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Oil Price Indexing Of Natural Gas Prices An Economic Analysis*

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Contents

Abstract

Oil price indexing is a peculiar feature of the natural gas markets in Germany and other European countries. It is closely linked to the existence of local monopolies (at least de facto) and of the so called “take–or–pay” (TOP) contracts. After discussing the relation between these features and the motivations for oil price indexing, we formally analyze this strategy in a differentiated good oligopoly with a monopolistic supplier of natural gas and competing oil distributors. Starting with a symmetric setting, we first point out how oil price indexing works as a collusive device. In a second step we account for the likely asymmetries between oil and gas distributors. We show that the result obtained under symmetry is not robust and we discuss how the impact of oil price indexing on prices, profits and welfare depends on the form and extent of the asymmetries.

Zusammenfassung

Die Ölpreisbindung des Erdgaspreises ist ein hervorstechendes Merkmal des Gasmarktes in Deutschland und anderen europäischen Ländern. Diese Besonderheit ist eng verknüpft mit der Existenz lokaler Monopole (trotz Liberalisierung bestehen diese bislang zumindest in Deutschland de facto weiterhin) und sogenannter “take–or–pay” Verträge (TOP contracts), d. h. fixer Abnahmeverpflichtungen zu einem an die Entwicklung des Ölpreises gekoppelten Abnahmepreises. Nach einer Diskussion der Beziehung zwischen diesen drei Besonderheiten des Erdgasmarktes und der möglichen Gründe für die Ölpreisbindung analysieren wir diese Strategie in einem Oligopolmodell mit differenzierten Produkten mit einem monopolistischen Erdgasanbieter und einem oder mehreren konkurrierenden Ölhändlern. Zunächst zeigen wir im Rahmen einer symmetrischen Spezifikation auf, wie die Ölpreisbindung die Kollusion zwischen Erdgas– und Ölanbietern ermöglicht. Anschließend berücksichtigen wir mögliche Asymmetrien zwischen den beiden Energieformen. Dabei zeigt sich, dass das Ergebnis bei Symmetrie nicht robust ist und wir diskutieren im Detail wie die Auswirkung der Ölpreisbindung auf Preise, Gewinne und Wohlfahrt von der Art und vom Ausmaß der Asymmetrien abhängt.

Keywords: Natural gas market, Oligopoly, oil price indexing, Take–or–pay contracts

JEL–classification: D 43, L 41, L 59

1 Introduction

Due to national implementation of EU regulation and the changing attitude of competition authorities and regulatory agencies, the institutional settings in the European national markets for natural gas are changing. Considering the present situation in the German natural gas market, three peculiar features attract attention: Natural gas is distributed by local monopolies, there exist long term contracts between importing firms and the local distributors as well as between these importing firms and the foreign gas producing countries in the form of long–term take–or–pay contracts, and, finally, the prices on all stages of the vertical chain are based on some average of oil prices in the past few month (so called "oil price indexing"). All these features are under scrutiny by competition authorities. However, it is not clear whether the discussed changes in law and institutional arrangements will actually result in a more competitive German natural gas market with lower prices for final consumers.

To shed some light on this issue we explore the competitive effects of oil price indexing in the present institutional setting. As oil and natural gas are close substitutes, at least for some purposes like heating or generating of electricity, this kind of competition might in principle yield highly competitive natural gas prices. However, whether this is actually the case depends on the competitiveness of the global and local oil markets, the actual degree of substitutability between the two energy sources, natural gas and oil, and, last but not least, on the effectiveness of oil price indexing as a collusive device. While some of these aspects must be explored empirically and are thus beyond the scope of the present analysis, we are going to discuss the interaction of substitutability, competitiveness in the oil market and the strategy of oil price indexing. This enables us to point out under what circumstances deviations from the competitive equilibrium are likely to be substantial.

In Germany oil price indexing of the natural gas price was introduced in private long term contracts between exporters and importers in the late 1960s (Auer 2003). The natural gas price is usually calculated according to the 6/3/3–rule (BET 2005): The oil price is observed for six months, then an average oil price is calculated for that time. After a short time lag of three months, the average price will be enforced for the following three months.

At the time of introduction, oil price indexing seemed appropriate for a number of reasons: In long–term contracts, there must be rules about the adjustment of prices. It seemed reasonable to peg prices to oil, the major competing energy source. As natural gas only had a very small market share the anti–competitive effect of such a move was almost negligible. Oil price indexing also insured the investment of local distributors and final consumers against the threat that the few natural gas producing countries would abuse their market power once substantial (specific) investments were made. However, the situation has changed as natural gas has become the dominant energy source for new installations in the heating market and also a major competitor in other sectors of the energy market. Therefore, recently more and more criticism emerged, arguing that oil price indexing is no longer appropriate (Gassmann 2004). Critics point out that nowadays the natural gas market has matured and so oil price indexing is only a distortion of competition. Industry lobbyists counter that liberalization of the natural gas market would jeopardize the security of supply since only the most "attractive" markets would be served (E.ON 2004). In 2005, the German *Bundeskartellamt* (Federal Antitrust Division) started an investigation on oil price indexing. Some of their arguments against oil price indexing were summarized in Beuret (2005): (i) The historic reasons are no longer valid, since more and more applications of oil are substituted through natural gas. (ii) The oil price is mainly driven by political events and therefore very unstable. (iii) As worldwide oil stocks are decreasing, oil prices will increase. Higher oil prices will drive up the price for natural gas although natural gas itself is not short.

