Lignite price and split of profit negotiation in bilateral monopoly of lignite opencast mine and power plant

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Lignite price and split of profit negotiation in bilateral monopoly of lignite opencast mine and power plant[1]

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ABSTRACT: The newest outcome of bilateral monopoly (BM) of lignite opencast mine & power plant analysis have been discussed. The determinism of optimal solution maximising joint profits not only in quantity of lignite - the size and shape of the ultimate pit (characteristic to classical solution) but also in its price has been stressed. It is proposed to treat negotiation between power plant and mine as a cooperative, two-stage, two-person, non zero-sum game. In the first stage the ultimate pit maximising joint profits of BM should be chosen and in the second one, during bargaining, the split of profit ought to be decided together with choosing the transfer price of lignite. The level of lignite prices has been presented in the time of their control and confirmation (1996-2003) as well as their new profit sharing role in the period of their freely negotiation. The Nash bargaining solution has been proposed as a tool for equitable split of profit in BM due to its rational conditions. The application of this solution on example from the "Szczerców" deposit has been presented.

1 MINE AND POWER PLANT AS A BILATERAL MONOPOLY

1.1 Classical solution for a bilateral monopoly

A lignite/coal opencast mine and a mine-mouth power plant creates specific system of two mutually interdependent firms. Such situation on the market is called bilateral monopoly (BM). It is the market structure with two firms from which one being an upstream monopolist sells its output to a downstream monopsony which after processing it sells the final product to end users. In output market a single buyer may be a price maker (monopolist) or a price taker (a firm competing on a free market). Both firms in described system are mutually interdependent. Some negotiation between buyer and seller is necessary for exchange to take place. It is the interest of both parties to come into agreement. A seller cannot sell his output to other customers and a buyer has no capability to find other sources of input. Such situation frequently leads to lengthy, repeated and thereafter costly negotiations over the price and quantity of intermediate product. It is difficult to attain agreement due to both parties feel the bargaining power.

In the classical solution price of an intermediate product has no influence on the choice of produced quantity, which is determined based on knowledge of marginal cost of lignite production MC_X and marginal revenue product of lignite MRP_X. Determination of optimal quantity maximizing joint profit requires mutual co-operation and disclosure of costs. Without trust and honesty both sides can take not optimal decisions, lower their profits or even have losses. In the case of vertical integration taking optimal decisions is therefore more probable. It was shown (Blair et al. 1989) that joint profit maximization solution could be attained nevertheless BM acts as the vertically integrated firm or as two independent firms maximizing their own profit. In the latter situation application of formula price contracts can be an attractive alternative of ownership integration (Blair & Kaserman 1987). The contracts between both

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sides are based on price formulas taking into account assigned share of profit. Thus the price itself is not a matter of negotiation but the parameter deciding about division of profit. Once accepted profit can be further mechanically adjusted to changes in resource costs in mine and power plant. Disclosure of own costs and their mutual control are necessary to proper operation of formula price contracts.

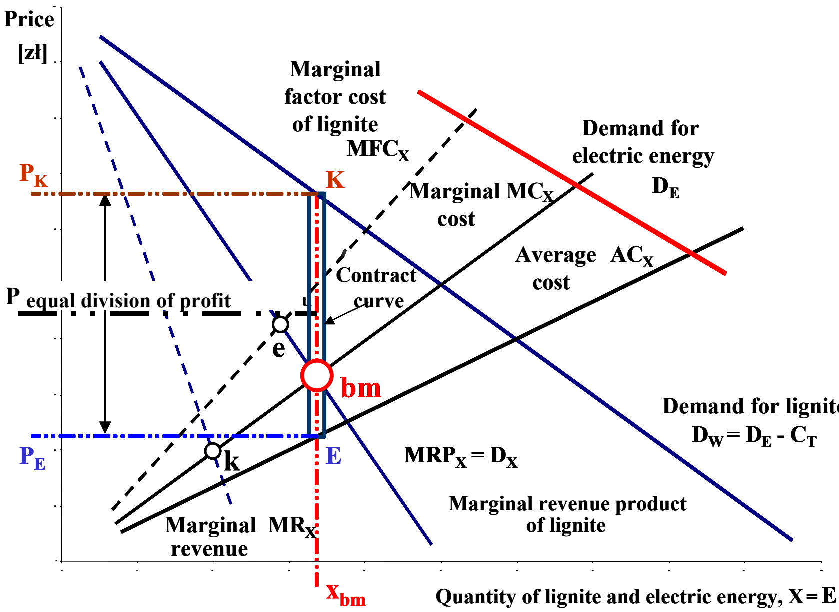

Figure 1. Maximisation of joint profits in a bilateral monopoly (Jurdziak 2004a).

