Working Paper No. 48/04

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SNF Project No. 4326
Konkurransestrategi, tilgangsprising og investeringsincentiv
i et europeisk integrert gassmarked

The project is financed by Research Council of Norway

INSTITUTE FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION
NOVEMBER 2004
ISSN 1503-2140

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JEL classification: L51, L95, Q48

Keywords: Regulation, transport network, EU's gas market directive.

Abstract: This paper addresses the issue of national optimal tariffs for transportation of natural gas in a setting where national gas production in its entirety is exported to end-user markets abroad. In a situation where the transportation network is owned altogether by a vertically integrated national gas producer, it is shown that the optimal tariff depends on the ownership structure in the integrated transportation company as well as in the non-facility based gas company. There are two reasons why it is possibly optimal with a mark-up on marginal transportation costs. First, there is a premium on public revenue if domestic taxation is distorting. Second, with incomplete national taxation of rents from the gas sector, the transportation tariffs can serve as a second best way of appropriating rents accruing to foreigners. In a situation where the network is run as a separate entity subject to a rate of return regulation, it will be optimal to discriminate the tariffs between shippers for the usual Ramseyean reasons.

1 Introduction

Norway is a major producer of natural gas in the European gas market. A miniscule part of the production is used domestically and mainly for industrial purposes. Hence, the national interests in the gas sector are almost completely aligned with export interests. The selling of natural gas in the downstream market used to be separated from the upstream production. A centralized body representing all gas producers on the Norwegian shelf in the North Sea conducted the bargaining with respect to new sales contracts before decisions had been made as to what gas fields were to supply the gas. The sold volumes were then allocated to productions fields according to production efficiency criteria after the sales contracts had been concluded. This way of organizing the gas sector was conducive to maximum bargaining power in the downstream market and overall cost efficiency in the upstream production. The customers were typically large distribution companies so that the gas was sold on a wholesale basis.

This model was ruled out by EU's Gas Market Directive which was adopted in Norwegian legislation as of January 1, 2002. The purpose of the directive is to open the common gas market for competition through laying down common rules for transmission, supply and storage of natural gas. An important part of the directive deals with measures aiming at securing third parties without transportation facilities access to the existing transmission network on non-discriminatory terms. The transportation facilities had earlier been reserved solely for the network owners. However, according to the directive large customers and gas producers without their own pipelines are to be considered legible to access the gas transmission network on equal footing with the facility owners on conditions that do not distort the competition in the downstream market. A neutral treatment of access to the network for third parties is facilitated by separating selling and transportation roles. Consequently, the network has been reorganized as a joint venture and an independent system operator has been established and has the assignment of transportation rights as one of its main tasks.

As a natural resource in limited supply there is an economic rent associated with the extraction of gas. Until the adoption of the Gas Market Directive the Norwegian policy had been that this rent should be harvested on the production fields and not in the transportation network. When the network was owned by the developers of the gas field, this issue was not very important as the transportation costs were considered an integral part of the total investment and operating costs of the gas fields in question. With the separation between transportation and selling of gas the problem of optimal tariffs has become an important issue; in particular with respect to the pricing policy towards third parties.

Clearly, if the economic rents from gas extraction were fully appropriable in the producing country, it would be first best optimal to price the use of the transportation facilities at marginal cost. That would maximize the contribution from the gas sector to the domestic value added. However, for various reasons the domestic appropriation of the economic rents is incomplete. An important shortcoming in this respect is that economic rents are rarely taxed fully in the producing country in so far as there is foreign ownership in domestic gas production. Moreover, multinationals can channel part of the rents out of the domestic tax jurisdiction through transfer pricing and internal financial transactions. Also, foreign customers with a strong bargaining position may get hold of some of the rents trough exerting monopsony power which has become more likely in the new regime with gas companies selling their gas independently of each other. Hence, the present paper is based on the explicit assumption that the producer country cannot capture fully the resource rent from gas production, and the main issue is whether the tariff rates for gas transport can serve as an imperfect substitute for a theoretically perfect but not fully implementable national tax on economic rents. We also assume that the domestic taxation is generally distorting so that there is a premium on public revenue.