As already mentioned, oil price indexing is closely linked to so called take–or–pay contracts (TOPs). TOPs are long–term supply contracts that last from one up to three decades and have typically high unconditional payment obligations (Auer 2003). They are justified by the long–term balance of risk between the natural gas producers and the importers. They guarantee the security of supply, and by also specifying the adjustment of prices they reduce the hold up problem for specific long term investments. Along this lines Masten and Crocker (1985) showed that TOPs are an appropriate instrument to achieve efficiency. While critics argue that there has never been a serious conflict between the natural gas importers and exporters — except for the recent dispute between Russia and Ukraine — there might still be a hold up problem due to the limited number of potential suppliers. However, note that natural gas prices must not necessarily be pegged to the oil price and even if oil price indexing prevails in long–term contracts in the upstream market, this does not necessarily imply that oil price indexing is also appropriate in local downstream markets.

In this paper we analyze the impact of oil price indexing in local markets in a differentiated good oligopoly model. We assume that oil and natural gas are imperfect substitutes. In a fully symmetric setting it is straightforward to show that oil price indexing serves as a collusive device and reduces welfare. However, this result is not necessarily robust if we introduce some reasonable asymmetries between oil and natural gas. From a theoretical point of view we discuss a very specific strategic commitment — pegging the own price to the price of a competitor — in an oligopoly model with asymmetries. Specifically, we consider differences in the valuation by consumers and differences in the degree of substitutability within a specific form of the differentiated good (competing oil suppliers) and between these specific forms (competition between oil and natural gas suppliers). As the kind of commitment under consideration is only a second best strategy (compared to the Stackelberg solution), it is not very surprising that this strategy might no longer be appropriate in a world with asymmetries. It is, however, our contribution to show which kind of asymmetries are likely to affect the outcome qualitatively and how prices, profits and welfare change in the different settings.

To discuss the impact of oil price indexing in different competitive settings we proceed as follows: Before analyzing our theoretical model, we discuss the various reasons for oil price indexing in section 2 in order to give a broader perspective on the issue. The following section 3 develops the baseline case, a duopoly model with differentiated products, and shows how the degree of gas–oil substitutability and preferences of consumers for one energy source affect the competitive impact of oil price indexing. In section 4 we extend the analysis by assuming an oligopoly in the local oil market. We are then able to consider the number of competing oil suppliers and differences between intra–oil and gas–oil substitutability as influencing factors. Finally, section 5 concludes by summarizing the results obtained in the model and deriving implications for the German natural gas market.

2 Oil price indexing: Motives and impact

Before we start analyzing the potential effects of oil price indexing in an differentiated product oligopoly model, we will highlight aspects of this kind of strategy in a more broader setting. The main points are (i) oil price indexing as a smart entry strategy, (ii) the interaction of TOPs in upstream and downstream markets and (iii) insuring consumers against absolute and/or relative price changes after investment.

In the 1960s coal and oil where the main energy source for heating and electricity generating in Germany. As natural gas tried to get a larger share of this market, oil price indexing was a very clever strategy: When deciding about their investment, consumers are insured against the possibility of hold–up by the natural gas suppliers and against absolute and relative price changes by pegging the natural gas price to the oil price that was quite stable at this time. Beyond that, from a game theoretic perspective oil price indexing was a “puppy dog” strategy, i. e. a promise to refrain from a aggressive pricing policy as long as the oil firms would accommodate entry, combined with the threat that natural gas prices would be adjusted downward when the oil firms would try to induce exit by lowering oil prices. At this point of time the strategy was not a problem for competition policy authorities as the small scale entry of a new competitor was definitely a pro–competitive act. Note, however, that this argument is no longer appropriate at present when the strategy of oil price indexing is still in place but natural gas has become a large scale competitor in the energy market.

Another line of reasoning for oil price indexing in the downstream market is based on the fact that there are long term TOPs upstream that use oil price indexing to address the hold–up problem in such a long term relationship. To ensure their sales of the provided natural gas, the national natural gas distributors have similar TOPs with local suppliers. However, while this affects the costs of these local suppliers it surely does not imply that they have to fix their pricing policy to oil prices.

A last argument that has been put forth by natural gas suppliers is the insurance of consumers against price uncertainty. There are two elements of this case for oil price indexing that should be distinguished: There might be a (partial) insurance against absolute price changes if spot markets for oil are less volatile than the few spot markets for natural gas (note, however, that oil prices have been quite volatile since the 1970s). The second element is a insurance against relative price changes — the investment decision of a consumer will than be optimal ex post if it has been optimal ex ante. Note, however, that the second point will be already addressed if there is oil price indexing in upstream markets only as this will affect costs and thus prices of local natural gas distributors accordingly without unnecessarily introducing a collusive element.

In our formal analysis of oil price indexing we want to concentrate on the strategic impact of this strategy. We show how it works as a collusive device and discuss how details of the market structure and asymmetries between oil and natural gas suppliers affect the results on prices, profits and welfare. To highlight these points it is necessary to abstract from other aspects: (i) We do not explicitly consider the dynamic structure of pricing. As explained earlier, in reality the price of natural gas does not depend on today's oil price but on an average of past prices. However, due to the fact that the pricing policy affects medium to long term investment decisions the basic strategic impact would remain: Oil suppliers would still be able to determine the price of natural gas by their pricing decision and consumers would foresee that natural gas will follow a lagged but otherwise identical pricing price path. (ii) In reality consumer switching costs are likely to be the main reason that natural gas and oil are only imperfect substitutes. However, a model with switching costs would have been much more complicated to analyze and it would have been almost impossible to introduce asymmetries in a meaningful way.