1.2 The influence of lignite opencast mine optimisation on solution of a bilateral monopoly in long run

Analysis of mine and power plant operation with usage of a BM model and pit optimisation presented in (Jurdziak 2004 a,b) has shown that:

1. The tandem opencast lignite mine & mine-mouth power plant as oppose to a classical BM has the determinate solution not only in the quantity of intermediate product (lignite) but also in its price.
2. The optimal lignite price p_{bm} with corresponding optimal ultimate pit, which maximise joint profit of the whole BM in long run (its non-discounted value Π_{Vmax}) can be found for given economic conditions, costs structure, future demand for electric energy or its prices (Jurdziak, 2004 a, b).
3. This optimal lignite price p_{bm} determines the division of profit between the mine Π_K and the power plant Π_E (Fig.2), what in fact excludes price negotiation, unless:
   a. An area around the maximum of joint profit is almost flat or there are a few local maximums on the same level and it is possible to depict the new contract curve (Fig.2) and
   b. During negotiation, in conditions of cooperation and mutual trust, other split of joint profit has been decided and realized through:
      i. side payments (in order to decrease the profit levels differences or realize agreed division),
      ii. determination of other lignite price – transfer price p_{wt} , which will be used only for clearing accounts between both sides of BM in order to attain agreed profit division. In such a case both the selection of ultimate pit as well as other decisions about its shape and size change should be done based on optimal price (economically justifiable) maximizing joint profits of the whole system in order to keep economic rationality and effectiveness of mine activity. Usage of transfer prices other than optimal requires close cooperation, so it is rather possible in a holding or in a vertically integrated firm.
4. Necessary condition for finding optimal solution for BM is the realization of pit optimisation and parameterisation process. Sensitivity analysis of the size and shape of ultimate pit on changes of

lignite base price is necessary to determine the influence of base price on long run supply of lignite, change of averaged quality parameters and costs of power plant and mine (Jurdziak & Kawalec, 2004). For this purpose it is also required to take into account the electric energy market through usage of long term forecasts of electric energy demand and expected level of electricity prices.

5. Realization of open pit optimisation process is not possible without prior creation of 3D structural and quality models of a lignite deposit which are the base for value model (Jurdziak, 2000). Geological modelling can be done in special mining and geology software such as e.g. Datamine Studio. The value model can be created there or in pit optimisation software e.g. NPVScheduler.
6. Described procedure of selection of ultimate pit maximising joint profits of BM can be used for optimal, 3D delimitation of mineable reserves based on economic criteria connected both with the mine as well as the power plant and electric energy market on which both are active.

