights are obtained using the initial estimate $\hat{\beta}$ for β. The loss function $\rho(.)$ is a Tukey biweight function:

$$\rho(u) = \begin{cases} 1 - \left[1 - \left(\frac{u}{k}\right)^2\right]^3 & \text{if } |u| \le k \\ 1 & \text{if } |u| > k \end{cases}$$

where k is commonly set at 1.547 for the starting value of the algorithm and then k is commonly set at 4.685 for the other steps. To increase both the robustness and efficiency of the estimation, it is better to have a measure of dispersion of the residuals that is less sensitive to extreme values than σ. Such a robust dispersion $\hat{\sigma}_S$ is chosen such that:

$$\frac{1}{n} \sum_{i=1}^{n} \rho\left(\frac{r_i}{\hat{\sigma}_S}\right) = b, \text{ where } b = E[\rho(Z)] \text{ and } Z \sim N(0,1), \text{ and}$$

$$\hat{\beta}_S = \arg\min_{\beta} \hat{\sigma}_S(r_1(\beta), \ldots, r_n(\beta))$$

This robust dispersion estimator is then used to obtain the final estimator $\hat{\beta}_{MM}$:

$$\hat{\beta}_{MM} = \arg\min_{\beta} \sum_{i=1}^{n} \rho\left(\frac{r_i(\beta)}{\hat{\sigma}_S}\right)$$

APPENDIX 3: Additional regressions

Table 1: Efficiency of EU ET