3 Baseline case: A monopolistic oil supplier

We do now consider a situation with a single natural gas distributor in a local area. While this firm is therefore a monopolist in the local natural gas market, this might not be the relevant market as there is competition by suppliers of other energy sources: Consumers are not per se interested in natural gas but look for some kind of primary energy to fulfill their energy needs. Given this broader definition of the relevant market, the natural gas distributor competes with suppliers of other forms of energy, namely suppliers of oil. Oil and natural gas are, however, only imperfect substitutes: Different forms of primary energy are more or less suited to perform the various needs of energy consumption for transportation, heating or else. There might also be switching costs which are due to specific investments in devices that are only usable with a specific form of primary energy.

For this reason we think that it is appropriate to discuss oil price indexing in an oligopoly model with differentiated products. For various assumptions about the degree of competitiveness among oil suppliers and about asymmetries between oil and gas we ask how oil price indexing affects the market outcome. As a baseline case we consider the competition between a natural gas distributor and one oil supplier under symmetric product differentiation with zero marginal cost. Because this fully symmetric setting is not likely to be an appropriate description of reality, we allow for the possibility that consumers may prefer natural gas over oil or vice versa: For the natural gas supplier the intercept of his linear inverse–demand schedule is assumed to be α instead of one. Formally we derive the inverse demand functions by assuming a representative consumer with linear–quadratic utility

$$U\left(x_1, x_2; x_0\right) = \alpha x_1 + x_2 - \frac{1}{2}\left(x_1^2 + x_2^2 + 2\beta x_1 x_2\right) + x_0 \tag{1}$$

with x_1 and x_2 indicating the consumption of natural gas and oil, respectively, and x_0 representing a numeraire good which is assumed to be produced in another sector of the economy and has been added linearly to ensure that the marginal utility of income is equal to one (thus allowing a partial equilibrium welfare analysis).[1] The parameter α is a measure of the preference for one of the two goods: A value of α that exceeds one indicates that the representative consumer obtains a higher utility by consuming one unit of natural gas while a value below one means that the consumer prefers oil instead. The parameter β describes the degree of substitutability between natural gas and oil: If the products were perfect substitutes $\beta = 1$, if they are independent $\beta = 0$. In our analysis

[1] This demand structure is adapted from Dixit (1979). It has been applied elsewhere, for example by Bester and Petrakis (1993) to analyze cost reducing R&D in a differentiated good industry or by Bandulet and Morasch (2003) to analyze incentives to invest in electronic coordination.

we will first normalize the market size parameter α to 1 in order to analyze the impact of β. In a second step we will then fix β to an intermediate value and check how $\alpha \neq 1$ might change the results.

Given the utility function in (1), the consumer maximization problem leads to linear inverse demand functions

$$p_1(x_1, x_2) = \alpha - x_1 - \beta x_2 \tag{2}$$
$$p_2(x_1, x_2) = 1 - x_2 - \beta x_1. \tag{3}$$

To analyze the duopoly with price strategies we need demand functions that express quantity demanded as a function of the two prices. Based on the inverse demand functions (2) and (3) straightforward calculations yield:[2]

$$x_{1,\ n=1} = \frac{(\alpha - p_1) - \beta(1 - p_2)}{(1-\beta)(1+\beta)} \tag{4}$$
$$x_{2,\ n=1} = \frac{(1 - p_2) - \beta(\alpha - p_1)}{(1-\beta)(1+\beta)}. \tag{5}$$

For $p_1 > \alpha$ we get $x_{1,\ n=1} = 0$ and for $p_2 > 1$ we get $x_{2,\ n=1} = 0$. The maximum demand (α for natural gas and 1 for oil) results if natural gas and oil are independent products and prices are zero. The higher the degree of substitutability between natural gas and oil, the higher is the negative effect of lower prices of the competing energy source on own demand.

Concerning cost we normalize marginal and average costs of both firms to zero. Fixed costs are not considered as they do not affect strategic reactions as long as both firms remain in the market (as is assumed further on). Assuming zero marginal cost can be easily justified in a model with linear demand, as qualitative results would not change if we assume positive marginal costs. Besides, due to oil price indexing in upstream markets procurement costs of local oil and natural gas suppliers should be the same and thus it seems reasonable to assume identical (marginal) costs.

Based on the demand functions and our assumptions about costs we are now able to compute the equilibria of the simultaneous move game under price competition and the sequential move game with oil price indexing. The equilibrium under price competition is derived by simultaneously solving the first order conditions of the profit maximization problems of the natural gas and the oil producer. Under oil price indexing the natural gas producer is assumed to move first by setting his price function $p_1^{opi}(p_2) = p_2$ (the superscript *opi* stands for "oil price indexing"). In the second stage the oil producer

[2] The subscript $n = 1$ indicates that we consider the situation with only one oil supplier.

replaces the variable p_1 in his profit function by $p_1^{opi}(p_2)$ and obtains his optimal price by maximizing the resulting function $\pi_2(p_2)$.

