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EU ETS CO2 emissions constraints and business performance: a quantile regression approach.

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I. Introduction

The European Union Emission Trading Scheme (EU ETS) is the first and largest international scheme for the trading of greenhouse gas emission allowances, the so-called European Union Allowances (EUA). It was launched in 2005, operates in 31 countries, and covers CO_2 emissions from approximately 11,000 installations.

In order to achieve its target of reducing CO_2 emissions, the price of EUAs must be sufficiently high to provide an incentive for companies to take steps to reduce their emissions, rather than purchasing emissions allowances to release CO_2. Unfortunately, prices during the period 2005-2012 have not been high enough, as has been remarked in studies by Bowen (2011), Dietz and Fankhauser (2009) and Abadie and Chamorro (2008), among others. In spite of this, the European Commission (2012) has stated that the EU ETS will remain in place and is still considered as the cornerstone of the EU in combatting climate change.

Considering that the EU ETS will be in operation for the long term, and that the global economic crisis is hurting corporate profits, an analysis of the implications of this policy for company performance is of significant interest for policymakers and for company management.

The comparison of assigned CO_2 emissions with those actually emitted each year - Surplus of Allowances - is essential to design policies affecting EUA prices. Nevertheless, it is extremely important to evaluate the effects of these climate change policy decisions on company business performance, in order to achieve a balance between environmental and economic goals.

In this paper, we consider this problem by analyzing the relationship between Surplus Allowances (SA) and Business Performance (BP) for a sample of Spanish companies. Spain provides an excellent framework for our research, as it has been particularly affected by the crisis.

Researchers have already studied the impact of company pollutant emissions on Business Performance (Hart and Ahuja, 1996; Clarkson *et al*., 2011; Iwata and Okada, 2011) and concluded that there is a positive impact of a reduction in emissions on business performance.

However, to our knowledge, an analysis of the relationship between business performance and company behaviour towards the CO_2 emission constraint imposed by the EU ETS has not been carried out. We aim to fill this gap.

To achieve our goal, we use quantile regression techniques that, given the non-normality of the SA and BP variables, allow us to study the relationship in depth by analyzing behaviour not only in the centre but in the intermediate and tail areas of the distribution (Koenker and Hallock, 2001). This methodology has proven useful in the context of analyzing policy implications at the firm level, as can be seen in studies by Zhang *et al*. (2009) and Ebersberger and Herstad (2013).

The remainder of this paper is organized as follows. Section 2 describes the data and methodology; section 3 presents our results and, finally, Section 4 concludes.

II. Data and methodology

Variables and data

We select Spanish installations whose emissions were traded in the EU ETS during the period 2005 to 2010 and had an open account in the Spanish national registry - "*Registro Nacional de Derechos de Emisión de Gases de Efecto Invernadero*" (RENADE) - providing a total of 1,131 installations corresponding to 839 companies. Due to data unavailability, this sample was reduced to 745 companies (1,015 installations).

For each company i and each period t, the surplus of allowances (SA) was calculated using the expression:

$$SA_{i,t} = \frac{A_{i,t} - E_{i,t}}{A_{i,t}}; \ i = 1,\ldots, N_t; \ t = 1, \ldots, T$$

where $A_{i,t}$ represents the assigned emissions to company i; $E_{i,t}$ represents the verified emissions of company i in period t, N_t is the number of firms with observed data in period t, and T is the number of periods. SA may have either a positive or negative sign, in such a way that a positive (negative) sign indicates a surplus (deficit) of allowances.

Data related to SA were taken from the Community Independent Transaction Log (CITL).

To measure BP, we select the Assets Turnover Ratio (ATR), which is an activity ratio that measures how efficient the company is in converting its assets into sales, and Return on Assets (ROA), which is a profitability ratio widely used in the literature. The ATR is given by the expressions:

$$ATR_{it} = \frac{\text{Operating revenue}_{i,t}}{\text{Assets}_{i,t}} ; i = 1,\ldots, N_t; t = 1, \ldots, T$$

$$ROA_{it} = \frac{\text{Operating income}_{i,t}}{\text{Assets}_{i,t}} ; i = 1,\ldots, N_t; t = 1, \ldots, T$$

Data related to these ratios were taken from SABI, a database that provides 1,250,000 Spanish and 400,000 Portuguese company reports.