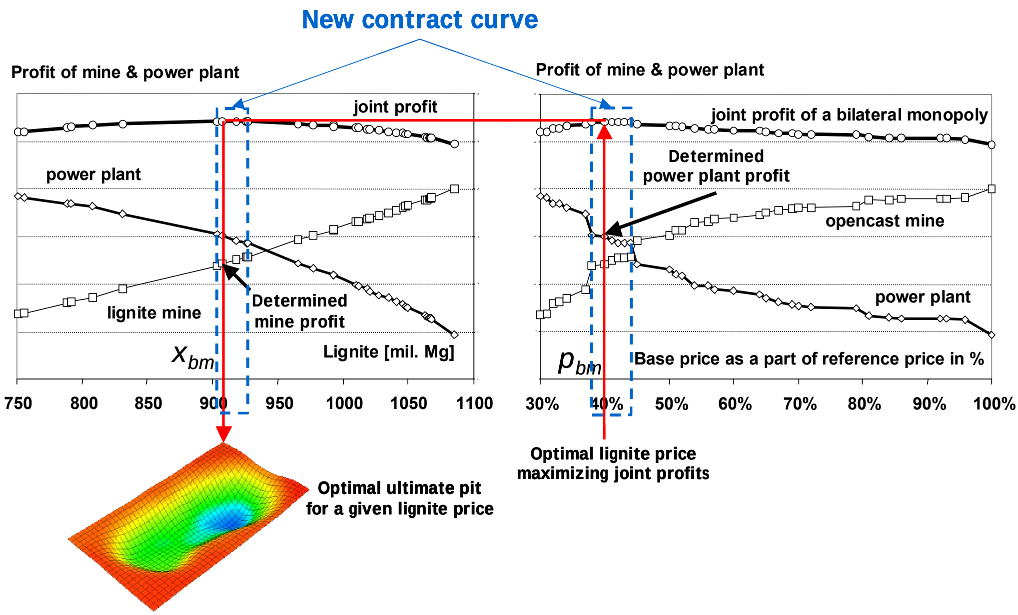

Figure 2. Joint profit of mine & power plant as a function of lignite quantity when the electric energy price p_e = 0.13 zł/kWh - the hypothetical solution for the pit placed on the "Szczerców" deposit.

2 NEGOTIATION BETWEEN POWER PLANT AND MINE AS A COOPERATIVE, TWO STAGE, TWO-PERSON, NON ZERO-SUM GAME

Utilization of a BM model and methods of open pit optimisation allows on treatment of lignite price negotiation between mine and power plant as a co-operative, two stage, two person, non zero-sum game (Jurdziak, 2006a). Due to improvement in economic results should be found in optimal adjustment of shape and size of ultimate pit to electric energy demand and not in prolonged negotiation of lignite price the game should be carried in two stages.

In the first one (strictly cooperative) both sides on the basis of disclosed cost data and outcomes of the parameterisation process of lignite deposit should choose ultimate pit maximising joint profits of the whole system. The first stage would be two person, non zero-sum game.

In the second stage, if the division of profit implicated by optimal solution is not satisfactory for one of sides, both of them should agree on different division and on connected with it lignite transfer price. So the problem of choosing appropriate transfer price would be only a technical one. It should be stressed that the agreed and accepted split of profit would determine the transfer price and not the other way round. This stage would be the positive-sum game in which the sum is equal to maximal profit Π_{Vmax}.

In the mine there would be two lignite prices: economically justified (determined by the solution of modified BM of lignite mine and power plant) and transfer price – used only for mutual clearing of accounts – realization of agreed profit division.
The organizational and ownership structure of BM of mine and power plant and attitude of both sides to mutual negotiation play a key role in its functioning and possibility of joint realization of optimal solution – maximizing joint profits. There are inherent contradictions in BM such as: conflict of individual and group rationality and asymmetry of information, which could lead to solutions which are not optimal in Pareto sense. These subjects are described in separate paper.

3 THE ROLE OF LIGNITE PRICES

3.1 Lignite prices in conditions of their control and confirmation

The history of price, price lists and price formulas of lignite used and proposed between 1990 and 2003 has been presented in (Jurdziak, 2005). In this period of time lignite prices could not be freely formed, but were regulated or ratified by the President of The Energy Regulatory Office. At the beginning of the 90-ies lignite prices were calorific value and ash content varying and were a simple multiplication of prices used in the 80-ties. Only the "Turow" lignite mine, instead of price tables, used its own individual price