In the simultaneous move game we obtain the following equilibrium values:

$$p^*_{1,\ n=1} = \frac{2\alpha - \beta(1+\alpha\beta)}{(2-\beta)(2+\beta)} \tag{6}$$

$$p^*_{2,\ n=1} = \frac{2 - \beta(\alpha+\beta)}{(2-\beta)(2+\beta)} \tag{7}$$

The highest prices result for $\beta = 0$ where the natural gas supplier charges $\alpha/2$ and the oil supplier $1/2$. For $\beta > 0$ the price of natural gas rises as α increases while at the same time the price of oil declines. Both prices decrease with a rising degree of substitutability between the two energy sources. For $\alpha = 1$ and $\beta = 1$ both firms charge a price of zero (the well known Bertrand paradox), for $\alpha > 1$ and β close to zero we obtain a corner solution where the oil supplier stays out of the market (but remains a potential competitor) while the natural gas supplier chooses the entry blocking price $\alpha - 1$.[3]

Under oil price indexing the oil supplier chooses the profit maximizing price under the assumption that the natural gas supplier will charge the same price. This yields

$$p^{opi}_{n=1} = \frac{1-\alpha\beta}{2-2\beta}. \tag{8}$$

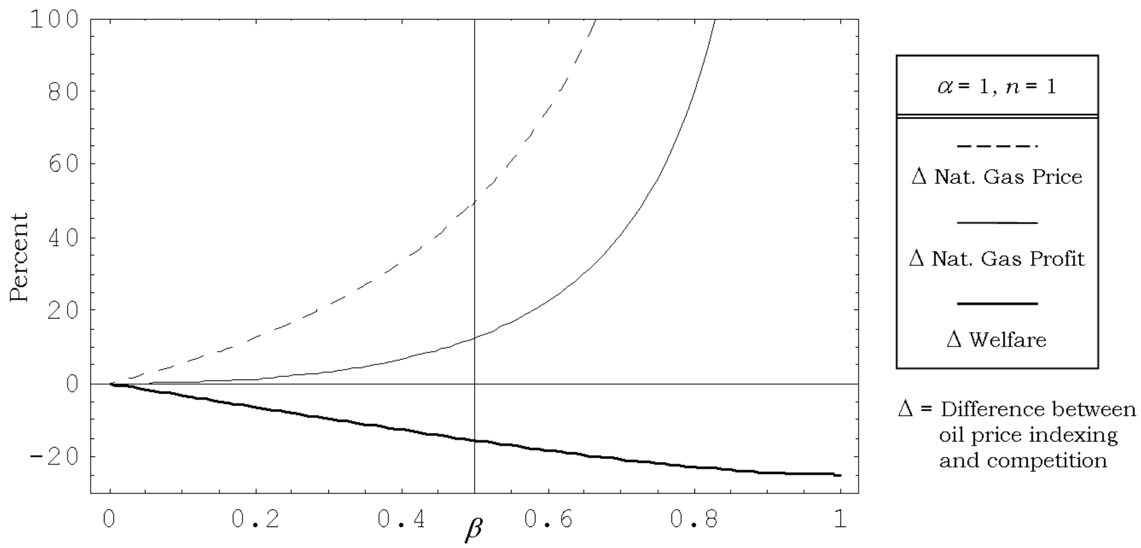
Note that for $\alpha = 1$ firms will charge the monopoly price $1/2$ irrespective of the degree of product differentiation — the oil supplier maximizes its profit by setting the monopoly price because it is assured that the natural gas provider will charge the same price. Oil price indexing will therefore have no effect for independent products while the collusive impact will increase as oil and natural gas become better substitutes (see figure 1). Note that the high percentage values for price and profit changes stem from the fact that prices under duopoly competition become quite low for close substitutes. The impact on welfare is less distinct as distributive effects between consumers and producers cancel out. Nevertheless, if the symmetric baseline case is an appropriate description of reality, competition authorities should be quite critical with respect to oil price indexing.

We will now deal with the question whether this result is robust if we introduce asymmetries. In this section we consider the case where $\alpha \neq 1$. A first interesting result is obtained by deriving the first order condition with respect to β:

$$\frac{\partial p^{opi}_{n=1}}{\partial \beta} = \frac{1-\alpha}{2(1-\beta)^2} \tag{9}$$

[3] In the further analysis we restrict attention to interior solutions but we wanted to point out that asymmetries could yield corner solutions if products are very close substitutes.

Figure 1: Impact of oil price indexing in the symmetric setting.