Table 1 shows the results of a descriptive analysis of SA and BP variables. It can be seen that the normality assumption is rejected for all variables and all periods, suggesting that both links (ATR and SA; SA and ROA) would not be suitably captured by the standard lineal regression. For this reason, we use quantile regression techniques, providing a more complete picture of the link between two variables by capturing the influence of the independent variables not only in the central but also in the intermediate and tail areas of the dependent variable distribution (Koenker and Hallock, 2001).

Table 1. Descriptive analysis

	Year	2005	2006	2007	2008	2009	2010
SA	Mean	0.08	0.14	0.12	0.20	0.32	0.33
	Std	0.26	0.31	0.32	0.33	0.36	0.40
	JB	11754*	5925.6*	774.01*	946.05*	309.18*	2207.90*
ATR	Mean	0.94	0.92	0.95	0.93	0.77	0.81
	Std	1.40	0.74	0.67	0.85	0.82	1.05
	JB	6156300*	267300*	8662.1*	104050*	659240*	1589700*

ROA	**Mean**	0.0486	0.0257	0.0404	0.0017	0.0038	0.017
	Std	0.1057	0.1258	0.1447	0.1653	0.1489	0.1196
	JB	2116.8*	739.21*	14969*	18255*	2156.5*	557.46*

* 1% significant

Methodology

Let $\mathbf{X} = (X_1, \ldots, X_k)$ be the independent variables and Y be the dependent variable. Let $\{(\mathbf{x}_{it}, y_{it});\ i=1,\ldots,N_t;\ t=1,\ldots,T\}$ be the data set where y_{it} is the dependent variable, and $\mathbf{x}_{it} = (x_{it,1}, \ldots, x_{it,k})$ is the (kx1) vector of the independent variables. We consider linear quantile regressions models[1] that assume that $\text{Quantile}_\theta(y_{it} \mid \mathbf{x}_{it}) = \mathbf{x}_{it}^{'}\boldsymbol{\beta}_\theta$ where $\text{Quantile}_\theta(y_{it} \mid x_{it})$ denotes the θ $(0<\theta<1)$ quantile of the conditional distribution $y_{it} \mid \mathbf{x}_{it}$ and $\boldsymbol{\beta}_\theta = (\beta_{\theta,j};\ j=1,\ldots,k)$ is the (kx1) vector of parameters that quantifies the impact of the independent variables on the θ–quantile of Y. The value of $\boldsymbol{\beta}_\theta$ is obtained by minimizing

$$min_\beta \ \frac{1}{n}\left\{\sum_{i,t:y_{it} \geq x_{it}'\beta} \theta \left|y_{it} - x_{it}'\beta\right| + \sum_{i,t:y_{it} < x_{it}'\beta} (1-\theta)\left|y_{it} - x_{it}'\beta\right| \right\}$$

where $n = \sum_{t=1}^{T} N_t$ is the total number of observations.

All the results have been obtained using the *quantreg* library of R (Koenker, 2006) that allows us to calculate the point estimations and the standard errors of $\boldsymbol{\beta}_\theta$.

[1] Non-parametric and non-linear regression models described in Koenker (2006) give essentially the same results as those shown here, and are omitted for the sake of brevity.

III. Results

We have analyzed the relationship between SA and BP variables from two viewpoints. First, we have studied the influence of production effectiveness (measured by ATR) on the surplus of CO_2 allowances, given that the production level of a company determines its level of CO_2 emissions. Our analysis is grounded in studies that analyze the drivers of greenhouse gas emissions performance; for example Zhou *et al.* (2010) and Pogutz and Russo (2009) who concluded that emissions are highly dependent on economic performance.

