ANALYSIS OF (IN)COMPLETE RISK MARKETS FOR POWER SECTORS WITH HIGH SHARES OF RENEWABLE ENERGIES

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Overview

Generating and retailing firms face considerable profit risks in liberalised electricity markets. The crucial risk factor is the electricity wholesale price which exhibits a high short- and long-term uncertainty since it is affected by fuel and CO_2 prices, demand and other risky parameters. Since risk affects firm decisions, its allocation is important for an efficient market outcome. An efficient risk allocation can be achieved via long-term markets in which, for example, futures are traded to hedge profits. However, up to today, these *risk markets* are typically incomplete, because they i.a. suffer from low liquidity especially for longer time horizons. Another challenge is the rising share of renewable energies (RES): it is well known that their very high capital intensity implies higher stand-alone risks compared to technologies with higher operational expenditures (e.g. Roques et al. 2008). Therefore, many observers fear an underinvestment in RES, if risk markets are incomplete (e.g. Finon 2013).

Against this background, we analyse the impact of risk aversion in electricity sectors on equilibrium investments. The long-term risks of CO_2 prices, demand and RES availability (weather) are considered. We derive the first best market outcome under risk aversion and forward trading and then compare this benchmark to the impact of alternative risk mitigation strategies, which firms use when risk markets are incomplete. More specifically, we analyse the effects of plant portfolio diversification, vertical integration and (incomplete) futures trading on the investment decisions.

While plant portfolio diversification as a means to reduce risks has been analysed frequently from a social planner (cost) perspective (e.g. Awerbuch & Spencer 2007), only some studies apply it from a private firm perspective (e.g. Roques et al. 2008; Lynch et al. 2013) as we do. However, the latter studies do not have an equilibrium framework or separate the portfolio optimization from the equilibrium model. In our model, firms endogenously optimize their portfolio within the equilibrium framework. Aïd et al. (2011) investigate vertical integration between retail and generation with respect to the retail and forward market outcomes. We additionally consider the impact of vertical integration on plant investment decisions. Finally, Ehrenmann & Smeers (2011) and Fan et al. (2010) analyse the impact of risk aversion on investments in different plant types within an equilibrium framework. However, they do not incorporate plant portfolio effects, vertical integration or futures trading.

Methods

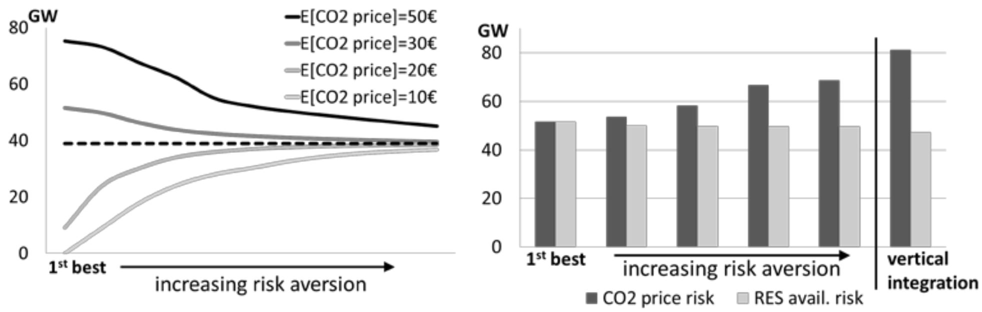
We apply a modified version of a standard two stage equilibrium model for electricity markets and assume that all firms are risk averse (mean-variance utility): In the first stage, generating firms maximize utility by investing in plant capacities under uncertainty. As in Aïd et al. (2011), retailing firms maximize utility by deciding about their share of total demand they want to deliver. Retail market clearing is satisfied by the retail price which is fixed in the second stage. In addition, generators, retailers, integrated firms and external speculators take positions in the futures market. In the second stage, uncertainty is resolved and generators can produce electricity up to their capacity level and sell it in the wholesale market. Retailers buy electricity in the wholesale market and sell it for the fixed retail price to consumers.

We assume that the second stage consists of 50 weighted time periods that represent a whole year. There is no uncertainty within a year, that is, we assume only long-term risks. Generators can invest in wind plants as RES technology with zero variable and high fixed costs and in the two gas plant types CCGT and OCGT, while the latter has higher variable, but lower fixed costs (peaker) compared to the former. There are different scenarios characterized by increasing expected CO_2 prices which imply increasing wind shares.

Results

Our first main result is that in the absence of risk markets and vertical integration, risk aversion has a positive impact on wind investments and a negative impact on investments in gas plants up to moderate wind shares in the generation mix (left figure). The reason is that risk averse firms can reduce their portfolio risk through more wind investments since the profits of wind and gas plants are negatively correlated. This overinvestment (compared to the first best) decreases with the wind share. Beyond a certain threshold (dotted line, left figure) firms underinvest in wind.

Figures: Effects of portfolio diversification (left) and futures trading and vertical integration (right) on wind capacity



The second main result is that if futures trading is possible, there can be over- or underinvestment in RES. The sign depends on how the wind profits are correlated to the wholesale price. The right figure shows that there is overinvestment if there is only a CO_2 price risk (which implies a positive correlation between wind profits and wholesale price) and underinvestment in the RES availability case (which implies a negative correlation), while the impact of the former is generally higher. Finally, the third main result refers to the impact of vertical integration: assuming that producers are also retailers, the over(under-)investment in RES is even more pronounced (right bars, right figure) since the retail profits are strongly negatively (positively) correlated to the wind profits. Therefore, investments in wind reduce (increase) the risk of integrated firms.

Conclusions

Our analysis highlights that, despite high stand-alone risks, there can be significant overinvestment in capital intensive RES plants if firms are risk averse. That is, we put the argument that market risks are an inefficient barrier for RES and therefore they should not be fully integrated into the market into perspective. An important implication of our results is that risk-reducing policies can have the unintended effect of worsening the investment attractiveness of a technology (e.g. feed-in tariffs for RES). However, if incomplete risk markets lead to over- or and underinvestment in a certain technology depends on several conditions prevailing a market. Hence policy makers should carefully consider the prevailing conditions when implementing risk-reducing policies.

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