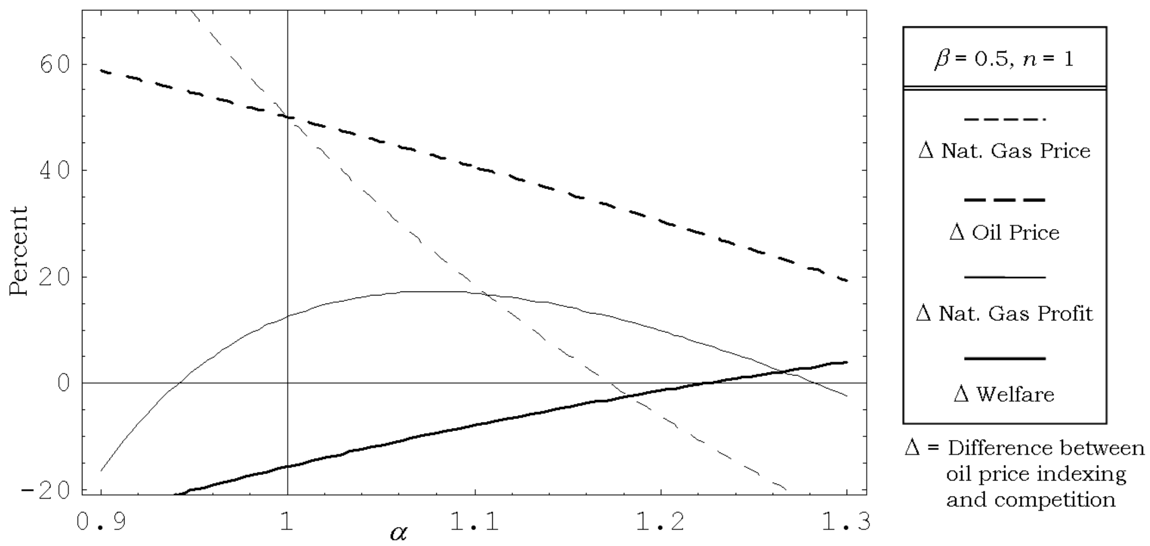


Source: Mathematica plot based on own calculations

As can be seen, for all $\alpha > 1$ the price under oil price indexing negatively depends on β while it depends positively on β for $\alpha < 1$ (as already stated above it does not depend on β for $\alpha = 1$). This is a first indication that oil price indexing may have a positive impact on welfare if natural gas is valued higher. On the other hand, if natural gas is an inferior energy source ($\alpha < 1$), the gas price under oil price indexing will always exceed the price under duopoly competition (and thus welfare will be reduced).

To take a closer look on the impact of α we do now fix β to an intermediate value to check how changes in α affect prices, profits and welfare. As can be seen in figure 2 (for $\beta = 0.5$) oil price indexing will not only reduce welfare but also result in lower profits for the natural gas supplier when the inferiority is sufficiently pronounced (in our setting if $\alpha \leq 0.94$) — intuitively, the oil supplier chooses a relatively high price because consumers have a higher willingness to pay and this price exceeds the optimal price for the natural gas supplier. If, however, natural gas is a sufficiently superior energy source ($\alpha > 1$), oil price indexing might yield a lower natural gas price than under competition (for $\alpha > 1.17$). This could be nevertheless in the interest of the natural gas supplier as the price of oil will be higher under oil price indexing and therefore natural gas will obtain a higher market share (profits remain positive until $\alpha > 1.28$). As oil prices are always higher under oil price indexing, welfare will not rise until α reaches a value of 1.22 — however, there at least remains a small corridor where oil price indexing yields both higher profits for natural gas suppliers and higher welfare. Intuitively this can happen because the market share of the natural gas supplier rises and this is both in the interest of consumers (who value natural gas more highly) and the natural gas supplier. Note that oil price indexing even yields a Pareto improvement for α between 1.22 and 1.28 as the profit of the oil firm also rises relative to the competitive solution due to higher oil prices under oil price indexing.[4] Considering the development in the German energy market since the introduction of oil price indexing in the 1960s, it seems as if natural gas has become the superior alternative for many purposes (especially heating) and therefore the case with $\alpha > 1$ is not unlikely. So we cannot exclude the possibility that oil price indexing could have unintentionally improved welfare.

Figure 2: Impact of oil price indexing for $\alpha \neq 1$ and $n = 1$.



Source: Mathematica plot based on own calculations

In the next section we generalize the analysis by considering an inverse demand system with $n > 1$ oil suppliers that allows different degrees of substitutability between oil and

[4]In an asymmetric oligopoly it is welfare improving if a firm with lower marginal costs (or as in our interpretation a higher valued product) increases its market share as long as prices and aggregate output remain constant. Therefore a first stage strategy that yields a combination of a higher average price (that benefits the less "efficient" firm) and more unequal market shares (that benefit the more "efficient" firm and consumers) in the second stage could yield a Pareto improvement. Note that this result is related to the analysis of Salant and Shaffer, 1999, who observe that aggregate production costs in a second stage Cournot oligopoly strictly decline (more efficiency) with no change in gross revenue or gross consumer surplus if the first stage actions strictly increase the variance of marginal costs without changing the marginal–cost sum. However, while they show that there is an incentive to invest in asymmetry, we show how a strategic commitment can exploit an asymmetry to yield a Pareto improvement relative to the competitive outcome.

natural gas (β) and among oil suppliers (γ). This will introduce additional possibilities for welfare improving effects of oil price indexing.

4 Extensions: Oligopolistic oil market

We do now proceed to the general case with n oil suppliers. Here the utility function is somewhat more complicated,[5]

$$U\left(x_1,\ldots,x_{n+1}\right)=\alpha x_1+\sum_{i=1}x_i-\frac{1}{2}\left(x_1^2+\sum_{i\neq 1}x_i^2+2\beta x_1\sum_{i\neq 1}x_i+2\gamma\sum_{j\neq\{1,i\}}x_ix_j\right). \quad (10)$$

As already mentioned $\alpha\neq 1$ refers to cases where consumers value natural gas more ($\alpha>1$) or less ($\alpha<1$) than oil. The interpretation of β remains the same as before. γ describes the degree of substitutability between two oil distributors. We get perfect substitutes if $\gamma=1$, however, γ may be smaller than one if firms supply different qualities of oil or if they may be considered to be different by consumers with respect to other attributes (e. g. location or service).