Second, we have studied the impact of surplus allowances on company profitability. As companies in the EU ETS have to buy EUAs in order to achieve their emissions targets, EUAs are considered to be inputs of the production process that impacts a company's cost function and, in turn, its profitability. In this context, some authors, such as Sadorsky (2006) and Henriques and Sadorsky (2010) conclude that controlling the risk of an increase in energy prices is essential, because energy and climate change policies are going to gain in importance in the future. Furthermore, as Peri and Valdi (2011) point out, the EUA futures market has become a financial instrument to support firms' profit-maximizing behaviour.

Influence of ATR on SA

We take Y = SA, k=2 and $\mathbf{X} = (1, \text{ATR})'$ (see Fig. 1) and the results corresponding to $\beta_{\theta,2} = \beta_{\theta,ATR}$ are shown in Table 2. It can be seen that, during the period 2005 to 2007, ATR did not have a significant impact on SA. In contrast, after the onset of the crisis in 2008, its influence was significantly negative, i.e., the more (less) efficiently a company was using its assets, the less (more) surplus of allowances it had. This impact was greater in companies with a medium-high surplus of allowances (quantiles 0.50, 0.75).

Thus, during the period of economic slow-down, the growth (decrease) of the activity effectiveness was linked to a higher (lower) use of allowances, or what is the same, an increase (decrease) in CO_2, which provides indirect evidence that those firms did not increase their investments in low-carbon technologies.

(Insert Fig. 1 about here)

Table 2. Estimations of the $\beta_{\theta,ATR}$ coefficients of the quantile regression of Surplus of Allowances (SA) on the Asset Turnover Ratio (ATR)

θ/Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
0.05	0.0526	-0.1000	0.0121	0.0397	-0.0049	0.0017
0.25	0.0124	-0.0011	0.0112	-0.0270**	-0.1600**	-0.2105**
0.50	-0.0121	-0.0012	0.0016	-0.0596**	-0.2282**	-0.2766**
0.75	-0.0160	-0.0118	-0.0125	-0.0792**	-0.2405**	-0.2988**
0.95	0.0055	-0.1141	-0.0275	-0.0386	-0.1429**	-0.1630*
Linear	-0.0006508	-0.03154	-0.01562	-0.05320**	-0.18006**	-0.21604**

** 1% significant * 5% significant

Influence of SA on ROA

We take Y = ROA, k=2 and **X** = (1,SA)' (see Fig. 2) and the results corresponding to $\beta_{\theta,2} = \beta_{\theta,SA}$ are shown in Table 3. It can be seen that, for the whole period, all the regression coefficients are 5% significantly negative. Thus, the higher (lower) SA, the lower (higher) ROA, i.e., companies that made less (more) use of EUAs, in relative terms, were those with lower (greater) profitability ratios. The impact of SA on ROA was more intense from 2008 onwards and in companies with extreme ROAs (quantiles 0.05 and 0.95).

The companies that made greater (lower) use, in relative terms, of their allowances tended to be more (less) profitable. From these results, it can be deduced that the price of EUA during the period 2005 to 2010 was not sufficiently high to create a cost advantage because a decrease in surplus of allowances (buy more EUAs or sell fewer EUAs) is linked to an increase in ROA.

(Insert Fig. 2 about here)

Table 3. Estimations of the $\beta_{\theta,SA}$ coefficients of the quantile regression of Return on Assets (ROA) on Surplus of Allowances (SA)

θ/Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
0.05	-0.068**	-0.048	-0.107**	-0.106*	-0.143*	-0.12**
0.25	-0.028**	-0.034**	-0.029**	-0.051**	-0.106**	-0.076**
0.50	-0.031*	-0.032**	-0.032**	-0.036**	-0.097**	-0.072**

0.75	-0.057**	-0.049**	-0.055**	-0.058**	-0.134**	-0.11**
0.95	-0.02	-0.018	-0.013	-0.027	-0.248**	-0.197**
Linear	-0.042*	-0.049**	-0.094**	-0.085**	-0.165**	-0.119**

** 1% significant * 5% significant

IV. Conclusions

Our results prove that the price of EUA during the period 2005 to 2010, and especially since the onset of the crisis in 2008, was not sufficiently high to be an incentive for Spanish companies to reduce their level of CO_2 emissions, as it did not create a cost advantage.

