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Risk Aversion and CO_2 Regulatory Uncertainty in Power Generation Investment: Policy and Modeling Implications

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We consider investors in electricity generation market who are planning to expand generation capacity. They are anticipating regulation of carbon dioxide emissions in the future, but do not know if or when it will be passed. Risk is increasingly important in this setting, so analyses that fail to assume certainty can be misleading. In the meanwhile, investors tend to be risk averse -- thus an amount of profit with certainty will generate a higher utility, compared to the uncertain profit of the same amount in expectation. One reason leading to their risk aversion is the large amount of sunk costs. Investments in generation capacity have lasting consequences for costs and emissions. There are significant fixed costs to building capacity and switching a given plant from one fuel to another is usually expensive or impractical. The other reason comes from a lack of ability to fully hedge themselves towards adverse outcomes via financial instruments.

This paper focuses on regulatory risk. Regulation of the sector to protect the global climate seems likely at some point in the U.S., and anticipated costs are large relative to past regulatory interventions. We are particularly interested in a cap-and-trade scheme. Under cap-and-trade, government authorities set a certain amount of emission cap to all the regulated installations and then distribute emission allowances, either for free (grandfathering scheme) or by auctioning (auction scheme). Emission allowances represent the right to emit carbon dioxide from installations -- installations can only emit to the amount of the allowances they hold. The allowances are tradable, so an installation can meet the emission target either by reducing the emission and selling extra allowances or by purchasing allowances from the market.

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We consider investments by two types of investors, one building highly polluting but low variable cost capacity (coal-fired plants), and the other building low polluting but high variable cost capacity (gas-fired plants). Our efforts focus on the changing incentives for investment in different technologies in the face of regulatory uncertainty as to whether or not a given carbon policy will be imposed. Investors make expansion decision before carbon regulatory regime gets revealed; then, under the specific regulatory regime, investors generate power constrained by the capacity they built earlier to serve the electricity market.

Our simulation shows that when investors are risk neutral, regardless of how the allowances are allocated in a cap-and-trade system, investors make the same decisions in terms of capacity and output, even though different allowance allocation and distribution schemes yield varying profits. Risk averse investors, however, hedge their bets to reduce their losses in the 'bad' outcome, and thus make the decision sensitve to how allowances are going to be allocated. To be more specific, risk neutral investors facing a regulation with certainty build more gas and less coal-fired generation capacity than in a business-as-usual (BAU) no regulation scenario, regardless of what form the potential carbon regulation takes. Risk aversion complicates matters: if allowances are grandfathered, risk aversion increases investment in coal -- which pays off in the bad, unregulated state -- and decreases it in gas relative to the risk neutral solution. If allowances are auctioned, the reverse is true. The result is driven by the gains from increased distribution of free allowances to coal plants under grandfathering. In contrast, an auction scheme provides a more direct signal to follow: firms see the rise in the expected relative price of coal under regulatory uncertainty and the more risk averse they are, the more they invest in less carbon-intensive generation that will pay off in the regulated state.

Our model suggests that in the presence of risk aversion, some carbon instruments will introduce perverse incentives favoring investment in dirty generation technology. Thus the choice between grandfathering and auctioning permits has implications for efficiency and costs, as well as the usual distributional effects.

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