From (10) we derive (11) and (12),

$$p_1(x_1,\ldots,x_{n+1}) \;=\; \alpha-x_1-\beta\sum_{i\neq 1}x_i \quad (11)$$

$$p_j(x_1,\ldots,x_{n+1}) \;=\; 1-x_j-\beta x_1-\gamma\sum_{i\neq\{1,j\}}x_i \quad j=2,\ldots,n+1. \quad (12)$$

To highlight the effects of asymmetries, we will now also consider the case with $n=2$, i. e. two competing oil suppliers (raising n further does not affect qualitative results). We apply the same steps as for $n=1$, e. g. rearrange for demand,

$$x_{1,n=2} \;=\; \frac{\left(\alpha-p_1\right)\left(1+\gamma\right)-\beta\sum_{i\neq\{1,j\}}\left(1-p_i\right)}{1+\gamma-2\beta^2} \quad (13)$$

$$x_{i,\;n=2} \;=\; \frac{\left(1-p_i\right)-\beta\left(\alpha-p_1\right)\left(1-\gamma\right)-\gamma\left(1-p_j\right)+\beta^2\left(p_i-p_j\right)}{\left(1-\gamma\right)\left(1+\gamma-2\beta^2\right)} \quad (14)$$

where $i,j=1,2$ and $i\neq j$. It is then straightforward to determine the equilibrium of the non–cooperative price game

$$p^*_{1,\;n=2} \;=\; \frac{\alpha\left[2-\beta^2\left(3-\gamma\right)+\gamma\left(1-\gamma\right)\right]-2\beta\left(1-\beta\right)\left(1+\beta\right)}{2\left[2\left(1-\beta\right)\left(1+\beta\right)+\gamma\left(1-\gamma\right)\right]} \quad (15)$$

$$p^*_{i,\;n=2} \;=\; \frac{2\left(1-\gamma\right)\left[\gamma+\left(1-\beta\right)\left(1+\beta\right)\right]-\alpha\beta\left(1-\gamma\right)\left(1+\gamma\right)}{2\left[2\left(1-\beta\right)\left(1+\beta\right)+\gamma\left(1-\gamma\right)\right]} \quad (16)$$

[5]Since it does not affect our later analysis we skipped the numeraire good x_0.

with i indicating the (identical) prices of the two oil suppliers. Again we compare this result with the equilibrium under oil price indexing. Note that we must now determine a non–cooperative equilibrium with the two oil suppliers as active players who both assume that the price of natural gas will be set equal to the average price of both oil suppliers, i. e. $(p_2 + p_3)/2$. Here we obtain

$$p_{n=2}^{opi} = \frac{2(1-\alpha\beta)(1-\gamma)}{4-\beta(3-2\beta)+\gamma(2-3\beta)}. \tag{17}$$

Comparing (8) with (17) we see that qualitatively the impact of α and β remains the same as in the case with $n = 1$ as long as $\gamma = \beta$,

$$p_{n=2}^{opi} = \frac{2(1-\beta)(1-\alpha\beta)}{4-\beta(1+\beta)}. \tag{18}$$

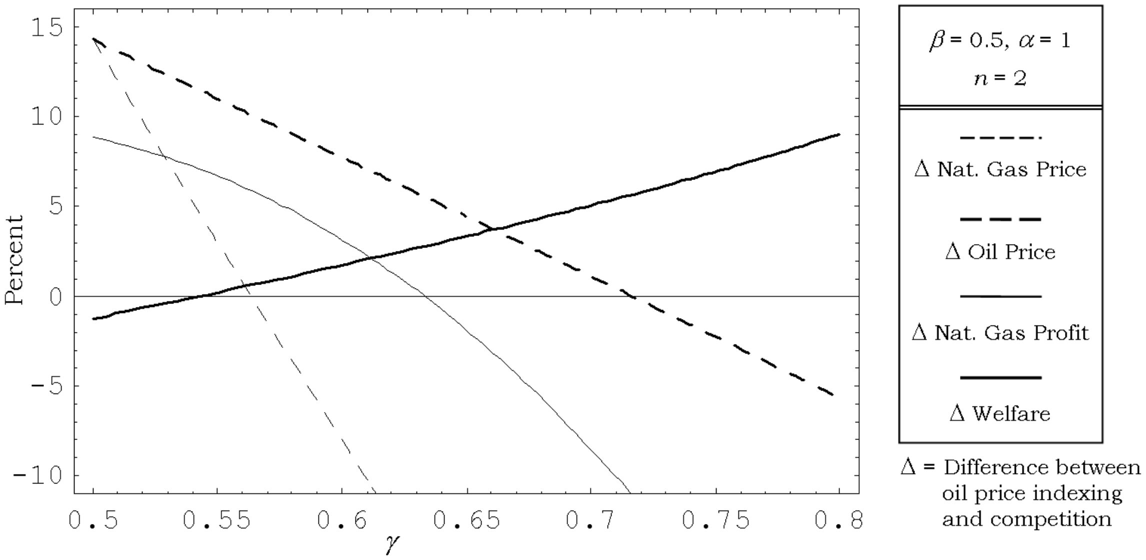
However, there is an additional effect if $\gamma > \beta$: The natural gas price under oil price indexing will decrease with the substitutability parameter γ — intuitively, oil suppliers that are closer competitors will set lower prices. It is therefore no longer assured that oil price indexing is beneficial for the natural gas supplier and even for $\alpha \leq 1$ welfare might be enhanced by oil price indexing.

To visualize the relative strength of the impact of $n > 1$, $\alpha \neq 1$ and $\gamma > \beta$ we will now again assume that $\beta = 0.5$ and show the result graphically. In the first two graphs we analyze the impact of $\gamma > \beta$ for $n = 2$ and $\alpha = 1$ and $\alpha = 0.9$ — the latter situation yields a reduction of profits and welfare for $\gamma = \beta$. In a next step we analyze the impact of the rising number of oil suppliers: First we show what changes result for the fully symmetric setting $\alpha = 1$ and $\beta = \gamma$. Finally, we check whether the results for $\alpha \neq 1$ are qualitatively affected if there are two competing oil suppliers instead of one supplier.