Thus, we consider that urgent measures should be taken to increase the prices of EUA. Nevertheless, in an actual crisis scenario, this policy should not be taken alone as it could harm company profitability.

In summary, since we have found that sales effectiveness is not linked to a lower use of EUAs, measures to reverse the situation, such as subsidies to invest in green technology should be taken. In this way, companies could be efficient in serving demand at the same time as being more efficient environmentally. According to our results, companies with intermediate-high surplus should be the priority beneficiaries of these subsidies.

VI. References

Abadie. L.M. and Chamorro. J.M. (2008) European CO_2 prices and carbon capture investments. *Energy Economics*, **30**, 2992-3015.

Bowen. A. (2011) The case for carbon pricing. Available at: http://www2.lse.ac.uk/GranthamInstitute/publications/Policy/docs/PB_case-carbon-pricing_Bowen.pdf. (accessed February 2013).

Clarkson. P., Li. Y., Richardson. G. and Vasvari. F. (2011) Does it Really Pay to be Green? Determinants and Consequences of Proactive Environmental Strategies. *Journal of Accounting and Public Policy*, **30**, 122-144.

Dietz. S. and Fankhauser. S. (2009) Environmental prices, uncertainty and learning. Centre for Climate Change Economics and Policy Working Paper No. 12. Grantham Research Institute on Climate Change and the Environment. Working Paper No. 10.

Ebersberger. B. and Herstad. S. (2013) The relationship between international innovation collaboration, intramural R&D and SMEs' innovation performance: a quantile regression approach. *Applied Economics Letters*, **20**, 626-630.

European Commission. (2012) Report from the Commission to the European Parliament and the Council. The state of the European carbon market in 2012. Available at: http://ec.europa.eu/clima/policies/ets/reform/docs/com_2012_652 (accessed January 2013).

Hart. S. and Ahuja. G. (1996) Does it pay to be green? An empirical examination of the relationship between emission reduction and firm performance. *Business Stratem and the Environment*, **5**, 30-37.

Henriques. I. and Sadorsky. P. (2010) Can environmental sustainability be used to manage energy price risk? *Energy Economics*, **32**, 1131-1138.

Iwata. H. and Okada. K. (2011) How does environmental performance affect financial performance? Evidence from Japanese manufacturing firms. *Ecological Economics*, **70**, 1691-1700.

Koenker. R. and Hallock. K.F. (2001) Quantile Regression. Journal of Economic Perspectives, **15**, 43-156.

Koenker. R. (2006) Quantile Regression in R: A Vignette. Available in pdf at http://cran.r-project.org/web/packages/quantreg/vignettes/rq.pdf

Peri. M. and Baldi. L. (2011) Nonlinear price dynamics between CO_2 futures and Brent. *Applied Economics Letters*, **18**, 1207-1211.

Pogutz. S. and Russo. A. (2009) Eco-Efficiency vs Eco-Effectiveness: Exploring the Link between GHG Emissions and Firm Performance. *Academy of Management Annual Conference Best Paper Proceedings.*

Sadorsky. P. (2006) Modeling and forecasting petroleum futures volatility. *Energy Economics*, **28**, 467-488.

Zhang. L., Liub. H., Huc. E. and Yueb. M. (2008) The relationship between size and growth: the case of Chinese listed companies. *Applied Economics Letters*, **16**, 1849-1853.

Zhou. P., Ang. B.W. and Han. J.Y. (2010) Total factor carbon emission performance: A Malmquist index analysis. *Energy Economics*, **32**, 194-201.