The transportation facilities can be seen as inputs in the production and distribution of gas and a mark up on marginal transportation costs will then be in the nature of an indirect tax on this particular input. An important result in the theory of taxation says that in a fully optimal tax system it will not be optimal to have distorting taxes on inputs in production.[1] From the tax perspective the issue is then

[1]Diamond and Mirrless (1971)

whether an input tax levied through the transportation tariffs can be an imperfect substitute when the economic rents cannot be fully taxed through a lump sum tax on pure profits.

There is an extensive related literature on optimal access pricing, see e.g., Laffont and Tirole (1994). Cremer and Laffont (2002) as well as Cremer, Gasmi and Laffont (2003) discuss optimal access pricing in the natural gas pipeline sector. Cremer, Gasmi and Laffont (2003) examine optimal tariffs in a competitive market, while Cremer and Laffont (2002) discuss pricing of transport under perfect as well as imperfect competition. Common to these papers is that the optimal policy is considering both consumer and producer interests while the present paper is examining optimal tariffs from the perspective of net export values and tax payer interests. In section 2 we set forth a simplified economic model for analyzing these issues. Section 3 discusses optimal tariffs in the case where the transport facilities are owned entirely by a national gas producer, possibly with some public ownership share. Some special cases are considered such as independent end-user markets, scarce capacity and competition between the network owner and third parties in the end-user market. Section 4 examines the consequences for the optimal tariffs in the case of separation between extraction and selling of gas on the one hand and transportation on the other.

2 A simplified model for transportation of gas

We consider a context where the transportation infrastructure is owned by a vertically integrated gas producer that serves the end-user market in a foreign country. There is also a gas producer without any transportation infrastructure of its own, and which depends on access to the established network in order to sell its gas. The non-facility based producer will be referred to as the third party, denoted by the subscript T, and the vertically integrated network firm is denoted N. The profit levels of the two firms are Π_T and Π_N, respectively.

The third party is privately owned, possibly by foreigners. More specifically, a share $0 \leq \alpha \leq 1$ of the profits of the third party accrues to private domestic owners and a share $(1-\alpha)$ to foreigners. The network firm is completely domestically owned, but we assume that a share $0 \leq \beta \leq 1$ of the firm belongs to the government. Public revenues from gas activities reduce the need to raise public revenues through general taxation, and the marginal social cost of raising tax revenue is $k \geq 0$. The value of the surplus accruing to the home country is thus given by

$$W = \alpha \Pi_T + (1 + \beta k)\Pi_N. \tag{1}$$

We do not explicitly consider national income taxation of the two gas companies and their owners.

The gas sales of the network owner are denoted x_N, with unit price p, and the sales of the third party are x_T, with unit price q. It seems natural to assume that the decision variables of both producers are gas volumes, while the prices are determined in the downstream markets. They may, however, be competing in the downstream market. In the general case the price-quantity relation facing each producer thus depends on both volumes, i.e.; $p = p(x_N, x_T)$ and $q = q(x_T, x_N)$.

The activity related costs in the gas sector consist of two parts. The first part, to be denoted $c_i^a(x_i)$, measures the costs of gas extraction and of accessing the transportation pipeline. This term depends solely on the producer's own volume. The other part is the transportation cost, which may depend on the transported volumes of both parties, and will be denoted $c_i^t(x_i, x_j)$, $i, j = N, T$. Total transportation costs are thus equal to $C^t \equiv c_N^t(x_N, x_T) + c_T^t(x_N, x_T)$. This means that the marginal cost of transporting company i's gas is $MC_i^t \equiv \partial C^t/\partial x_i = \partial c_i^t/\partial x_i + \partial c_j^t/\partial x_i$, where the term $\partial c_j^t/\partial x_i$ may be interpreted as a cost externality. This externality may for instance be due to the fact that it is necessary to activate compressors in order to increase the pressure if too much gas is fed into the pipeline. That will increase the marginal costs for transporting gas for both producers.