Figure 3 shows for $n = 2$ and $\alpha = 1$ the impact of a higher degree of substitutability between oil producers, $\gamma > \beta$. As the oil firms compete more intensively, the oil price under competition is lower than the natural gas price. Given this, oil price indexing, while still raising the oil price, might yield a lower price for the natural gas supplier. And if the degree of substitutability between oil producers rises further, even the profits for the natural gas supplier will be lower under oil price indexing. As in figure 2 there is a parameter range where both profits of the natural gas supplier and welfare are higher under oil price indexing (for values of γ between 0.54 and 0.63).

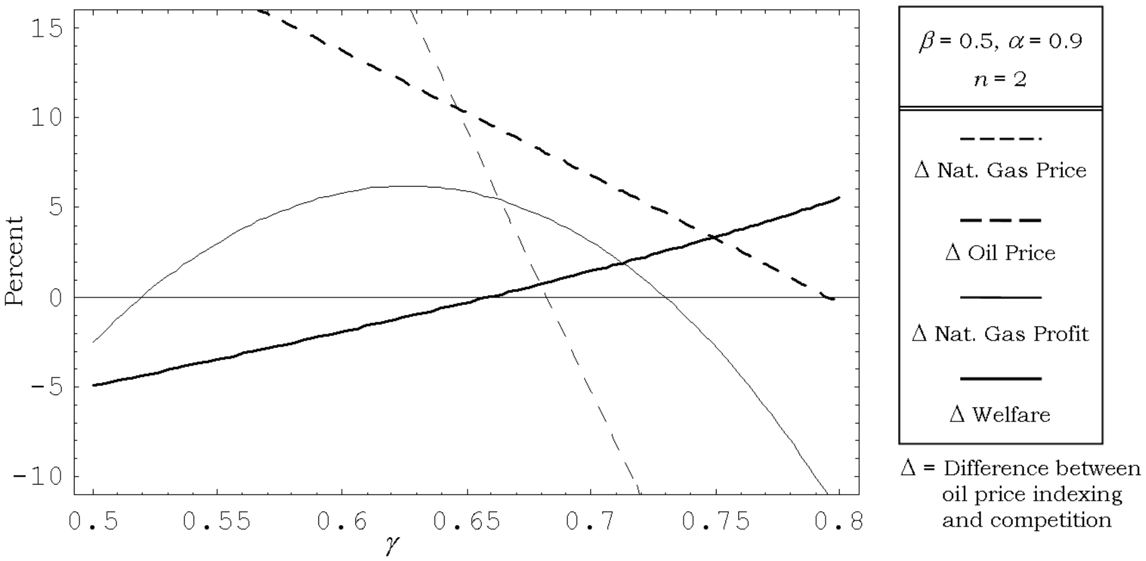
Figure 4 visualize an interesting interaction between the two different forms of asymmetry: For symmetrically differentiated products ($\gamma = \beta$) oil price indexing decreases the profits of the natural gas supplier whenever α is substantially below 1 (a closer inspection shows that this will be the case for all values of γ if $\alpha \leq 0.94$) — see also figure 2. If,

Figure 3: Impact of oil price indexing for $\gamma > \beta$ and $\alpha = 1$.



Source: Mathematica plot based on own calculations

Figure 4: Impact of oil price indexing for $\gamma > \beta$ and $\alpha = 0.9$.

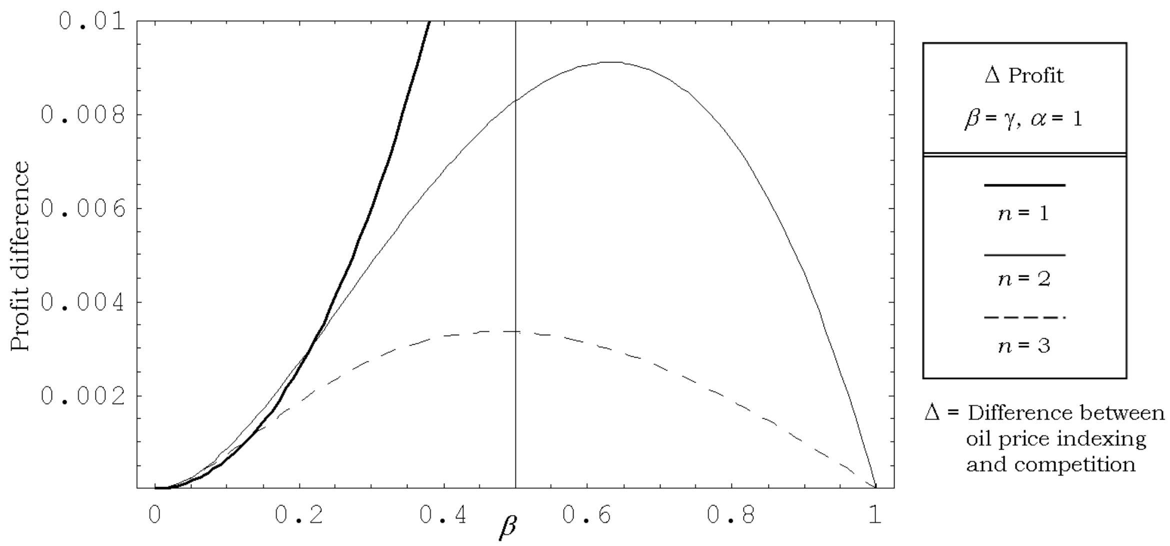


Source: Mathematica plot based on own calculations

however, $\gamma > \beta$, oil firms choose lower prices and therefore oil price indexing may increase profits of a natural gas supplier although α is substantially below 1 (in the figure $\alpha = 0.9$).

