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Does European primary aluminum sector is exposed to carbon leakage? New insights from rolling analysis

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Abstract

This paper is an original contribution to investigate the risk of carbon leakage from primary aluminum sector under the EU ETS. We attempt to fill the gaps present in previous research through the technique of rolling cointegration that accounts for both structural breaks and time-varying connections. Our findings show that the European primary aluminum sector is affected by a negligible carbon leakage. However, results indicate that this carbon leakage is relatively more intense in the final period of the analysis.

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1. Introduction

There have been a growing ex ante studies that explicitly attempt to assess the carbon leakage effect on the aluminum industry under the European Emissions Trading Scheme (EU ETS) (see, for example, Reinaud, 2004, McKinsey & Company and Ecofys, 2006, Smale et al., 2006, Hourcade et al., 2007, De Bruyn et al., 2008, Graichen et al., 2008). Most of these studies have focused on analyzing the impact on production costs and their results show that significant cost increases could be observed, with carbon leakage rates diverging. However, the literature offering ex post estimates of the carbon leakage remains very scarce. To the best of our knowledge, only two studies to date investigated the carbon leakage effect on aluminum sector. In the first study, Reinaud (2008) examines the impact of the EU ETS on the primary aluminum sector's trade flows and profit margins. Using quarterly data for the period 1999-2007, she found no evidence to support a significant effect of the EU ETS on EU' trade in aluminum. In the second study, Sartor (2012) similarly analyzes the impact of the EU ETS on primary aluminum smelters using a multiple linear regression model. He found no trade effect during the first six and a half years since the start of the EU ETS.

The aim of this paper is to extend the existing empirical literature along three dimensions. First, we extend the period of analysis through 2015. Our analysis therefore incorporates the third phase of EU ETS in which aluminum sector is included. Second, we take into account the role of energy prices in order to reduce the omitted variable bias in our model. Third, and probably most significantly, we assume that the use of the full sample periods without taking into account structural break will not provide useful information about the effective exposition to the risk of carbon leakage. For this purpose, we use the rolling cointegration which allows for the emergence of a clearer picture of the possible carbon leakage in the EU ETS since time-varying connections are taken into account.

The paper is organized as follows : Section 2 describes the methodology and the data. Then, in Section 3 we present and discuss the empirical results. Section 4 concludes the paper.

2. Methodology and Data

Following Reinaud (2008) and Sartor (2012), we use the change in international trade flows of carbon constrained products as an indicator of carbon leakage. We consider a multivariate model of the form :

$$NI_t = \delta_0 + \delta_1 CO_{2t} + \delta_2 IP_t + \delta_3 COAL_t + \delta_4 ELEC_t + \delta_5 GAS_t + \delta_6 OIL_t$$
$$+ \delta_7 EXCHANGE_t + \varepsilon_t$$

Where the subscript t refers to time and ε to error.

The variable *NI* captures net imports and it is obtained as the difference between EU imports and exports for the primary aluminum sector. This variable is measured in million ton per month and is extracted from Eurostat's COMEXT database.

CO_2 is the closing price on EU allowance futures contracts (one year ahead) denominated in euro and is sourced from the Institute of Climate economics.

IP refers to the indicator of demand for primary aluminum which proxied by the index of manufacture of fabricated metal products, except machinery and equipment. This variable is taken from Eurostat's database.

COAL, *ELEC*, *GAS* and *OIL* respectively denote the prices of coal, electricity, natural gas and oil. The coal price is the monthly average spot price of Rotterdam coal and is obtained from the IMF world commodities database. The gas price is the natural gas spot price at the National Balancing Point, the oil price is the Crude Oil-Brent Dated FOB and the electricity price is the German electricity spot price. These three variables are sourced from the Institute of Climate Economics.

EXCHANGE is the average effective exchange rate of the Euro Area vis-a-vis a group of 40 trading partners. This variable is extracted from the ECB's Statistical Data Warehouse.

Carbon, coal and electricity prices are converted into USD using the monthly EUR/USD exchange rate (source : European Central Bank) as aluminum is priced internationally in USD.

The study uses monthly data spanning from June 2005 to July 2015 for estimation.

3. Empirical results

As a first step of our empirical analysis, we check whether the variables in our dataset are stationary. To this end, we first conducted two conventional unit root tests: ADF-GLS test of Elliott et al. (1996), which applies the well-known ADF test after a GLS correction to demean, and the KPSS test of Kwiatkowski et al. (1992). However, these tests do not take into consideration structural breaks in the series. To capture a possible structural break during the sample periods, the Zivot and Andrews (1992) test is used, which treats the presence of a structural break in the series under investigation endogenously. Table 1 and 2 report the results of these tests and indicate that the unit root null hypothesis cannot be rejected for all variables suggesting that variables are non-stationary in levels and stationary in first differences.

