Green inventors

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Research proposal

1 Background and Research Question

Climate change is the most pressing issue of this century. Tackling climate change requires rapid innovation, leading to the widespread adoption of green technologies in the global economy. A growing literature has assessed theoretically (e.g. Bovenberg and Smulders 1995; Goulder and Schneider 1999; Peretto 2009; Acemoglu et al. 2012) and empirically (e.g. Newell et al. 1999; Popp 2002; Aghion et al. 2016; Calel and Dechezleprêtre 2016; Calel 2020; aus dem Moore et al. 2025) the extent of directed technical change, i.e. how climate policy can spur innovation in green technologies, thus also reducing such policy's cost (Porter and van der Linde 1995; see Ambec et al. 2013 for a review). Little is known, however, about how such directed technical change occurs in practice, in particular concerning one of its main ingredients, inventors. Hence, the goal of this project is to contribute to the abovementioned strands of literature on directed technical change and to a growing body of work on employment transitions related to environmental policy (e.g. Walker 2013; Curtis 2018; Vona et al. 2018; Marin and Vona 2019), yet unconcerned with inventors. In particular, we aim to examine how inclusion in the European Union Emissions Trading System (EU ETS) may lead covered firms to attract inventors who either had themselves previously engaged in green innovation or had been at firms that were. Our research question is as follows: do firms under the EU ETS are more likely to hire experienced green inventors as well as former employees of green innovating firms, compared with counterfactual firms?

With our study, we also aim to contribute to another strand of literature, focused precisely on innovators, but absent climate policy or directed technical change at large (e.g. Almeida and Kogut 1999; Jaffe et al. 2000; Kerr and Lincoln 2010; Akcigit et al. 2017; Zacchia 2020; Bahar et al. 2024). We also contribute to a stream of work examining the economics of the EU ETS (e.g. Hintermann 2010; Fabra and Reguant 2014; Martin et al. 2014; Fageda and Teixidó 2022; Colmer et al. 2025), the European Union's flagship

climate policy instrument covering more than 40% of its CO_2 emissions, as well as a related literature on emissions trading systems at large (e.g. Stavins 1998; Fowlie 2010; Fowlie et al. 2012; Hernandez-Cortes and Meng 2023).

We plan to tackle this research question as follows. First, by following experienced green (gray) inventors, i.e. inventors whose name appears on at least one green (gray) technology. To distinguish between green and gray technologies, we rely on the Cooperative Patent Classification (CPC) and the International Patent Classification (IPC) systems. A patent family is classified as green (gray) if it contains at least one code corresponding to green (gray) technologies. For green technologies, we adopt the definition of Haščič and Migotto (2015), while for gray technologies, we follow the classification proposed by Dechezleprêtre et al. (2017). Generally speaking, a green technology aims at offering a clear alternative to a carbon-intensive (brown) technology, or at making an existing green technology more efficient. A gray technology aims at making a carbon-intensive (brown) technology more efficient and thus relatively less carbon intensive.

Second, we plan to address our research questions by following former employees of firms with experience in green (gray) innovations, i.e. firms to which at least one green (gray) patent is associated.

For either type of employee, we are interested in determining if inclusion in the EU ETS makes covered firms more likely to seek such talent, i.e. workers with prior direct or indirect exposure to green (and gray) innovation. If companies under the EU ETS aim to progress technologically, they may do so by recruiting from pioneering companies in green(er) technologies – we just do not know and this paper aims to fill the gap. Section 2 describes exactly how, presenting the paper's methodology.

2 Methodology

As previously described, we are interested in following the career trajectories of green inventors as well as former employees of green firms. More specifically, we are interested in determining to what extent such workers may be more likely to be hired by a firm once

it is subject to a carbon market, which implies a positive carbon price and, accordingly, an incentive to decarbonize.

To identify green inventors, we plan to adopt a two-step approach. First, we look for inventors associated with green patents, using the EPO Worldwide Patent Statistical Database (PATSTAT). Standard disambiguation techniques, as described for instance in Li et al. (2014), are applied. We also zoom in on the French economy, which has often been used as a laboratory given the available data, and reconstruct individual inventor trajectories using a dataset from the Déclaration Annuelle de Données Sociales (DADS), following the methodology developed by Babet et al. (2023). Data from DADS allow us also to validate the exercise based on PATSTAT data, as we would be able to observe inventors at different firms regardless of whether they patent at each of them.

Second, we classify as green inventors those who, at any point in their career trajectory, have been affiliated with at least one green firm. We proceed analogously for gray inventors.

To identify green firms, we rely on the Orbis Intellectual Property database, which provides information linking patents to the firms that filed them. Using the identifiers of green patents, we retrieve the corresponding firm identifiers, allowing us to construct a list of green firms. Consistently with the analysis of green inventors, we also zoom in on the French economy, complementing our exercise with data from the French patent office (INPI), which also include information about applicants and their employers.