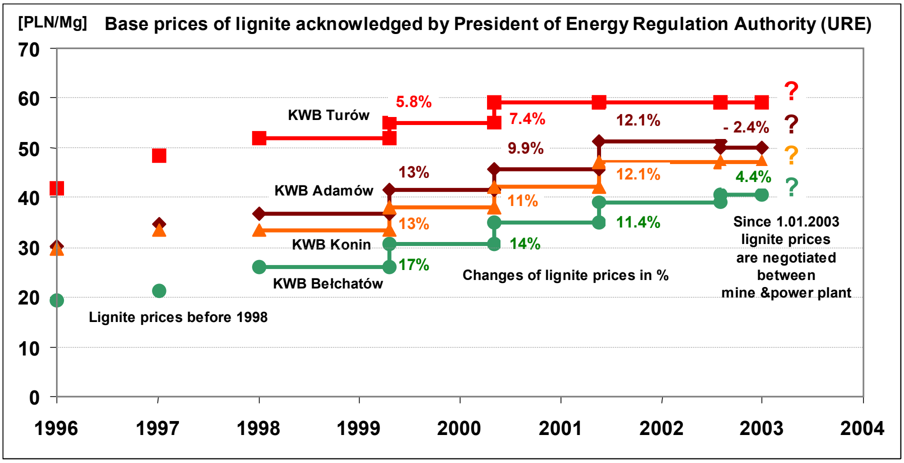

Figure 3. Changes of lignite prices in different mines in the period 1996-2003 (Jurdziak, 2005).

formula taking additionally into account the influence of sulphur and water content in lignite. Prices did not satisfy mines and power plants. Mines with price levels which did not guaranteed them profitability and power plants with price structure which exaggerated the influence of lignite quality on their profits. Several lignite price formulas taking into account calorific value, sulphur and ash content were worked out. Formulas designed in the Polish Academy of Science (CPPSMiE PAN) were based on three elements: price level (the base price of reference lignite), price structure (lignite quality parameters varying) and the rent allowing on price differentiation according to geology & mining conditions in a particular mine. The authors tried to connect lignite and hard coal prices and determine the influence of lignite quality deviation from reference coal on environmental costs.
New "Energy Industry Law", voted in April 1997, introduced the requirement of lignite price confirmation by the President of The Energy Regulatory Office and precisely regulated formation of lignite prices (Art.48). Base prices of referenced lignite could cover only justified expenses of mines (which were described in detail by this law), margin of profit not greater than 10% and appropriate tax. In paper (Jurdziak, 2005) trials of mines to increase lignite prices during the period 1998-2003 and confirmed lignite prices for different mines has been presented (Fig. 3).
On the 1.01.2003 the art. 48 of the "Energy Industry Law" has been cancelled, what eventually ended the period of control and confirmation of lignite prices in Poland. Since that moment lignite prices can be

freely negotiated between power plants and mines. This new situation has opened the area of research and analysis of BM operation and the role of lignite price in relation of both sides on a free market.

3.2 Lignite price as a profit sharing tool in Nash bargaining solution

In case of negotiation between mine and power plant the Pareto optimal set is the line of joint profit $\Pi_K+\Pi_E=\max(\Pi_V)=\Pi_{Vmax}$ (where $x=\Pi_K$ and $y=\Pi_E$) drawn for the ultimate pit (one of phases) which maximises joint profit for a given cost structure and future level of electricity prices (treated as a profit of vertically integrated energy producer Π_V). It is the line with slope coefficient -1 located furthest from the point (0,0) and going through one of points representing optimal phase (Fig.4). Methodology of finding the optimal pit has been described in paper (Jurdziak, 2004a).
The area of grey triangle located in the 1st quarter of coordinate system (a positive one) below the Pareto optimal line (Fig.5) can be treated as the acceptable set of solutions of negotiation/bargaining between mine and power plant. Nor the mine neither the power plant will voluntary accept loses when their joint profit is positive. It is impossible to attain greater profit than Π_{Vmax}, so all solutions should be in the triangle determined by points: (0,0), (Π_{Vmax}, 0) and (0, Π_{Vmax}). In case of linear transferability of utility function of payoffs (in this case a profit is treated as payoff in bargaining game) the problem of profit sharing is much simpler and appropriate Nash solution is given by point (x_0, y_0) (Owen, 1975):

$$x_o=0.5\,(x^*-y^*+\Pi_{Vmax}) \qquad (1)$$

$$y_o=0.5\,(y^*-x^*+\Pi_{Vmax}) \qquad (2)$$

where $\Pi_{Vmax}=x+y$ and (x^*, y^*) represents coordinates of the status quo point.

