Carbon Pricing and Regional Innovation:
An EU-ETS Assessment at the NUTS-2 Level

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Carbon pricing instruments (CPIs) are widely recognized as one of the most effective economic tools for reducing greenhouse gas emissions, and the scientific literature provides unambiguous evidence of their positive environmental outcomes. However, a thoroughgoing evaluation of carbon pricing's accomplishments needs to take into account its capacity of spurring an equal and fair shift toward a low-carbon economy, in line with the global claim for a "just transition". Specifically, the economic and social impacts are still being debated. From an economic point of view, a carbon tax could be expected to increase production costs, resulting, at least in the short-term, in lower output and welfare. In this context, in these last decades a whole field of research has begun to investigate the relationship between carbon pricing and inequalities. In particular, the major issue is the vastly acknowledged regressivity of carbon taxes, and their consequential unequal impacts on households and higher burden on the poorer. The inquiry is related to the driving channels and factors that enable this kind of uneven effects - income distribution, consumption baskets, carbon intensities of goods and services, budget shares of carbon-intensive goods, assets ownership - and, more recently on the effectiveness of revenues-recycling schemes to counteract the regressivity of carbon taxes

In any case, the literature on inequality and the distributional impacts of carbon pricing has focused on vertical disparity, among different income groups. However, it is likely that carbon pricing also produces horizontal inequality, within homogeneous groups, according to a wide range of factors, such as consumption and investment behavior, political power relationships, political preferences. This fact could potentially shift the focus of academic research on carbon pricing, reducing the absolute centrality of households as the only unit of analysis, toward an increased consideration of different actors and factors involved. In particular, some researchers have pointed out that the effects of carbon pricing can be heterogeneous among countries and within a country, due to urban/rural composition, availability of energy resources, or consumption patterns associated with different geographic areas or climatic conditions. However, the distributional effects of carbon pricing have been studied mainly at the country level or within a specific region, but very few have been assessed from a multi-regional perspective; moreover, territorial differences have not been addressed in the literature. This also relates to a common critique directed at existing analyses of the green transition, which is the lack of a context which may lead to the erroneous conclusion that sustainability can take place anywhere through similar processes. Relatedly, there have been growing calls to adopt a spatial analytical lens to the study of the low-carbon transition, considered as a place-based process, in which contextual factors have the capacity to shape how transitions unfold in various territories.

This study aims to elucidate whether CPIs contribute to deepening regional disparities or, conversely, foster territorial development and cohesion. In particular, it investigates the impacts of the EU Emissions Trading System (EU-ETS) at the NUTS2 level. Thus, it will be possible to understand the role of carbon pricing in reinforcing, or, viceversa, in alleviating, with-in countries asymmetries.

The analysis draws primarily on data extrapolated from the European Transaction Log (now Union Registry), the administrative backend of the EU-ETS, Orbis IP and on Eurostat data. A "regional carbon burden" variable has been constructed by aggregating micro-level compliance data from all emitting installations across the EU at the regional level, subsequently weighted by the annual EU-

ETS price. This approach yields a regionalized carbon price series that reflects geographic variability, and that corresponds to the regional monetary outflow attached to highly-emitting production. The aim of the study is to evaluate the impacts of the EU-ETS, represented by the carbon burden variables, on regional development, through the quantile regression's model, typically used to estimate the conditional quantiles of a response variable, here related to regional development, based on our predictor variable. In particular, the study focuses on green innovation, here identified as a factor of territorial well-being, and proxied by a set of indicators related, for example, to the regional patent, employment in technology and knowledge-intensive sectors. The motivation behind this choice is twofold. On one side, according to the environmental economic related literature, and in line with the Porter hypothesis, a key motivation behind carbon pricing is to create an incentive for directed technical change, ultimately to spur (green) innovation, thus improving productivity and employment. The European Commission itself recognized that part of the vision for the EU ETS is to promote investment in clean, low-carbon technologies, crucial to sustain emission reductions without permanently lowering output. Moreover, the development of decarbonization technologies in high-emission sectors has the potential to reduce the regional imbalance caused by the regressivity of carbon pricing, given that advances in decarbonization technologies are spread across regions and sectors, theoretically allowing all territories to benefit.

On the other hand, literature on territorial development points out innovation as a significant factor capable of boosting processes of regional convergence, and enhancing a sustained economic growth in the long-run. The goal is ultimately to capture an aspect of the multifaceted concept of "territorial capital," which arguably offers a more nuanced representation of regional prosperity than traditional GDP measures.

Positioned at the confluence of environmental economics, political economy, and regional science, the study adopts a multidisciplinary perspective that extends beyond a narrow growth-oriented framework, and integrates, therefore, a multidisciplinary approach to the subject, with the ultimate goal of providing a comprehensive and wide-ranging knowledge. It represents an endeavour to integrate various branches of research, given that both sustainability's analysis, both regional science need to move beyond a narrow perspective, in order to enhance the understanding of climate policies and their role in sustainable development. The findings are expected to yield important policy implications, particularly in relation to the potential of CPIs to underpin a just and sustainable low-carbon transition, as advocated by contemporary policy debates.

Keywords:

Carbon pricing; EU Emissions Trading System; Regional disparities; Innovation; Just

transition

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