The price that company i has to pay for transporting one unit of its gas is τ_i. Company i thus pays a marginal transport price which is higher than marginal costs if $\tau_i > MC_i^t$, while it pays less than marginal costs if $\tau_i < MC_i^t$.[2] It should be noted

[2]A substantial part of the variable transportation costs is made up of loss of energy in the pipeline which varies positively with the distance that depends on the location of the input and

that firm N perceives τ_N as an immaterial transfer price unless it is forced to run the network and the downstream subsidiary as independent units (see Section 4).

We presuppose that the profit functions are sufficiently concave so that all second-order conditions are satisfied in the subsequent analysis. In particular, we assume that $dc_j^a/dx_j > 0$, $\partial c_j^t/\partial x_j > 0$ and $\partial^2 c_j^t/\partial x_i \partial x_j \geq 0$. We will also consider the special case where the network has an absolute capacity limit $\bar{K}$, such that $MC_i^t \to \infty$ when $x_N + x_T \to \bar{K}$.

2.1 Fully integrated network

Downstream profit for producer N is equal to $p(x_N, x_T)x_N - \tau_N x_N - c_N^a(x_N)$, while its network profit is $[\tau_N x_N + \tau_T x_T] - [c_N^t(x_N, x_T) + c_T^t(x_N, x_T)]$. The internal price τ_N is irrelevant if the firm maximizes the sum of network income and downstream profit. In this case we may therefore write its object function as

$$\Pi_N = p(x_N, x_T)x_N - \left[c_N^a(x_N) + c_N^t(x_N, x_T)\right] + \tau_T x_T - c_T^t(x_N, x_T), \tag{2}$$

We further have

$$\Pi_T = q(x_T, x_N)x_T - c_T^a(x_T) - \tau_T x_T, \tag{3}$$

We consider a two-stage game where the government sets the tariff rate at stage 1, and the two firms compete in quantities at stage 2. Letting $C_N(x_N, x_T) \equiv c_N^a(x_N) + c_N^t(x_N, x_T)$ we can solve for the last stage to find

$$\begin{aligned} \frac{\partial \Pi_N}{\partial x_N} &= p + x_N \frac{\partial p}{\partial x_N} - \frac{\partial C_N}{\partial x_N} - \frac{\partial c_T^t}{\partial x_N} \equiv 0 \text{ and} \\ \frac{\partial \Pi_T}{\partial x_T} &= q + x_T \frac{\partial q}{\partial x_T} - \frac{\partial c_T^a}{\partial x_T} - \tau_T \equiv 0. \end{aligned}$$

At stage 1 we solve $dW/d\tau_T = (1 + \beta k)d\Pi_N/d\tau_T + \alpha d\Pi_T/d\tau_T = 0$.

Totally differentiating Π_N in (2) with respect to τ_T yields

$$\frac{d\Pi_N}{d\tau_T} = \left[p + x_N \frac{\partial p}{\partial x_N} - \frac{\partial C_N}{\partial x_N} - \frac{\partial c_T^t}{\partial x_N}\right] \frac{dx_N}{d\tau_T} + \left(\tau_T + x_N \frac{\partial p}{\partial x_T} - \frac{\partial C_N}{\partial x_T} - \frac{\partial c_T^t}{\partial x_T}\right) \frac{dx_T}{d\tau_T} + x_T,$$

terminal point of the gas shipment. The transportation element in the cost function may therefore not be symmetric in the volumes of the two shipping parties, e.g., because their gas fields may located differently related to the downstream market.