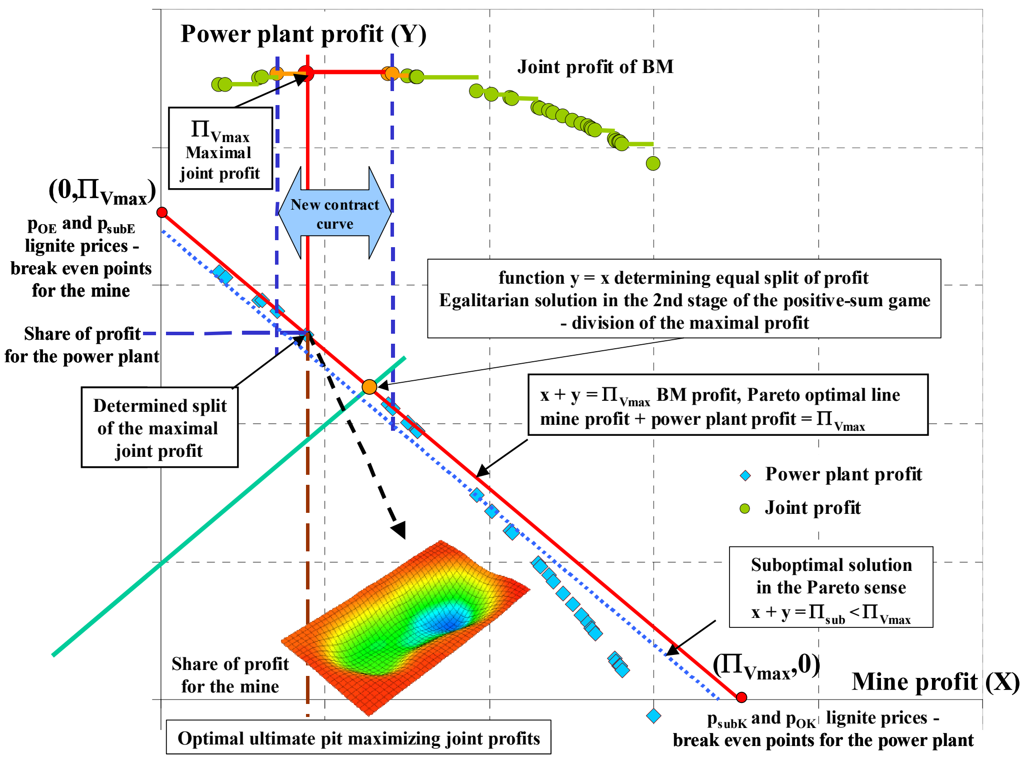

Figure 4. Power plant and joint BM profits as a function of mine profits for 35 ultimate pits generated for the “Szczercow” deposit” for different lignite prices and stable electric energy price 0.13PLN|/kWh.

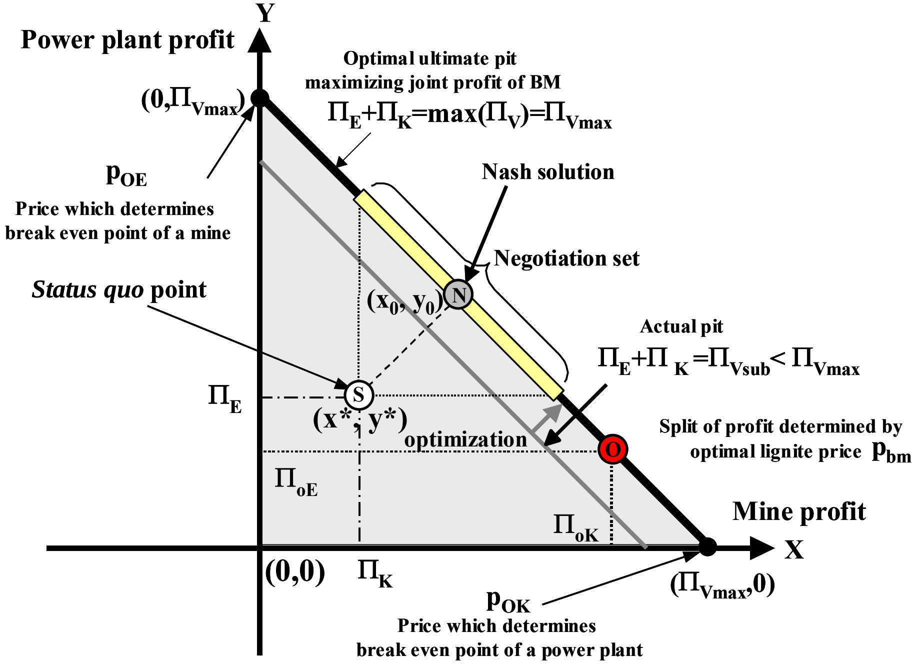

Figure 5. Set of acceptable solutions - game outcomes (the area of grey triangle), the status quo point (S) determining negotiation set on the Pareto optimal line plus the Nash solution (N) and the optimal solution (O).

