Investment with incomplete markets for risk: The need for long-term contracts

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\section*{A B S T R A C T}

Barring subsidies, investment in the power generation sector has come to an almost complete halt in the restructured European power sector. Market and regulatory failures such as the well known missing money (see Joskow, (2006)) but also normal market features such as risk, possibly also affected by market failures like market incompleteness are mentioned as common causes for the situation. This paper discusses incomplete risk trading and its impact on investment. The analysis applies computable stochastic equilibrium models on a simple market model of the Energy Only type. The paper first compares the cases of complete and fully incomplete markets (full risk trading and no risk trading). It continues by testing the impact of different risk trading contracts on both welfare and investment. We successively consider Contracts for Difference, Reliability Options with and without physical back up that we add to our Energy Only market model. We test the impact of market liquidity on the results. Finally, we compare these methods to a Forward Capacity Market that we also add to the energy only model. We complete the paper by interpretation of these results in terms of hurdle rate implied by these risk-trading situations.

1. Introduction

European investment in non-subsidized generating capacities has now come to an almost complete halt. Recent years have even seen a shift from investing to mothballing and anticipative retiring of technologically advanced plants. Various reasons explain this evolution. The familiar “missing money”, the lower demand due to the economic situation and energy conservation as well as several market imperfections are often mentioned. The uncertainty surrounding the restructuring and energy transition processes and the economic recovery also play a role. We focus on long-term demand risk in energy only markets (EOM) and discard other considerations.

The importance of risk in investment pervades corporate finance since the early days of Management Science. Valuations of risky assets can roughly be classified in two major approaches. One is based on the so-called Capital Asset Pricing Model (CAPM) and is mainly used for long-term investment. The other is based on contingency pricing and the literature of derivative pricing: it is commonly applied for hedging short and medium-term operations (see Cochrane (2005) for an extensive discussion of both approaches and Eydeland and Wolyniec (2003) for the application of derivative pricing to power and gas). Derivative pricing is also used to value flexible power plants. “Reliability options” is a particularly original application of derivatives to remedy the missing money (Vasquez et al. (2002), Oren (2005), Chao and Wilson (2004) and more recently Pöyry (2015) and several other authors).

CAPM and contingency pricing are technically different but commonly applied under similar fundamental assumptions: both rely on exogenous (econometrically estimated) price processes and risk premium. Both also generally neglect issues of market incompleteness (see Magill and Quinzi (2002) for an extensive treatment in finite horizons). These simplifications were probably sufficient in the past but may now be inadequate in the highly uncertain context of the restructured power market.

This paper contributes to the literature by presenting different stochastic equilibrium problems to quantify the impact of risk, market incompleteness and contracts in investment in power generation. These models are easily interpretable in standard investment criteria and are treated in a single computational framework. We illustrate the approach on a stylized stochastic equilibrium investment problem for which we assume exogenous processes of fundamentals (such as demand and fuel costs). In contrast with most of the literature, we

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2. Background: investment problems in different market contexts

The paper is formula free but based on fully formalized models. The mathematical formulation and its economic interpretation are given in de Maere d’Aertrycke et al. (2016). Technical results are presented in Abada et al. (2015) and (2016).

This paper analyses the impact of long-term demand risk on investment in energy only markets (EOM) where the missing money is corrected by a price cap. Taking stock of that basic framework we add risk mitigation instruments such as long-term contracts (contracts for differences (CfD), reliability options (RO) or forward capacity markets (FCM) under different assumptions of market liquidity). We complete the analysis by also considering a capacity market. We report welfare and investment levels. The analysis is conducted in an investment context; transposition to mothballing and anticipated decommissioning are more relevant today but probably also less usual in the literature. This transposition will be the subject of another paper.

The paper is structured as follows. Section 2 recalls the basic ideas underpinning investment problems in the different market settings. Section 3 introduces the methodology and the illustrative very simple physical model of generation and demand and the different instruments examined in the case study. We discuss the results in Section 4 with welfare and investment presented in unified graphic form for the different instruments. Section 5 reinterprets the analysis in more financial terms. Conclusions terminate the paper.

2.2. Risk neutral agents

Suppose first that investors facing the demand scenarios are risk-neutral. The investment criterion of the risk free world is modified as follows: one invests in some equipment as long as its expected gross margin computed for the different demand scenarios is larger than or equal to its capacity cost. This modified investment rule combined with the unchanged merit order rule defines the new equilibrium model.

This model simultaneously determines investment, generation and prices. These prices are defined for the different states of the world describing uncertainty and are endogenous to the system. Because agents are risk neutral the discount rate remains the risk free rate. The risk neutral stochastic model is well established (see for example Murphy et al. (1982) or Haurie et al. (1988)).

2.2.2. Risk averse agents

Neither investors nor consumers are risk neutral. The von Neumann-Morgenstern utility functions that appeared in economics in 1953 (van Neuman Morgenstern, 1953), and risk functions (Artzner et al., 1999) developed more recently in finance are two methods that associate a deterministic equivalent to risky payoffs. The latter is directly related to risk criteria used in risk management practice. We thus use a CVaR, which has become the most widely used coherent risk function (a function that satisfies the properties of monotonicity, sub-additivity, positive homogeneity, and translational invariance), and refer the reader to the general literature about coherent risk functions. The investment criterion is then restated as follows: one invests in a new equipment as long as the CVaR of its gross margin computed for the different demand scenarios is greater than or equal to its capacity cost. In other words in equilibrium for the investments decided by the risk averse agents are price taking. Agents influence their risk exposures, which implies that investment and cost of capital must be determined simultaneously. We briefly and verbally describe how this is done and refer the reader to Ehrenmann and Smeers (2011b), Ralph and Smeers (2015) and de Maere d’Aertrycke et al. (2016) for the technical development.

Note for the rest of the discussion that the equilibrium model simultaneously determines investment, operations and electricity prices. The endogenous price process is one of the important features of the equilibrium approach.
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