where we have used the fact that $\partial C_N/\partial x_T = \partial c_N^t/\partial x_T$. At the profit maximizing volume for the network owner the term in the squared brackets vanishes, so that we have

$$\frac{d\Pi_N}{d\tau_T} = \left(\tau_T + x_N\frac{\partial p}{\partial x_T} - \frac{\partial C_N}{\partial x_T} - \frac{\partial c_T^t}{\partial x_T}\right)\frac{dx_T}{d\tau_T} + x_T. \tag{4}$$

Similarly, we have for the third party that

$$\frac{d\Pi_T}{d\tau_T} = x_T\frac{\partial q}{\partial x_N}\frac{dx_N}{d\tau_T} - x_T. \tag{5}$$

The necessary condition for an optimal transportation tariff is

$$(1+\beta k)\left[\left(\tau_T + x_N\frac{\partial p}{\partial x_T} - \frac{\partial c_N^t}{\partial x_T} - \frac{\partial c_T^t}{\partial x_T}\right)\frac{dx_T}{d\tau_T} + x_T\right] + \alpha\left(x_T\frac{\partial q}{\partial x_N}\frac{dx_N}{d\tau_T} - x_T\right) = 0. \tag{6}$$

To get an intuitive feeling for what (6) tells us, we will consider some special cases.

2.1.1 Market independence

Assume first that the two downstream markets are independent, so that $\partial p/\partial x_T = \partial q/\partial x_N = 0$. For the moment we disregard capacity constraints. Defining $\varepsilon_T = -\frac{dx_T}{d\tau_T}\frac{\tau_T}{x_T}$ as the elasticity of demand for gas transport with respect to the tariff rate, we can rewrite equation (6) as

$$\frac{\tau_T - (\partial c_T^t/\partial x_T + \partial c_N^t/\partial x_T)}{\tau_T} = \frac{1+\beta k - \alpha}{1+\beta k}\frac{1}{\varepsilon_T}. \tag{7}$$

Condition (7) is an ownership adjusted version of the inverse elasticity rule. Assume that the third party is totally domestically owned ($\alpha = 1$) and that the government has no shares in the network company ($\beta = 0$). It is then immediately seen that the optimal tariff rate for transporting the third party's gas equals the marginal transportation costs, including the marginal cost externality for the net owner's own transport ($c_N^t/\partial x_T$).

From (7) we also see that it is socially optimal for the government to set the tariff rate above total marginal transportation costs if the third party is partly owned by foreigners or if the network company is partly owned by the government. Indeed, for $\alpha = 0$ monopoly pricing is socially optimal irrespective of whether the government has ownership shares in the network company (note that the interests of the government and the network owner coincide if $\alpha = 0$).

If the government has a positive ownership in the transportation network and $k > 0$, it is optimal to charge the third party a price in excess of the total marginal cost also in the case that the company is entirely domestically owned. The reason for this is that the social value of shifting one unit of profit from T to N is βk, or $\beta k/(1+\beta k)$ if measured in units of the social value of N's profits. More generally, the term $(1 + \beta k - \alpha) / (1 + \beta k)$ can be interpreted as the optimal downscaling factor of the monopoly transport price. As the marginal cost of taxation goes to infinity ($k \to \infty$) or $\alpha \to 0$, the optimal downscaling factor approaches unity (implying that monopoly pricing is socially optimal for the country).

2.1.2 Scarce capacity.

To the extent that scarce capacity is showing up as increasing marginal transportation costs this is taken care of in the optimal pricing rule (7). We therefore assume that there is an absolute capacity limit given by $\bar{K}$, and we maintain the assumption that the downstream markets are independent, $\partial p/\partial x_T = \partial q/\partial x_N = 0$. Moreover, the gas of both producers is assumed to be symmetric from a capacity point of view. The problem is then to maximize (1) subject to the constraint that $x_N + x_T \leq \bar{K}$.