Table 1. Conventional unit root tests

Variable	ADF-GLS		KPSS	
	Level	First Difference	Level	First Difference
	Test statistic	Test statistic	Test statistic	Test statistic
CO_2	-2.51	-7.67***	0.27**	0.05
COAL	-2.34	-7.49***	0.18**	0.02
OIL	-2.14	-6.49***	0.21**	0.05
GAS	-2.53	-8.89***	0.19**	0.04
ELEC	-4.28	-8.62***	0.18**	0.02
IP	-2.16	-4.5***	0.22**	0.10
EXCHANGE	-2.30	-8.84***	0.27**	0.04

Note: ADF-GLS critical values are taken from MacKinnon (1991). KPSS critical values are sourced from Kwiatkowski et al. (1992). ADF-GLS null hypothesis is unit root; while, in KPSS null is stationarity.
*** 1% significance level.
** 5% significance level.

Table 2. Zivot–Andrews unit root test

Variable	t-statistic	Period
NI	-3.65	2010:02

Note: NI is estimated from a break in intercept and trend model. Critical values are those reported in Zivot and Andrews (1992).

The second step in our analysis is to test whether the variables are cointegrated using rolling cointegration approach. This approach is suitable in accounting for multiple structural changes and ensures that the effects of regime shifts are isolated and restricted to the event period, rather than being allowed to cloud the overall picture. Hence, this approach may assess the possible gradual carbon leakage over time. To assess the impact of carbon price, industrial output, energy prices and exchange rate on net imports, cointegration is estimated by the fully modified OLS (FMOLS) method in the rolling windows. Each time the size of the rolling windows is set at 3 months. Such number of observations is enough for cointegration test to ensure adequate statistical properties and for variables to return to the long-term equilibrium. Fig. 1 presents the time series of t students values for the coefficients of the estimated model. The horizontal axis indicates the final point of subperiods. The first value represents the value of the t student for the subperiod from June, 2005 to May, 2009. The last one represents the value of the t students for the corresponding variable estimated for the subperiod from September, 2011 to July, 2015. Fig. 2 depicts the t-student for the error correction term for all rolling windows. Several conclusions can be drawn from these two figures. Firstly, the null hypothesis of no cointegration is strongly rejected, as for all sub-periods the error correction term is negative and the Student's t-statistics is above 2.58. The estimated coefficient on the error correction term is -0.89 on average.