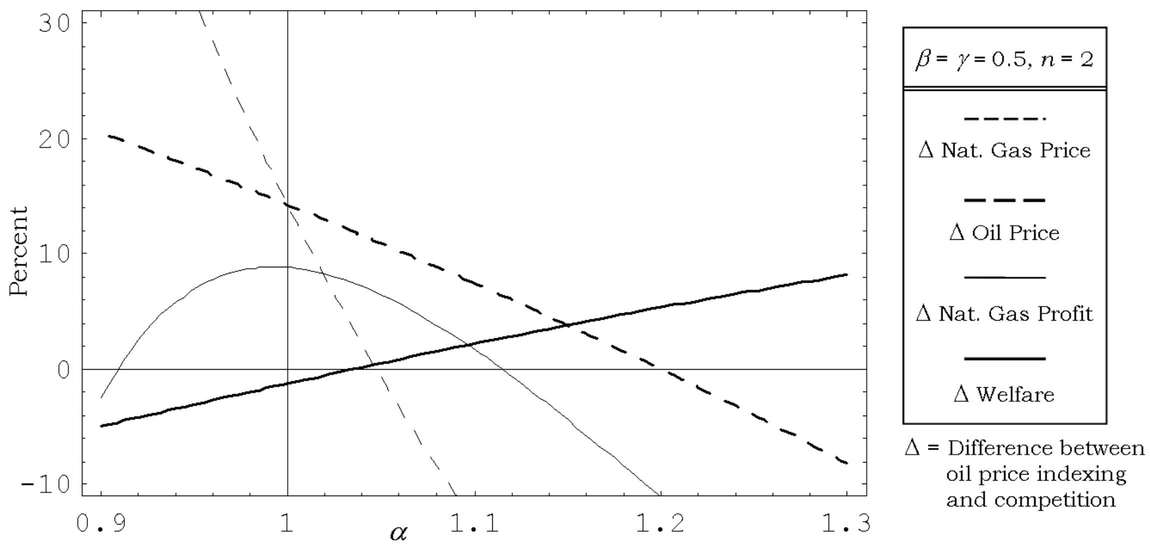
For the symmetric setting with $\alpha = 1$ and $\beta = \gamma$, raising the number of oil suppliers has only one qualitative impact: While the percentage change of profits under competition vs. oil price indexing still increases with rising γ, the absolute change in profits has a peak

Figure 5: Impact of oil price indexing on profits of natural gas suppliers for various numbers of competing oil firms.



Source: Mathematica plot based on own calculations

Figure 6: Impact of oil price indexing for $\alpha \neq 1$ and $n = 2$.



Source: Mathematica plot based on own calculations

for medium values of β (see figure 5). This result stems from the fact that competition between the oil suppliers is very intense for close substitutes (for $\beta = 1$ it does not even make any difference whether there are two, three or more competitors — the well known Bertrand paradox) and therefore the impact of oil price indexing on prices and profits becomes quite small in absolute terms (as profits in the competitive setting are even smaller due to the intense competition this result does not show up when we look at percentage changes).

Finally let us consider possible effects of a larger number of oil suppliers on the results for $\alpha \neq 1$. Figure 6 and figure 2 are based on the same assumptions, except that $n = 2$ in figure 6. A closer look shows that results do not change qualitatively, but the relatively low percentage change of welfare (less than 2 % compared to almost 20 % for $n = 1$) indicates that competiton authorities should be less concerned about oil price indexing if there are competing oil suppliers in local markets (as will be mostly the case) that are not able to coordinate their pricing policies (which might very well be the case).

5 Conclusion

We pointed out that the strategy of oil price indexing can serve as a collusive device whenever oil and natural gas are imperfect substitutes and the oil market is not perfectly competitive. That does not mean that oil price indexing will not serve other purposes as well — e. g. insuring market participants against absolute and/or relative price changes or enabling a system of long term contract. We only want to stress that this strategy is not likely to be innocuous in the competitive interaction between oil and natural gas suppliers.

As has been shown the negative impact on competition will be small as long as oil markets are highly competitive. However, there exists evidence that collusive behavior among oil suppliers is not uncommon. Oil price indexing might then have a significant impact on competition and welfare. In a symmetric setting the strategy of oil price indexing is always anti–competitive. But it seems to be more realistic to assume asymmetries: Consumers are likely to assign a higher valuation to one of the two energy sources and oil from another supplier should be a closer substitute than natural gas. We discussed how the form and extent of these asymmetries influences the effects of oil price indexing.

As there exists some empirical evidence that the relative valuation of natural gas has been increased since the introduction of oil price indexing (the rising market shares of natural gas are one indication), we cannot rule out the possibility that oil price indexing might have increased welfare and that prices and profits of the natural gas suppliers under differentiated good price competition might have been higher. Nevertheless, even if these would be actually the case, these are only unintended and more or less accidental results and therefore we would like to join the critics by stating that this kind of strategy should be abandoned. Considering the possible advent of competition in local markets for natural gas, this argument is reinforced by the fact that oil price indexing is likely to facilitate collusion between competing natural gas suppliers by providing a focal price.

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