The first order conditions for the network owner's own transport and pricing of the third party's transport are given by

$$\frac{p - [\partial C_N/\partial x_N + \partial c_T^t/\partial x_N + \gamma/(1+\beta k)]}{p} = \frac{1}{\eta_N} \tag{8}$$

$$\frac{\tau_T - [\partial c_T^t/\partial x_T + \partial c_N^t/\partial x_T] + \gamma/(1+\beta k)}{\tau_T} = \frac{1+\beta k-\alpha}{1+\beta k}\frac{1}{\varepsilon_T} \tag{9}$$

where $\eta_N \geq 0$ is the price elasticity of the demand for gas in the downstream market and $\gamma \geq 0$ is the shadow price of capacity. From (8) and (9) we see that scarce capacity has the same effect on the relative mark-ups for the network owner and the third party as a uniform increase in the marginal transportation costs for both shippers' use of transportation capacity. Hence, it does not make any difference for the optimal tariff whether the network capacity on the margin is enlarged by increasing the pressure through costly compressors or demand is decreased through an increase in the mark-up factor. Since the network owner and the third party compete for scarce capacity, their willingness to pay for capacity must in either case match the scarcity value in addition to the variable cost.[3] Intuitively, the imputed shadow price should be increased until the capacity restriction is fulfilled. The numerical value of the shadow price γ is therefore determined in optimum.

Solving for the optimal prices yields

$$\begin{aligned} p &= \frac{1}{1-\frac{1}{\eta_T}}\left[\frac{\partial C_N}{\partial x_N}+\frac{\partial c_T^t}{\partial x_N}+\gamma(1+\beta k)\right] \\ \tau_T &= \frac{1}{1-\frac{1+\beta k-\alpha}{1+\beta k}\frac{1}{\varepsilon_T}}\left[\frac{\partial c_T^t}{\partial x_T}+\frac{\partial c_N^t}{\partial x_T}+\gamma(1+\beta k)\right] \end{aligned}$$

Thus the rationing of scarce capacity is handled through an equal calculated capacity cost increment for the two shippers. The calculated cost of using scarce capacity increases with the government's share in the network's profit when the social value of profits accruing to the government is larger than one. The effect on the optimal tariff rate depends on the mark-up factor. Assuming that the demand for transportation of both the network owner and the third party has the same price elasticity in the relevant interval, the optimal mark-up factor will be largest for the network owner when $\alpha > 0$. The reason for this is that with national owner interests in the third party, part of the efficiency costs due to scarce capacity is born by domestic owners, which is in itself an argument for a lower tariff rate. For the network owner the shadow cost of scarce capacity is added to the cost base which is subject to a monopolistic mark-up. In that sense its scarcity cost is born by the foreign end-users. When the third party is owned by foreigners, it will be optimal to charge a full monopoly mark-up also for the third party's use of the network. With equal elasticities the price effect from scarce capacity will then be the same for both users. This means that it will be optimal to exert fully the market power both as to the foreign owners of the non-facility based third party as well as to the foreign consumers of the network company.

[3] The shadow price is divided by $(1 + \beta k)$ in order to have it denominated in the social value of the network owner's profit.

2.1.3 Competition between the network owner and the third party in the end-user market for gas

We now assume that the network owner and the third party compete for consumers in the end-user market. This means that the two markets are connected, so that gas delivered by the producer without transportation facilities is a (possibly imperfect) substitute for gas delivered by the integrated producer. In this case it follows from (6) that the first order condition for the socially optimal tariff can be written as

$$\frac{\tau_T - \left(\frac{\partial c_T^t}{\partial x_T} + \frac{\partial c_N^t}{\partial x_T} - x_N \frac{\partial p}{\partial x_T} - \frac{\alpha}{1+\beta k} x_T \frac{\partial q}{\partial x_N} \frac{dx_N}{dx_T}\right)}{\tau_T} = \frac{1+\beta k - \alpha}{1+\beta k} \frac{1}{\varepsilon_T} \tag{10}$$

The expression in the parenthesis on the left hand side of (10) is the total incremental costs of transporting another unit of T's gas. In addition to the pure transportation costs, which are captured by the two first terms in the bracket, we must now correct for the price effects of a marginal increase in x_T. More specifically, an increase in x_T reduces the price that the network owner can charge in the end-user market ($\partial p/\partial x_T < 0$). This is a cost for the producer country, and is captured by the third term. At the same time the network owner will reduce its output if x_T increases ($dx_N/dx_T < 0$), and the partial effect of this is that q increases. The fourth term therefore represents a gain for the producer country if domestic residents own shares in firm T ($\alpha > 0$). This effect on private sector profits has to be divided by $(1 + \beta k)$ in order to make it comparable with costs incurred by the network owner.

