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CO_2 emission intensity and exporting: Evidence from firm-level data

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ABSTRACT

This paper analyses whether exporting firms are less CO_2 emission-intensive than non-exporting competitors. It exploits a novel and unique dataset for Germany, a major exporting country. Due to the direct link between CO_2 emissions and fuels consumed, we argue that it is necessary to employ a production function framework to consistently analyse CO_2 emission intensity. We show that such an approach solves the issue of omitted variable bias that standard regressions approaches on CO_2 emission intensity of firms are exposed to. Furthermore, it enables us to apply latest econometric techniques from the productivity literature to resolve the endogeneity problem of unobserved productivity and to include a measure of export activity into the estimation. Our findings suggest a positive relation between export intensity and CO_2 productivity—the inverse of emission intensity. This exporter's environmental premium holds for most of the German manufacturing industries at the two-digit level.

1. Introduction

Climate change is not only a global problem, it is a challenge that must be understood within the context of a globalizing world with increasing amounts of goods being traded. For multiple reasons international trade may affect carbon dioxide (CO_2) emissions. One reason is a trade-induced change in the average emission intensity (cf. Grossman and Krueger, 1993; Copeland and Taylor, 1994; 2004). Empirical evidence at the sector-level suggests that trade leads to a reduction in the average emission intensity—hence, an environmentally beneficial partial effect (Antweiler et al., 2001).[1] This finding is commonly explained by a trade-induced increase in income that strengthens the demand for a healthier environment and,

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[1] The overall impact of trade on the environment is estimated to be beneficial for local pollutants (cf. Antweiler et al., 2001; Frankel and Rose, 2005). For CO_2 emissions (Cole and Elliott, 2003) find that trade openness leads to an increase in emissions despite a reduced average emission intensity. This result is partly confirmed by Managi et al. (2009) for OECD countries. These papers abstract from firm differences and the unbalanced impact of trade on them. See McAusland (2010) and Copeland (2011) for comprehensive surveys.

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therefore, the claim for tougher environmental regulation by the citizens. Recent findings reject this view (cf. Cherniwchan, 2017; Barrows and Ollivier, 2016), hinting at firm-level explanations that drive sector-level changes in emission intensity.[2]

Hence, it is crucial to understand differences across firms. In this paper, we test whether exporters are less CO_2 emission-intensive than non-exporters, thereby contributing to the literature in various ways: first, we exploit the particularity of CO_2 as being directly linked to the usage of fossil fuels as no end-of-pipe filter technology exists. While this link is previously used for the calculation of CO_2 emissions (cf. Jaraitė and Di Maria, 2016; Forslid et al., 2015; Petrick and Wagner, 2014), we are the first to also take into account its important implications on the methodology applied. It allows the incorporation of CO_2 emissions directly into the production function, similar to other input factors.[3] Doing so, we are able to directly estimate CO_2 productivity—the inverse of CO_2 emission intensity—within a production function framework. Second, we show that such an integrated approach solves the potential omitted variable bias that previous regression approaches are exposed to. Third, and implied by our first two contributions, we deviate from previous studies by applying methods and ideas from the productivity literature to this new research field. More specifically, we are the first to structurally estimate CO_2 productivity along the lines of Ackerberg et al. (2015). In the spirit of Aw et al. (2011), De Loecker (2007, 2011, 2013), De Loecker and Warzynski (2012), and Van Biesebroeck (2005), we thereby include a measure of export activity directly in the estimation. Fourth, and finally, we tackle this research question using novel and unique firm-level data for the manufacturing sector in Germany, a major exporting country. To this end, we construct a panel dataset covering the years 2003 to 2011 that contains detailed information on CO_2 emissions as well as a multitude of other firm characteristics.

Our main results show that exporting firms in Germany have a significantly higher CO_2 productivity than non-exporting competitors—an exporter's environmental premium. More specifically, we find that, on average across all industries, an increase in export intensity by one percentage point leads to improved CO_2 productivity by 0.22%. Our results are robust to the use of a simple export dummy and to different production technologies. In addition, the finding of an exporter's environmental premium holds for the vast majority of the two-digit manufacturing sectors. These results support the idea that firm-level differences may explain trade-induced changes in emission intensities at the sector-level as indicated above.

The remainder of this paper is organized as follows. Section 2 discusses the related literature on the difference between exporters and non-exporters in environmental and non-environmental characteristics. Section 3 takes a closer look at the particularity of CO_2 emissions that frames our empirical strategy as explained in Section 4. Section 5 introduces our dataset, while we present our empirical findings, provide robustness checks, and make some final remarks in Section 6. Section 7 concludes.

2. Related literature and derivation of hypothesis

There is a large and growing empirical literature on the difference between exporters and non-exporters benefiting from an unprecedented availability of firm-level data.[4] Initiated by the seminal paper of Bernard and Jensen (1995), it is by now well-established in the literature that exporters share distinct characteristics: They are found to be larger, more capital- and skill-intensive, and to pay higher wages than non-exporting firms. In particular, the literature provides overwhelming evidence that exporters are significantly more productive.[5]

More recently, the literature has turned to the question of whether exporting firms perform better environmentally than their non-exporting competitors. Holladay (2010) is the first study to analyse this research question with respect to toxic releases.[6] Controlling for industry and output, the study finds that exporters emit significantly fewer toxic chemicals—based on a composite of 500 different substances—both in terms of quantity and hazardousness: an exporter's environmental premium. Similarly, Cui et al. (2016) and Cui and Qian (2017) investigate US plant-level emission intensities of the toxic releases of SO_2, CO, O_3, and particulate matter. While using the same data, empirical strategies differ. Relying on an OLS regression controlling for industry, time trends, and productivity, Cui et al. (2016) find evidence for an exporter's environmental premium for all four analyzed pollutants with lower emissions per value of sales. In contrast, there is mixed evidence across industries in Cui and Qian (2017) that uses a matching approach to compare exporting and non-exporting firms.

Batrakova and Davies (2012), Roy and Yasar (2015) and Girma and Hanley (2015) investigate the difference between exporters and non-exporting firms relying on proxies for environmental performance, like fuel purchases or responses to a

[2] This micro perspective is in line with the trade literature highlighting the importance of trade-induced changes at the firm-level that drive empirical observations at the sector-level (Melitz and Trefler, 2012). For instance, firms are differently affected by trade liberalization: low-productive firms exit the market (Trefler, 2004), while high-productive firms gain market shares (Pavcnik, 2002). Accordingly, Kreickemeier and Richter (2014) argue that the trade-induced reduction in sector-level emission intensities potentially originates from the reallocation of factor inputs to the most productive—and least emissions-intensive—firms.

[3] Relatedly, specifications of the *RICE model (Regional Integrated Model of Climate and the Economy)*, an *integrated assessment model* to analyze the interactions between climate change and economic activity based on seminal work by Nordhaus (1992, 1993), include 'carbon energy' as input into the production process (cf. Nordhaus, 2010).

[4] This literature also inspired theoretical modeling efforts in international trade leading to the workhorse model with heterogeneous firm by Melitz (2003).

[5] See Greenaway and Kneller (2007) and Bernard et al. (2012) for detailed discussions on firm differences as well as Bernard and Wagner (1997) and Wagner (2007b) for evidence on Germany. Moreover, regarding the existence of a exporter's wage premium, we refer to Egger et al. (2013) and Schank et al. (2007, 2010).

[6] See Holladay (2016) for an updated version.