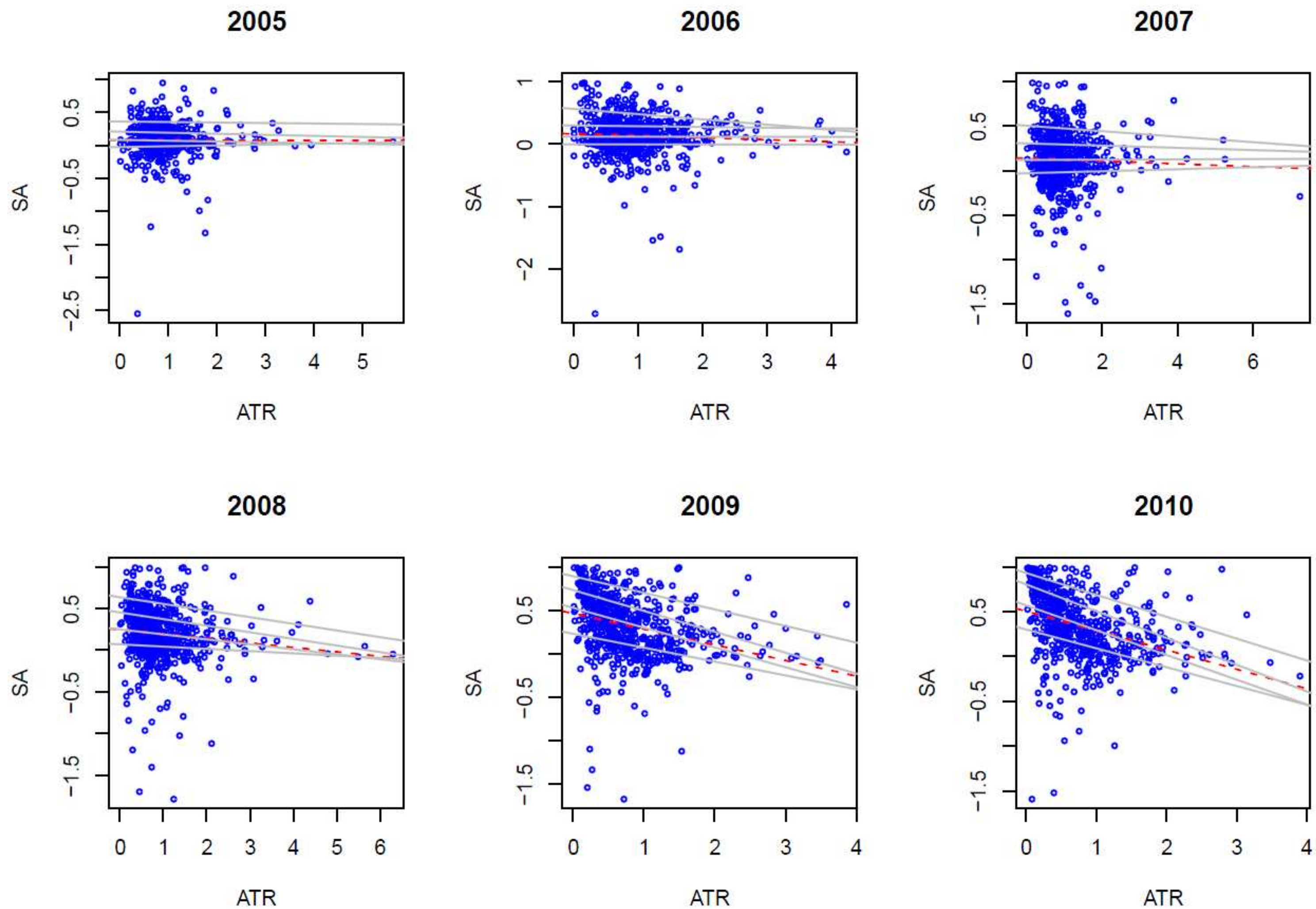

Fig 1. This figure shows the 25th, 50th, 75th and 95th, regressions (solid lines), as well as the mean value estimate from linear regression (dashed line). The 5th regression line is not shown due to lack of significance.