Finally, to identify a suitable control group to firms subject to the EU ETS, we leverage the fact that assignment to the EU ETS happens at the facility level, so that firms with comparable characteristics may be subject or not subject to the EU ETS. In this respect, we follow Calel and Dechezleprêtre (2016) and apply a similar matching approach, while extending the analysis to the period 2002-2022. Figure 1 provides a naive comparison of green patenting between regulated and unregulated firms for the extended period, as well as a time series indicating the price of oil. The definition of green patenting used is the one from the European patent classification (ECLA), specifically the Y02 category for

"technologies or applications for mitigation or adaptation against climate change." Figure 2 then estimates the impact of the EU ETS after applying propensity score matching. Having established that the impact of the EU ETS on clean innovation detected by Calel and Dechezleprêtre (2016) continues over time and, if anything, strengthens as the cap becomes more stringent and allowance prices rise, it makes sense to turn to the role of innovators, the main focus of this project, applying a similar strategy relying on propensity score matching.

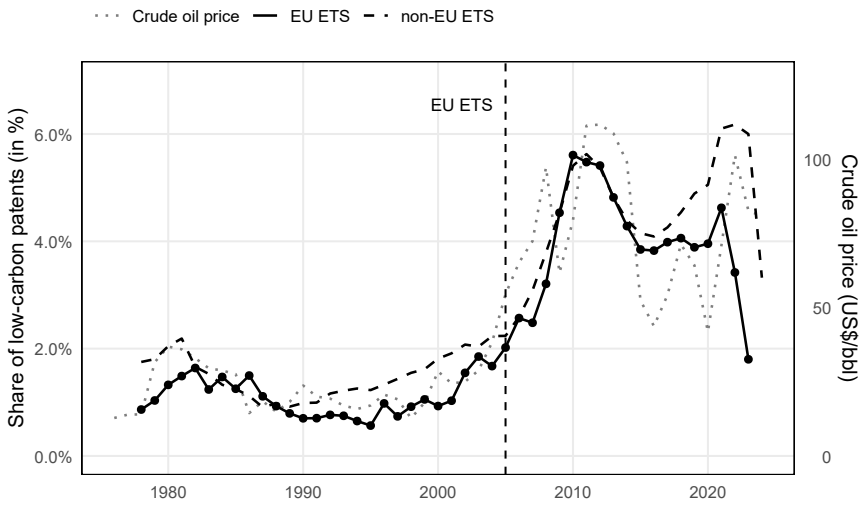


Figure 1: *Share of green patents for regulated and unregulated firms and crude oil prices over time.*

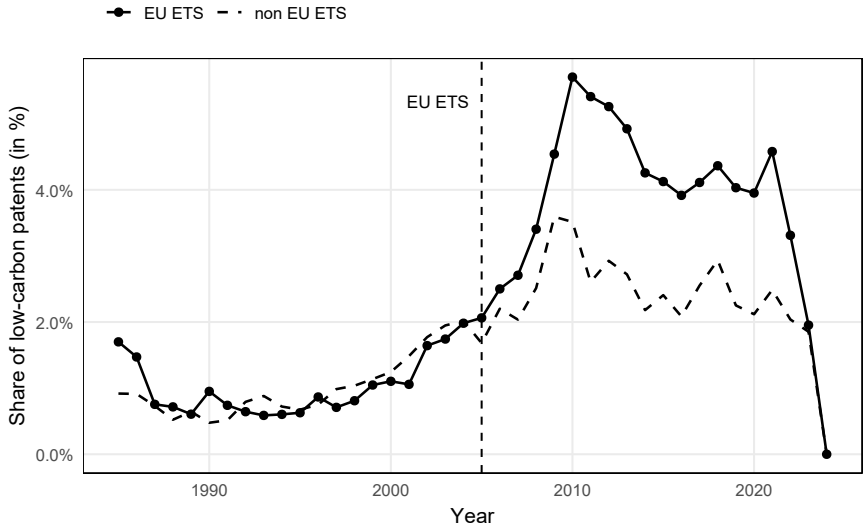


Figure 2: *Matched difference in differences and impact of the EU ETS on low-carbon patents.*

In the meantime, however, the literature on difference in differences has expanded considerably, in particular addressing biases that may arise in a non-canonical setting with staggered implementation, heterogeneity across cohorts, and dynamic effects (see the reviews in de Chaisemartin and D'Haultfœuille 2023; Roth et al. 2023). Hence, we also take advantage of these advances to examine the impact of joining (or knowing to be joining) and leaving (or knowing to be leaving) the EU ETS. On average, we have about 240 firms joining every year and 296 firms leaving every year, because of their establishments' coverage, without accounting for firms joining from or leaving to a national trading scheme. We consider both a binary treatment as in Calel and Dechezleprêtre (2016) for having establishments under the coverage of the EU ETS as well as a continuous treatment allowing us to capture the intensity of the treatment, namely variation in the price of permits compared with firms that do not face such a price as well as firms coming from and leaving to national schemes. Given the non-absorbing nature of treatment, we proceed with de Chaisemartin and D'Haultfœuille (2024) and de Chaisemartin et al. (2022), first focusing on patents over the extended period and then on innovators, the

key innovation of our paper. There are 207,339 innovators who developed green patents in our dataset (and many more who have gone through firms with a history of green patenting).

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