It easy to see that x_o+y_o_=Π_{Vmax} and x_o-y_o =x*-y*, so in this case mutual location of both sides is kept unchanged and surplus utility of payments (profit) is equally divided between both sides (Owen, 1975).
Graphical solution can be found on the intersection of line with slope coefficient +1 going through the status quo point and the negotiation set on the Pareto optimal line (N) (Fig.5).
The division of profit determined by the optimal lignite price p_{bm} (O) can be placed outside negotiation set (Figs 5, 6), what means that it can not be the solution of the game. The mine can not expect to get profit Π_{oK} due to the power plant profit Π_{oE} is below Π_E – its safety level determined by the status quo point. It should be remembered that all data are only hypothetical and mutual location of all points in real situations can be different (compare with Fig.4). Profits, the optimal lignite price, border prices of lignite determining break even points for mine and power plant as well as lignite contours have to be calculated individually for the particular deposit based on revenues and costs of mine and power plant and taking into account their specificity.
Additional space is required for the discussion of proper choice of status quo point and its usage in tactical and strategic negotiations as well as treatment of described here optimisation process as a real option to change the scale of mine activity.

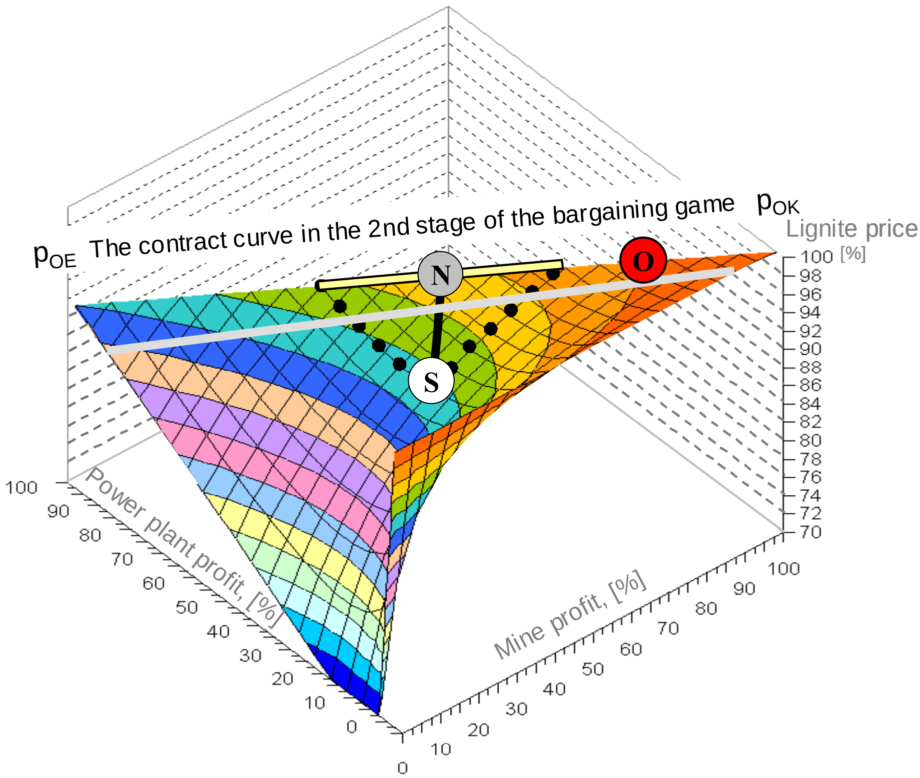

Figure 6. Acceptable solutions with hypothetical contours of lignite prices as a function of two profits, the status quo point (S) determining negotiation set with the Nash solution (N) and the optimal solution determined by the optimal price p_{bm} (O) plus the contract curve in the 2nd stage of the game - the Pareto optimal line between prices p_{OE} and p_{OK}.

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