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Risk trading in capacity equilibrium models

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Risk is commonly recognized as one of the factors affecting investment in capacity. Nowadays in the European electricity sector, risk is asymmetric depending on the type of capacities: support policies strongly mitigate the risk supported by renewable plants, while in contrast, these continuously changing support policies (and the reductions of electricity prices that they have implied) have created additional risks for conventional generators. While a reduction of investment in conventional plants may not be considered dramatic, indeed may be desirable for a long term objective of a fossil free system, this issue is crucial for the mid-term where these plants remain necessary both for the continuity of energy supply and grid services. This paper presents a unified computational framework for analysing the class of *risky capacity equilibrium problems*, motivated by the electricity sector. These models can be used for policy analysis of how market imperfections may lead to a mismatch between capacity and demand, and for assessment of potential remedies. Among market imperfections, the paper mainly focuses on the issues of missing markets and market power.

The "missing money" is the standard conceptual instrument in analysis of inadequate investment in conventional generations. It characterizes a situation where the market insufficiently remunerates the production of a commodity (typically energy but possibly also ancillary services) and hence reduces the incentive to invest. The notion underpins the well-known debate between energy-only and capacity markets. Missing markets [37, 39] is related but different: it refers to situations where there is no market for remunerating the production of some good or service or when these markets are insufficiently developed. The situation applies to both the risk free world (for instance when there is no market for reactive power or, in today's market, for "flexible energy") and risky worlds (where there is no market for trading certain risks). The paper addresses missing markets for trading risk in capacity investment. The motivation for this analysis should be obvious if one thinks of the role of insurance in

the housing market: private house construction would be quite different without intermediaries (the insurance companies) that trade and thereby share risk (through fire and life insurance contracts) between house-owners. The paper also analyses the situation when firms exercise market power in the commodity market, i.e., they strategically limit their outputs in to influence prices. Studying the full impact of imperfect competition on investment can quickly lead to intractable models. We here simplify the setting by only considering market power in the commodity market, via the Cournot paradigm, while excluding strategic considerations at the point of investment or risk trading.

We analyse investment using a simple representation of capacity expansion and short-term commodity markets (the same representation as in standard capacity expansion models); we complete this representation by a model of risk trading for which we consider different degrees of development. We look at three different types of situations. One extreme case occurs when there are no instruments for trading risk. The other extreme situation (complete market) happens where there is a full set of financial contracts. The third class considers intermediate cases when there exists some types of financial trading contracts. These can be long term futures or (reliability) options as often discussed in the literature [37]. Whatever the case the systematic risk of the sector is not modified, it is simply allocated differently depending on the contracts. Because market power has been and remains an important subject, we conduct the analysis for two versions of the commodity market: the market is perfectly competitive in one case and subject to exercise of market power à la Cournot in the second case.

We use a series of small numerical illustrations to show the negative impact of risk aversion on the capacity equilibrium, in terms of both welfare and total capacity. Those examples show the benefit of risk trading, even in the incomplete case of a single traded financial product, when agents have diverse views about which outcomes are bad: risk trading allows for agents to hedge each other's risk exposures. It also indicates that the negative influence of market power prevails when comparing the results with and without risk trading. These findings have obvious policy implications. First of all, it confirms the straightforward economic intuition that market power should be monitored and mitigated by competition authorities (and probably reduced by a good market design that removes market segmentation). Secondly, it indicates that even in a competitive market without missing money problems, capacity might still fail to develop due to investment risk and the lack of contracts to hedge it. Partial hedging, even with single type of contract, can drastically improve the situation. The relevant question is whether this suffices in practice: observation [18] reveals that current financial markets do not provide long-term hedging possibilities in that contracts become illiquid for a maturity beyond four years. Alternative remedies could take place by introducing a capacity mechanism that would force long-term hedging

or provide more stability in revenues by either developing bilateral long-term contracts, as in the Exeltium project in France founded by electro-intensive industries, or sharing investment risk with consumers via co-financing, as in the nuclear development by TVO in Finland. Traditionally some sort of vertical integration, guaranteeing stability in the retail portfolio, has also been seen as a valuable long-term hedge. Given today's competition in retail activities (and the associated churn ratio of consumer), it is not sure that it is still possible to regain this stability.

These different questions illustrate the need for computable models for getting into these questions in detail. The paper does not explicitly discuss all the instruments invoked in this summary but it develops a unified framework, the class of risky capacity equilibrium problems, where risk trading may be complete or incomplete.
This class of problems is “open loop” in the sense that capacity investment and risk trading decisions are made without anticipating the response of other agents at that point or later in the commodity market. From a modelling viewpoint, this framework is realized by converting any two (or multi-) stage risk neutral capacity equilibrium problem into a risky capacity equilibrium problem via the bridge of risky design equilibrium problems [43].

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