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Strategic behaviour in international metallurgical coal markets ☆

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ABSTRACT

This paper analyses whether prices and trade-flows in the international market for metallurgical coals were subject to non-competitive conduct in the period 2008 to 2010. To do so, I develop mathematical programming models – a Stackelberg model, two varieties of a Cournot model, and a perfect competition model – for computing spatial equilibria in international resource markets. Results are analysed with various statistical measures to assess prediction accuracy of the models. The results show that real market equilibria cannot be reproduced with a competitive model. However, real market outcomes can be accurately simulated with the non-competitive models suggesting that market equilibria in the international metallurgical coal trade were subject to strategic behaviour of coal exporters.

1. Introduction

Economies all over the world crucially rely on commodities that are procured from international resource markets. One category is energy resources such as imported natural gas and thermal coal for electricity generation or crude oil for petroleum production. Another field is natural resources and minerals that are essential in industrial production: iron ore for steel making, lithium for batteries, bauxite for aluminium production, or rare earth elements for various high-tech products to name but a few. Recent price spikes for such commodities have given rise to concerns about security and reliability of supply of natural resources. Moreover, many markets for natural resources and minerals are highly concentrated and do not appear to be competitively organised at first glance.

The international metallurgical coal (or coking coal) trade – metallurgical coal is a key input in steel-making – is another such example.[1] Prices for this coal variety have reached record levels in recent years and the market structure is oligopolistic. Specifically, four giant multinationals, BHP-Billiton, Rio Tinto, Anglo-American, and Xstrata (henceforth the "Big-Four"), together control around 50% of the global metallurgical coal export capacity. The Big-Four produce their metallurgical coal in Australia and compete against a handful of smaller players mainly from Canada, the United States, and Russia.

In the context of the oligopolistic market structure and the high prices in recent years, this paper seeks to shed light on the question of whether metallurgical coal prices were indeed subject to non-competitive market conduct and if so, which strategy may have prevailed in reality. It is a priori unclear which model of oligopoly captures the characteristics and market conduct in the international metallurgical coal trade best. Therefore the analysis comprises four different strategies with regard to the oligopolists' output decision: first, assuming quantities to be the strategic variable and exporters to engage in Cournot–Nash competition is the obvious baseline scenario (henceforth "Cournot oligopoly" scenario). Second, there are also specific market characteristics that suggest a first mover advantage of the Big-Four in this market. The key price in the international metallurgical coal trade is the so-called "hard coking coal benchmark price". This price, and the corresponding delivery-contracts, is regularly determined in negotiations between major Australian exporters, essentially the Big-Four, and large Asian steel mills. Other exporters subsequently use this benchmark price for their pricing, subject to their respective coal qualities (Bowden, 2012; Chang, 1997).

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[1] Metallurgical coals (hard coking coal, semi-soft coking coal, Pulverised-Coal-Injection coal) are used to produce the coke utilised in blast furnaces or as in the case of Pulverised-Coal-Injection (PCI) coal, to reduce the consumption of coke in blast furnaces. Often the terms metallurgical coal and coking coal are used interchangeably, although strictly speaking PCI coals are not necessarily coking coal. Metallurgical coal is distinct from thermal (or steam) coal which is typically used to produce electricity or heat.

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Although the benchmark price is mostly set by BHP-Billiton, the other three multinationals set the price occasionally too, and the Big-Four provide mutual support in enforcing this price (McCloskey, 2012a).[2] There is no hard evidence for the Big-Four cooperatively determining the benchmark price but the revolving system of individual companies setting the price suggests that there is a potential for (tacit) collusion. To account for the potential first mover advantage and the possibility of collusion between the Big-Four I employ a Stackelberg model. In this model the Big-Four cooperatively determine their output in the benchmark price and delivery negotiations, taking into account the other exporters' reaction to their decision. Third, I combine the Cournot–Nash model with the hypothesis of collusive behaviour between the Big-Four. Specifically, I assume that the Big-Four determine their output cooperatively but simultaneously with their competitors (henceforth "Cournot cartel" scenario). Finally, various market characteristics can lead to perfectly competitive equilibria despite an oligopolistic market structure. Consequently, in the fourth scenario I test for perfectly competitive conduct of all players.

To test which of the outlined market structures explains the real market best I develop mathematical programming models in this paper – a Stackelberg model, two varieties of a Cournot model, and a perfect competition model – for computing spatial equilibria in international resource markets. The models are applied to the international metallurgical coal trade in the period 2008 to 2010. The models for Cournot-style and perfectly competitive behaviour are implemented as Mixed Complementarity Programmes (MCP). The Stackelberg model is initially formulated as a Mathematical Programme with Equilibrium Constraints (MPEC) and then automatically reformulated as a standard non-linear programme to facilitate solution. The models are based on a detailed supply-side focused dataset comprising e.g. mining and transport costs of individual mines, seaborne freight rates and supply cost developments. As the price elasticity of demand is a key unknown in my analysis, I test for a large bandwidth of elasticity cases. Model prediction accuracy is assessed using various statistical measures like Theil's inequality coefficient, Spearman's rank correlation coefficient, and linear hypothesis testing. The numerical results suggest that market equilibria in the seaborne metallurgical coal market cannot be explained by perfectly competitive behaviour. However, the Stackelberg and the Cournot oligopoly scenarios reproduce market outcomes accurately. Departing from different market structure assumptions both models produce similarly convincing results for slightly different, but in any case realistic, ranges of elasticities.