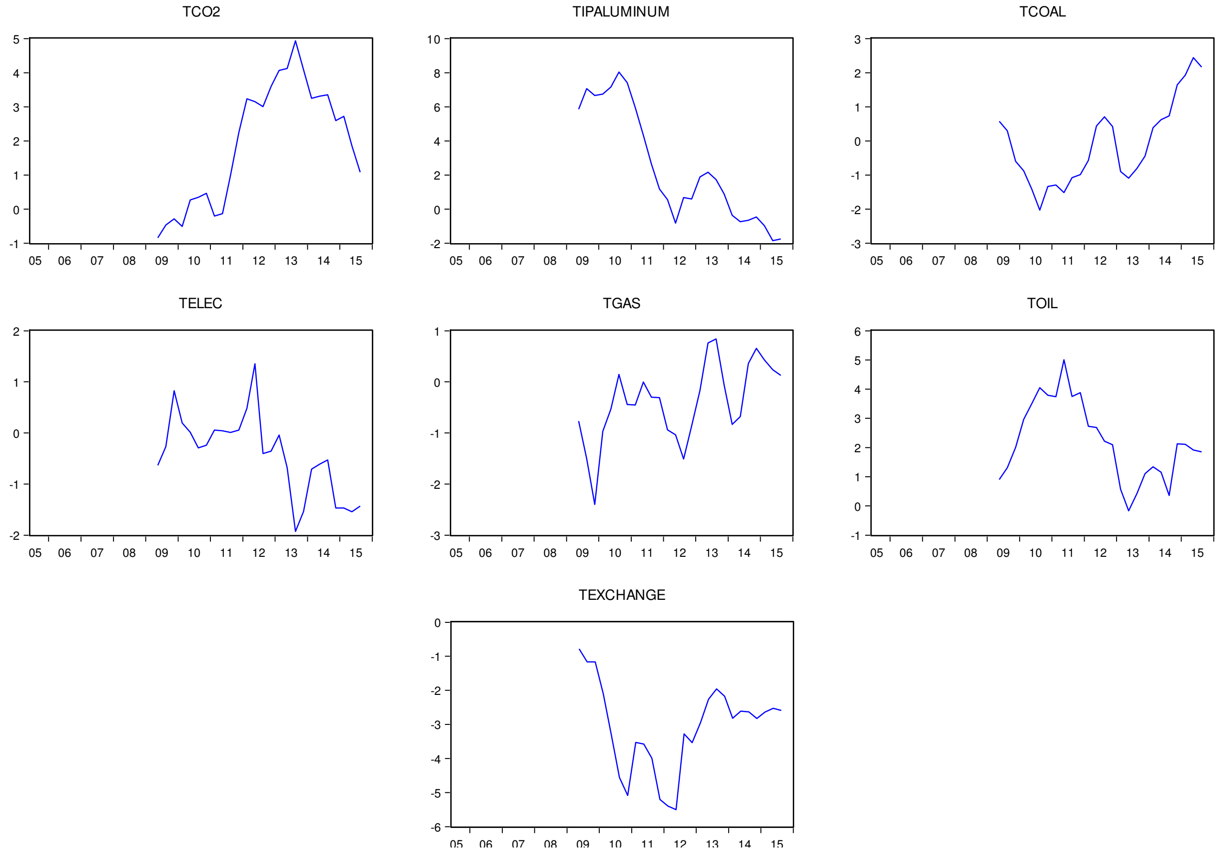

Fig 1. Rolling student tests of the coefficients for window of 3 monthly observations. The horizontal axis indicates the final point of subperiods. The vertical axis shows t-statistics values for the coefficients of the estimated model. Absolute values of t-statistics greater than 2.58, 1.96 and 1.64 indicate significance at 1%, 5% and 10% level, respectively.

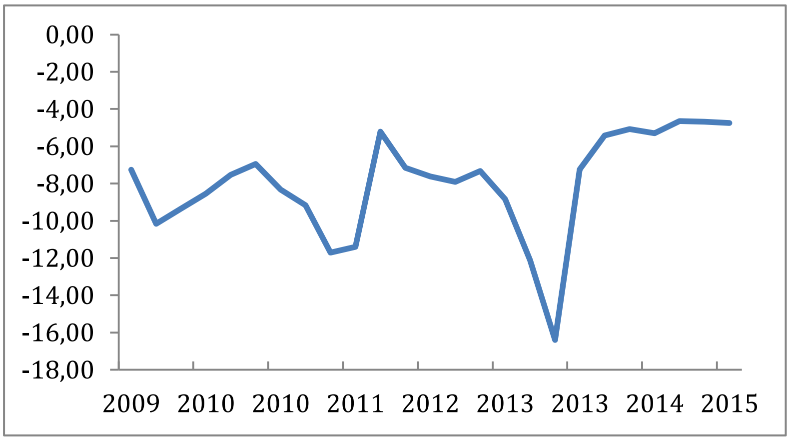

Fig 2. Rolling estimates of the student tests of the error correction term for window of 3 monthly observations. The horizontal axis indicates the final point of subperiods. The vertical axis shows t-statistics values for the error correction term. Absolute values of t-statistics greater than 2.58 indicate significance at 1% level.

Secondly, the rolling cointegration analysis reveals that the estimated coefficient of CO_2 was not the same over the full sample period. For most subperiods beginning between December, 2007 (that is, the subperiod from December, 2007 till November, 2011) and June, 2011 (that is, the subperiod from June, 2011 till May, 2015), the estimated coefficient of CO_2 is positive and statistically significant. However, this coefficient is statistically insignificant at the starting of the sample between June, 2005 (that is, the subperiod from June, 2005 till May, 2009) and September, 2007 (that is, the subperiod from September, 2007 till August, 2011). Thirdly, an increase of 10 USD in carbon price would induce an increase of about 0.1 million ton of net imports on average, suggesting that the primary aluminum sector is subject to a negligible carbon leakage for subperiods beginning between December, 2007 and June, 2011. This finding is different from Reinaud (2008) and Sartor (2012), whose studies do not reveal any impact of the CO_2 price on net imports of primary aluminum. Fourthly, the results obtained indicate that carbon leakage is relatively more intense in the final period of the analysis[1]. This result may be explained by the fact that aluminum sector was covered in the third phase of the scheme beginning in 2013. Fifthly, the estimated coefficient of the exchange rate is positive and statistically significant between Mars, 2006 (that is, the subperiod from Mars, 2006 till February, 2010) and September, 2011 (that is, the subperiod from September, 2011 till July, 2015). Indeed, a lower Euro stimulates exports and makes imports more expensive. Conversely, a higher Euro hampers exports and makes imports cheaper. Finally, the significance of the estimated coefficients of the indicator of demand for primary aluminum, coal and oil vary over time ; however, the estimated coefficient of gas and electricity are statistically insignificant for most subperiods.

[1] The rolling estimates of the coefficients of the independent variables are available upon request.

4. Conclusion

In this study, we examine the effect of the EU ETS on trade flows for primary aluminum sector using rolling cointegration. In contrast to previous work, we find that the impact of carbon price on nets imports is positive and statistically significant over several periods; however, the intensity of this impact is negligible. These findings provide useful insight to policy-makers and industry on the actual incidence of carbon leakage, but also on policies to limit negative impacts, as well as processes to improve the understanding and the functioning of the EU ETS.

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