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Hedging spark spread risk with futures[☆]

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ABSTRACT

This paper discusses the spark spread risk management using electricity and natural gas futures. We focus on three European markets in which the natural gas share in the fuel mix varies considerably: Germany, the United Kingdom, and the Netherlands. We find that spark spread returns are partially predictable, and consequently, the Ederington and Salas (2008) minimum variance hedging approach should be applied. Hedging the spark spread is more difficult than hedging electricity and natural gas price risks with individual futures contracts. Whereas spark spread risk reduction for monthly periods produces values of between 20.05% and 48.90%, electricity and natural gas individual hedges attain reductions ranging of between 31.22% and 69.06%. Results should be of interest for agents in markets in which natural gas is part of the fuel mix in the power generation system.

1. Introduction

In the transition path to ‘low greenhouse gas emissions development’ under the Paris Agreement, the decarbonisation of the electricity sector is a central factor. To meet this target, the energy sector needs to begin a transition process to a less contaminant future in which gas acts as a ‘bridge fuel’ to a low-carbon power generation system (Peters, 2017). The European Commission has agreed ambitious targets to reduce CO2 emissions by more than 40% (80%) by 2030 (2050) as compared to 1990 levels; and to increase the share of low carbon technologies in the electricity mix from approximately 45% today to nearly 100% by 2050, when renewable energy sources will represent more than 50% (Boie et al., 2014). In addition to the target of reducing CO2 emissions, another goal of EU energy policy is the security of supply. For meeting greenhouse gas emissions reductions and peaking electricity demand at times of low renewable energy supply, natural gas is the backup energy source because natural gas fired generation can rapidly ramp output in response to variable output from renewable sources – particularly solar and wind (Pless et al., 2016).

The deregulation of energy markets initiated in the 1990s has led to competition and price uncertainty in many countries. In the case of an energy market agent whose payoffs depend simultaneously on electricity and natural gas prices, this uncertainty is doubled. The spark spread can be defined as the gross profit margin earned by buying and burning natural gas to produce electricity. The size of this profit depends on energy prices and generator efficiency. The clean spark spread reduces the spark spread with the cost of emitting CO2 to the atmosphere. Further to the spark and clean spark spreads, the range of the energy and commodities spreads family is quite wide: quark (nuclear to electricity); dark (coal to electricity); clean dark (coal to electricity and CO2); crack (oil to gasoline and heating oil); and crunch (soy bean to soy oil and soy meal). In many cases, these spreads can be traded in a closed combination of futures contracts bought and sold in the market.

Following Emery and Liu (2002), the spark spread became available when the NYMEX initiated trading in electricity futures in March 1996 and remained possible until 2002. However, in May 2002 electricity contracts on Nymex became over-the-counter (OTC), and so spark spreads had to also become OTC on NYMEX. Spark spreads have also started OTC trading in Europe. The spark spread forward curve is very important to energy industry planners as it provides a method for electricity producers to lock in generation profits. The forward curve of the spark spread and its average values can indicate to gas-fired generation companies how to maximise profits in their forward trading by choosing maturities with higher spreads. The spark spread can also help regulators monitor if electricity forward prices are directly influenced by gas prices, and in case of remarkable divergences, help reveal if a market anomaly has occurred (Capitán Herráiz and Rodriguez Monroy, 2013).

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As Borovkova and Geman (2006) remarked, in the energy industry, inter-commodity spreads are as important as prices. In this paper, we deal with several important issues related to the joint risk management of electricity and natural gas prices. Our approach for futures hedging will be useful to those agents involved in the simplest tolling agreement who want to reduce uncertainty on payoffs.[1] That is, a contract in which the payoffs are computed as the spark spread. Such agents will be interested in studying the alternative of trading in the spot market: the spark spread being a proxy of its payoffs. Risk management of these contracts can be improved using futures contracts. There are several papers on electricity and natural gas price risk management, but no paper has attempted to simultaneously determine the optimal position in futures on electricity and natural gas to hedge spark spread risk (see for example Torró (2011), and Martínez and Torró (2015)). We show that clean spark spread risk and spark spread risk are two indistinguishable variables for futures hedging purposes. Therefore, this paper looks for the simultaneous optimal futures hedging positions on electricity and natural gas that minimise the profit risk in a spark spread contract. Before this decision is made, a manager will try to guarantee that spark spread contract payoffs ensure a profitable activity for the company.[2] In fact, the spot price in the electricity market is determined by the intersection of the supply and demand curves at an auction in which the price for the 24 h of the following day is settled. Power producers make their electricity offers according to their short-term marginal costs, principally fuel costs and CO2–costs. Offers are then sorted from lowest to highest, obtaining the merit order curve, that is, the electricity offer curve. As power producers from renewable sources offer electricity at nearly zero marginal costs, they are the first to enter the merit order, followed by nuclear energy, coal or gas (depending on the country, coal before gas for UK and Germany and gas for the Netherlands) and fuel oil plants.[3] When electricity demand is low, the price setting units are coal power plants and in hours of high demand the price is set by gas units.