Literature on market conduct in international coal markets is relatively scarce and most papers focus on thermal coal markets (e.g. Abbey and Kolstad, 1983; Haftendorn and Holz, 2010; Kolstad and Abbey, 1984; Trüby and Paulus, 2012). Yet, there are two notable exceptions, Bowden (2012) and Graham et al. (1999), who specifically deal with market power in the coking coal trade. Bowden (2012) is an excellent qualitative analysis of the history of the coking coal trade in the Pacific basin. The author investigates the rise and fall of a buying cartel in this market and describes the emergence of a powerful oligopoly of coking coal exporters since 2001. Graham et al. (1999) quantitatively analyse international metallurgical coal trade in the year 1996 using a mathematical programming model. The authors test for various non-competitive market structures and find that an all consumer oligopsony reproduces actual market data best.

The contribution of this paper is threefold: first, by modelling some players as a cooperative Stackelberg leader and implementing it as an MPEC, I apply a novel approach to resource market analysis, which potentially delivers insights for other markets as well. Second, I show that prices and trade-flows in the international metallurgical coal market are consistent with strategic behaviour by coal exporters in the period 2008 to 2010. Third, by extending the analysed period to three years and using the most recent data, I am updating the research started by Graham et al. (1999) and provide empirical evidence for Bowden's (2012) most recent findings with regard to market power exertion of large resource companies.

The remainder of the paper is organised as follows: Section 2 briefly introduces the international metallurgical coal market. Section 3 describes the models developed in this paper. The data is presented in Section 4. The statistical measures used to validate the models are described in Section 5. Results are shown in Section 6. Section 7 discusses the results and Section 8 concludes the paper.

2. The seaborne metallurgical coal market

Supply-side market power is a rather recent phenomenon in the metallurgical coal market. For more than 40 years the metallurgical coal trade, especially in the Pacific basin, was characterised by a buying cartel keeping prices low. The Japanese Steel Mills (JSM), one of the world's largest metallurgical coal consumers, was the core of this cartel. The JSM's trade strategies were underpinned by other Asian steel mills, mainly from South Korea and Chinese Taipei, subordinating to the negotiations led by the JSM. From a strategic perspective, the buying cartel faced a trade-off between constantly driving down prices at the risk of making some mining operations unprofitable and paying a price premium to maintain a diversified procurement portfolio (Bowden, 2012).

A phase of unsustainably low coking coal prices during the 1990s resulted in an exit of producers and a wave of industry consolidation striving for efficiency gains. This reversed the market structure and, by the early 2000s, the JSM faced an oligopoly of large and efficient mining companies. Bowden (2012, p. 19) for example concludes that "the shift to a seller's market, dominated by a handful of giant mining conglomerates – BHP-Billiton, Rio Tinto, Xstrata (formerly Glencore), and Anglo-American in Australia and the Fording-Teck consortium in Canada – was confirmed in the decade after the 2001 price increases."

The consolidation on the supply side was complemented by a sharp increase in demand for metallurgical coal from entrant Chinese and Indian steel mills that have so far not subordinated to the JSM's pricing policy and hence may have further eroded buyer-side market power. These structural changes were paralleled by steeply rising hard coking coal benchmark prices since the mid-2000s. In recent years, hard coking coal benchmark prices reached an unprecedented 300 USD/t in 2008, plummeted to 129 USD/t in 2009 and rose to 227 USD/t in 2010.[3]

In this context the Germany-based coal importer's association VDKI notes in their annual report (VDKI, 2011, p. 24) that "the small number of coking coal producers is essentially an oligopoly which is able to dictate prices…with relatively little effort." The Big-Four are thought to have substantial market power due to good coal qualities, large export capacities and their close location to the main importers.[4] This hypothesis is not only backed by soaring prices

[2] This became obvious in recent negotiations between Anglo-American and the South Korean steel mill POSCO. As POSCO did not accept the benchmark price proposed by Anglo-American, the company refused to supply high quality coking coal to the steel maker for the whole quarter, supported by other exporters, most notably BHP-Billiton and Xstrata, who also refused to deliver this specific quality for the whole quarter (McCloskey, 2012a).

[3] All prices FOB ("Free On Board") Australia.

[4] The exertion of market power may be supported by important barriers to entry and capacity expansion restrictions in the metallurgical coal market. High political risk and/or the lack of financial resources and technical capability are effective barriers to solo market entry of developing countries with so far untapped metallurgical coal resources. Furthermore, export capacity expansion usually requires coordination of infrastructure and mining capacity upgrading with different stakeholders being involved — a very time consuming process (for details and examples see IEA, 2011b). Such restrictions are particularly delaying for greenfield projects which also need the construction of export infrastructure. A good example is Mozambique where metallurgical coal projects have been underway since around 2005; the first small-scale coal shipments began in 2011 but sizeable coal exports are not to be expected before 2016 (IEA, 2011b).