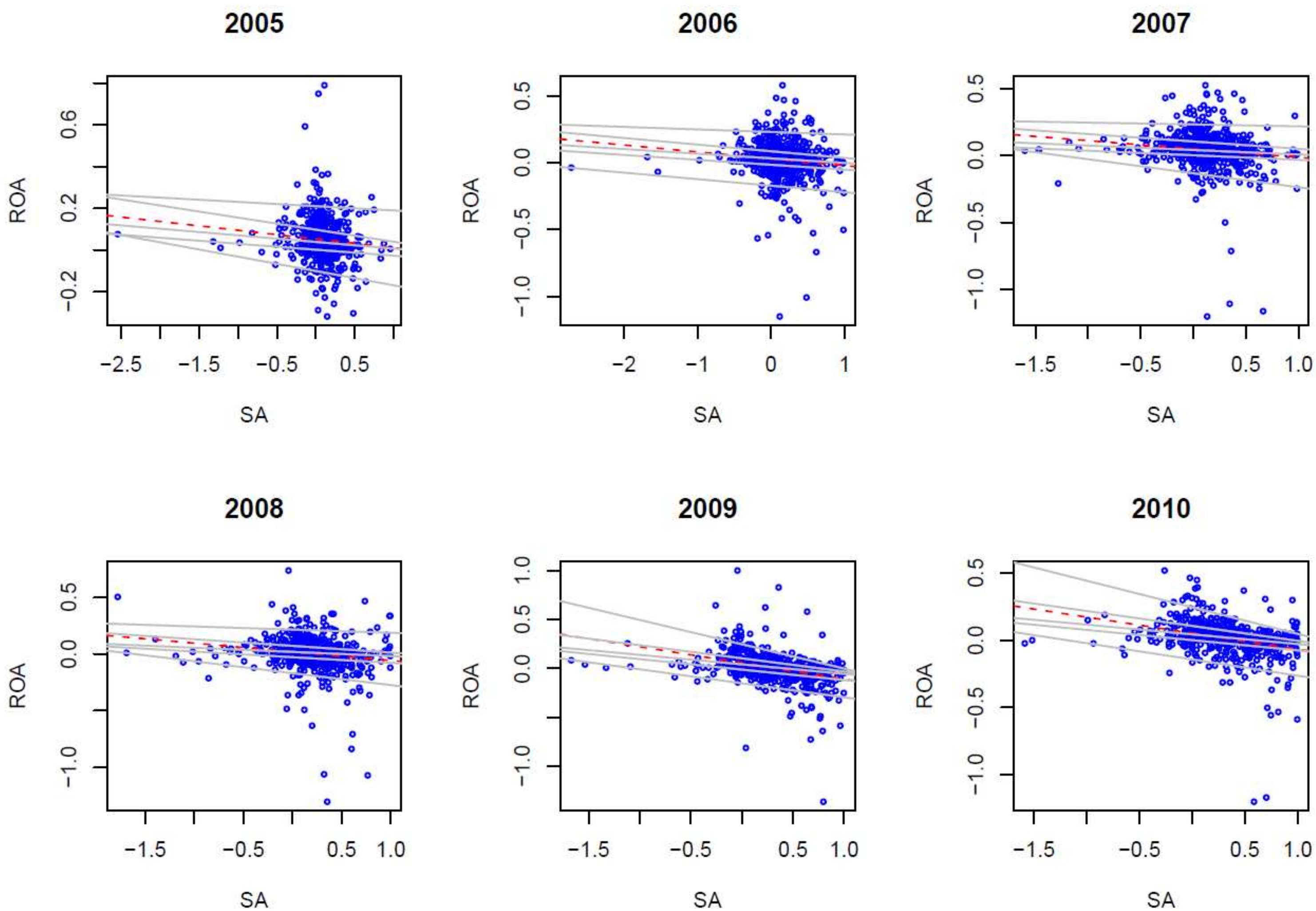

Fig. 2. This figure shows the 5th, 25th, 50th, 75th and 95th, regressions (solid lines), as well as the mean value estimate from linear regression (dashed line).