In the last few decades the demand for natural gas in Europe has consistently increased, reducing the use of coal and oil products in the space heating and industrial sectors. From the 1990s onwards, the proliferation of combined-cycle gas turbine (CCGT) plants in Europe has reinforced the importance of gas as an energy source, especially in power generation. Nevertheless, the demand for natural gas in Europe has stopped growing since 2008 because of several simultaneous factors: (i) stagnant power demand after the economic crisis of 2008; (ii) the rising share of renewables in the energy mix as part of the transition to a low carbon economy; (iii) the arrival of cheap coal after the US shale gas production boom in 2009 put gas-fired plants at a disadvantage in the merit order although in the last few years, it is usually coal before gas for the UK and Germany, and gas before coal for the Netherlands; and (iv) the fall of CO2 allowance prices that exacerbated competition between natural gas and coal. Because of all these factors, gas-fired plants have been operating mostly in peak periods (except in the UK and Italy where gas plants still run on base load). The future of natural gas in the long-run European power generation mix will improve as it provides backup for the intermittency of renewables, and the effects of emissions legislation, and the retirement of coal and nuclear capacity in the coming decades (see Honoré, 2014, for more details). However, in the International Energy Outlook for 2016, an average increase of the 3.6% per year in natural gas consumption for power generation for the period 2020–2040 is projected for OECD Europe – this being the largest increase in the sector for any energy source (EIA, 2016).

Our empirical study has been applied to three European markets: the UK, the Netherlands, and Germany. These three markets have several important differences, especially notable because of the fuel mix in the power generation system and the shares of natural gas.[4] Electricity generation in Germany had the following fuel mix in 2014: 10% natural gas; 45% coal; 15% nuclear; 21% renewables; 7% biofuels; and 2% other fuels (see IEA, 2014). The sharp increase in renewable capacity in Germany has lowered electricity prices and gas-fired plants must face negative spark spread. Furthermore, backup for the intermittency of renewables is mostly provided by flexible lignite plants. This situation has prompted several gas-fired plants to apply for closure. Electricity generation in UK had the following fuel mix in 2015: 30% natural gas; 22% coal; 21% nuclear; 25% renewables; and 2% other fuels. Coal and gas-fired shares change each year, with some of the switching between the two reflecting fuel prices (see UK Government, 2016a). Gas power plants have a long-term role in the UK energy system by providing both flexibility and critical capacity, although utilisation is reducing over time (UK Government, 2016b). Electricity generation in the Netherlands had the following fuel mix in 2014: 50% natural gas; 31% coal; 4% nuclear; 10% renewables; and 5% other fuels (see IEA, 2014). The Dutch gas transfer facility has grown enormously in the past years, and is now the biggest on mainland Europe. Recently, an induced earthquake caused by the extraction of natural gas from the Groningen field has forced the Dutch government to reduce extraction volumes (since 2014) to avoid more severe quakes. Nevertheless, Dutch market prices continue to be the most important reference across continental Europe.

A common feature of natural gas and electricity prices is that spot price changes are partially predictable due to weather, demand, and storage level seasonalities.[5] Our paper is also innovative in uncovering and considering the seasonal effects detected in the spark spread that makes its changes partially predictable. Ederington and Salas (2008) showed that in these cases the linear regression hedging ratio estimate is inefficient, the riskiness of the spot position is overestimated, and the achievable risk reduction underestimated. We apply to the spark spread the methodology proposed by Ederington and Salas (2008) that overcomes these problems. In the Ederington and Salas (2008) framework the expected spot price changes are approximated using the information contained in the basis (futures price minus spot price). If futures prices are unbiased predictors of future spot price, the basis will be a measure of the expected change in the spot price until maturity (Fama and French, 1987).

The most insightful results obtained in the empirical experiment with the above three markets are: (i) the spark basis has an important predictive power explaining spot spark price changes (between 19.83% and 54.14% for the base load spark spread and between 3.67% and 44.43% for the peak load spark spread).; (ii) we analyse five possible futures hedging strategies and find that no hedging strategy clearly

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[1] Extracted from Risk.net glossary: a tolling agreement can be defined as a processing agreement for the conversion of an input product for a fee. In the electric power market, tolling agreements are typically between a power buyer and a power generator, under which the buyer supplies the fuel and receives an amount of power generated based on an assumed heat rate at an agreed cost. A tolling contract can contain contractual and operational constraints as, for example, start-up or shut-down charges, heat rate depending on the output level, minimum-run levels, a maximum number of restarts, etc. (see Deng and Xia (2005) and Woo et al. (2012)).

[2] The decision to run the plant may be made even if the spark spread is anticipated to be negative because the ramp-down (and subsequent ramp-up) costs are higher than the cost implied by a negative but lower spark spread value. Contractual and operational constraints if a tolling agreement is underwritten may also require the plant to sometimes run even when the spark spread is negative. Moreover, if the hedging strategy is considered, then hedging costs (bid-ask spread, for instance) may also affect the decision to run the plant or not. We thank one of the referees for this comment.

[3] See Sensfuß et al. (2008) and Cludius et al. (2014).

[4] The observed energy mix in a country is the result of an interaction of fuel prices, available technologies, and energy policies. Atalla et al. (2017) analyses the evolution of the fossil fuel mix in the US, Germany and the UK. The US has experienced a relatively stable fossil fuel mix since 1980, while in Germany and the UK, the share of natural gas increased dramatically at the expense of coal. They found that fossil fuel prices dominated in determining the mix in the US, but that energy policy actions played an important role determining the transition from coal to natural gas in European countries.

[5] See, for example, Koopman et al. (2007) and Martínez and Torró (2015) for electricity and natural gas prices, respectively.