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Does risk aversion affect transmission and generation planning? A Western North America case study

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Electricity transimssion planning models have been around for a long time; they help transmission planners and policy makers make optimal expansion decisions. In the last decade, these models have become increasingly detailed. In particular, stochastic models have been developed, which try to capture the uncertainties about future costs, energy demand, policies, and other variables faced by planners, and bi-level approaches have been proposed, which capture the reaction of generation investment to changes in the network structure. Still, the vast majority of planning models assume that all investors are risk neutral: they maximize expected profits, averaging over a number of future scenarios, without being affected by the degree of uncertainty.

In reality, all investors are risk averse: they try to avoid the worst outcomes, even if that decreases profits on average. In this paper, we investigate how risk aversion affects transmission and generation planning. To do so, we formulate a stochastic model that minimizes a weighted average of expected transmission and generation costs and their conditional value at risk (CVaR), such that investors place a higher weight on the worst outcomes. We show that the solution of this optimization problem is equivalent to the solution of a perfectly competitive risk-averse Stackelberg equilibrium, in which a risk-averse transmission planner maximizes welfare, choosing where to upgrade the network, after which risk-averse generators maximize profits, choosing where to build new generation capacity.

We then apply this model to a 240-bus representation of the Western Electricity Coordinating Council, a large network covering the west coast of the United States.

We consider a wife range of scenarios, with different federal and state-level Renewable Portfolio Standards (RPSs), fuel prices, average and peak demand levels and nuclear availability. We then solve the model for different levels of risk-aversion, ranging from risk-neutrality to extreme risk aversion, to examine the impact of including risk aversion in planning models on levels and spatial distributions of different types of generation and transmission investment.

We show that the impact of risk aversion remains small at an aggregate level. There are several reasons for this. First, there exist some relatively cheap actions that can be taken to significantly reduce the exposure to risk (e.g., investment in renewable capacity in high-resource locations, which is already close to competitive in a risk-neutral world). Second, once these actions are taken, there is little that can be done to further reduce risk. Even if investors had certainty that a scenario with high RPS levels, high demand growth and high fuel prices would occur, there is no 'get out of jail free'-card – costs can be reduced somewhat but this future would still be expensive. Finally, the existing literature has shown that it is not so much the number of scenarios that drives a risk-neutral model but the range of scenarios, which suggests that the most extreme scenarios are already a main determinant of investment levels in a risk-neutral world; increasing their weight even further does not change the outcomes much.

However, the more important conclusion is that risk aversion has significant state-level impacts on generation and transmission investment, since many of the cheap actions to reduce risk that are mentioned above involve changing types, and therefore, locations of generation capacity. In our particular case study, risk aversion leads to more investment in renewable generation capacity, because these insure investors against future high fuel prices or strict renewable targets. Anticipating that, the transmission planner builds more transmission to areas with good renewable resources but less transmission overall, since more generation capacity is available locally.

These results emphasize the importance of explicit consideration of risk aversion in planning models, especially if they are used to consider the local impacts of expansion policies.

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