**Technology Adoption in Emission Trading Programs with Market Power**

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This article focuses on two relevant tools to fight against climate change, namely environmentally friendly technology adoption and emission permits trading. Specifically, we study if there is a systematic link between market power in emission permit markets and the adoption of cleaner technologies, and how these two aspects relate to permit allocation. Both the existence of market power and the incentives for technology adoption have been pointed out in the literature as relevant and controversial practical issues that deserve a careful analysis. In the European Union Emission Trading System (EU ETS), there have been claims that large electric firms might have benefited from strategically increasing the permit price during Phase I of the EU ETS, since the pattern and extent of these firms' allowance holdings during this phase are consistent with strategic price manipulation.

By studying the interaction between the existence of market power in the permit market and the incentives for technology adoption we contribute to two strands of the literature. The first focuses on cap-and-trade programs with market power, where a dominant firm coexists with a competitive fringe. Our contribution to this literature is to ask how the possibility to adopt new abatement technology modifies the position of the dominant firm in the permit market and its optimal strategy. In our framework, the dominant firm now has two strategic variables (the demand for permits and the level of technology adoption) instead of one, and it becomes relevant to ask about the interaction between the two variables as complements or substitutes in manipulating the permit price. In other words: *Does the consideration of new technology adoption weaken or reinforce the dominant firm's incentives to manipulate the price of permits up or down?* Or put differently: *Does the possibility of technology adoption dilute or exacerbate market power?*

The second strand of the literature studies the incentives provided by different environmental policies for firms to invest in more efficient abatement technologies (the so-called dynamic efficiency). To our knowledge, this literature is silent about the incentives to adopt better abatement technologies under emission trading with market power. By including this consideration, we can address the following question: *does the existence of market power weaken or strengthen the incentives to invest in new abatement technologies?* In particular, we are interested in analyzing whether the dominant firm has more or less incentives to invest in new technologies than the competitive firms, and also if it has more or less incentives than it would have in the absence of market power.

To answer these questions, we present a model in which a group of firms make decisions regarding technology adoption and permit trading, after they become aware of their initial permit allocation. Technology adoption is costly, but it decreases abatement costs. We first consider a benchmark scenario without market power, i.e, all the firms are price-takers in the permit market. In this setting, all the firms simultaneously decide on their amounts of technology adoption and permit holding. Then, we consider an alternative situation where one firm takes a leading role in the permit market, as a price-setter. In this scenario, all the firms

first decide on their technology investments, then the dominant firm selects its permit holding (i.e., the permit price), and finally the remaining firms select their respective permits, taking the permit price as given.

By comparing a benchmark model of perfect competition in permit trading with a situation of market power with a dominant firm, we conclude that the initial amount of permits given to the dominant firm is crucial in determining not only under- or over-pollution with respect to the benchmark case, but also under- or over-adoption in clean technology. Thus, if the dominant firm is initially endowed with more permits, its monopolistic position will prompt it to over-pollute and under-adopt with respect to the benchmark case of perfect competition. The opposite arises if the dominant firm is initially given relatively less permits, acting then as a monopsonist. We also find that the existence of market power results in a divergence of pollution and technology adoption levels with respect to the cost-effective solution as the effectiveness of technology adoption in reducing abatement costs increases. Paradoxically, this happens while the permit price under market power converges to the permit price under perfect competition due to the fact that the role of the dominant price as a price-setter decreases.

As a policy implication, our results reinforce a previously suggested result that, when technology investment is very effective, the regulator should be especially careful with the initial allocation of permits and, more specifically, with the amount of permits initially given to the dominant firm. In fact, it is not difficult to construct limiting scenarios where a dominant firm may decide not to trade permits at all, and simply adjust to this decision by investing much less or much more in technology adoption than under perfect competition. Although these extreme situations may not be realistic, they serve to stress the point that the distortion due to market power can be particularly severe when technology adoption is a very relevant factor.