To highlight the difference between the tariff rate preferred by the government and the network owner, assume that $\alpha = 1$ and $\beta = 0$. The welfare maximizing tariff rate then simplifies to

$$\tau_T = \left(\frac{\partial c_T^t}{\partial x_T} + \frac{\partial c_N^t}{\partial x_T}\right) - x_N \frac{\partial p}{\partial x_T} - x_T \frac{\partial q}{\partial x_N} \frac{dx_N}{dx_T}, \tag{11}$$

while the profit maximizing tariff rate for the network owner is[4]

$$\tau_T = \left(\frac{\varepsilon_T}{\varepsilon_T - 1}\right) \left[\left(\frac{\partial c_T^t}{\partial x_T} + \frac{\partial c_N^t}{\partial x_T}\right) - x_N \frac{\partial p}{\partial x_T}\right]. \tag{12}$$

The terms in the square bracket of (12) show that the network owner would charge a mark-up on the sum of marginal transportation costs and the lost profit in the

[4]Technically, this is found by setting $\alpha = 0$.

downstream market due to a marginal increase in x_T. The size of the mark-up depends on the elasticity ε_T; the higher the elasticity, the lower the mark-up (with no mark-up in the limit case $\varepsilon \to \infty$). Equation (11), on the other hand, shows that the optimal tariff is independent of the elasticity. Indeed, this equation may be seen as a version of the efficient component pricing rule.[5] According to this rule the socially optimal price for giving access to a network should include the marginal cost for giving access plus the lost profit in the downstream market due to increased competition. This latter effect is represented by the second term. The last term reflects the positive indirect effect on the profits of the third party due to the fact that crowding out some of the network owner's sales increases the price for the third party's gas. This positive externality will not be taken into account by the network owner. Hence, also for this reason the profit maximizing tariff will be too high.

The difference between the monopoly tariff and the socially optimal tariff is particularly large in the special case where $\alpha = 1$ and $\beta = 0$, since the elasticity in that case is irrelevant for the socially optimal price. However, if $\beta > 0$ (and $k > 0$) the regulator finds it optimal that N has a relatively high profit, since that reduces the need for taxation elsewhere in the economy. Thereby it will be socially optimal to exert some monopoly power in order to indirectly tax private sector profits through the transportation tariff, and more so the higher the foreign ownership share in firm T.

The extent to which the monopoly power should be exercised by the government depends on the elasticity ε_T. In any case, the monopoly tariff will always be higher than the socially optimal one. For example, with $\varepsilon_T = 2$ and $\beta = k = 0.5$, we can use equation (10) to find that the optimal monopoly mark-up factor will be 100 % on marginal costs whereas the socially optimal mark-up is 11 %. [6]

[5] This rule was first proposed by Robert Willig (1979).

[6] Moreover, it should be noted that the social marginal costs are lower than the private marginal costs of the network owner, since the former includes the term $-x_T \frac{\partial q}{\partial x_N} \frac{dx_N}{dx_T} < 0$.

2.2 Separation of ownership between transportation network and extraction and marketing activities

The offshore network for transportation of natural gas is a prime example of a natural monopoly. In the North Sea more than 90 % of the costs are fixed and sunk for the infrastructure. This renders the transportation network an essential facility which it is neither commercially nor socially worth-while to duplicate, everything else equal. Thus, the network owner has some market power over third parties that need access to the transportation network. The fact that the integrated gas producer has a monopoly on the transportation facility and competes with non-facility based producers in the end-user markets may be unfortunate from a competitive point of view. Clearly, competitive neutrality is best served by unbundling the transportation network from upstream production and downstream market activities. Generally, separation of networks from production and market activities has also been a policy stance taken by the European Union to the effect that networks within railways, telecom and gas should be organized in such a way that the services of the natural network monopoly do not interfere with the competitive services depending on access to these networks. The conditions for access to the network services should then be regulated as they are supposed to be natural monopolies.

We assume that the transportation company is subject to a cost-plus regulation. This means that total revenue should cover variable and fixed costs including a regulated return on the investments, but no profits in excess of that. Thus cost recovery requirement will be a budget constraint. We consider two varieties of this regulation. One is where the regulatory agency is free to differentiate the tariff rate for the two gas companies, and the other one where the two companies are to be faced with equal tariff rates.

2.2.1 Differentiated tariff rates

We let F denote total fixed costs in the transportation network including the regulated returns to invested capital. Then the budget constraint takes the form

$$\left[\tau_N x_N - c_N^t(x_N, x_T)\right] + \left[\tau_T x_T - c_T^t(x_T, x_N)\right] - F = 0, \tag{13}$$

and the profit levels of the companies are

$$\begin{aligned} \Pi_N &= p(x_N, x_T)x_N - c_N^a(x_N) - \tau_N x_N \\ \Pi_T &= q(x_T, x_N)x_T - c_T^a(x_T) - \tau_T x_T \end{aligned} \tag{14}$$

Socially optimal tariffs now maximize $W = (1 + \beta k)\Pi_N + \alpha\Pi_T$, subject to (13) and (14). Letting $\partial C^t/\partial x_j \equiv \partial c_j^t/\partial x_j + \partial c_i^t/\partial x_j$, $i, j = N, T$ $(i \neq j)$, denote total marginal costs (inclusive of marginal external costs) of transporting gas for each shipper, the first order condition for optimum tariff rates can be written as

$$\frac{\left(\tau_N - \frac{\partial C^t}{\partial x_N}\right) + \left(\tau_T - \frac{\partial C^t}{\partial x_T}\right)\frac{dx_T}{dx_N} + \frac{(1+\beta k)x_N\frac{\partial p}{\partial x_T}\frac{dx_T}{dx_N} + \alpha x_T\frac{\partial q}{\partial x_N}}{v}}{\tau_N} = \frac{v - (1 + \beta k)}{v}\frac{1}{\varepsilon_N} \tag{15}$$

and

$$\frac{\left(\tau_T - \frac{\partial C^t}{\partial x_T}\right) + \left(\tau_N - \frac{\partial C^t}{\partial x_N}\right)\frac{dx_N}{dx_T} + \frac{(1+\beta k)x_N\frac{\partial p}{\partial x_T} + \alpha x_T\frac{\partial q}{\partial x_N}\frac{dx_N}{dx_T}}{v}}{\tau_T} = \frac{v - \alpha}{v}\frac{1}{\varepsilon_T}, \tag{16}$$

where v is the shadow price of the budget constraint. Thus v represents the marginal social value of profits in the transportation company. Observing that v reflects the reduction in total national surplus W from an increase in fixed costs by one unit, we must have that $v > 1$ as marginal cost pricing will not cover fixed costs if the transportation network is a natural monopoly. Thus, they must be covered in a distorting way. If marginal cost pricing in the transportation company were financially viable, $v = 1$.

The first two terms in the numerator of (15) and (16) reflect the marginal contribution to fixed costs in the network unit from a marginal increase in the transportation of gas for N and T, respectively. The third term in (15) is the indirect effects on profits accruing to national owners due to the cross-price effect in the two end-user markets from a marginal increase in the transportation of gas for company N. The effect on N's profits is adjusted for the marginal welfare effects from reduced public revenue due to public ownership, while the effect on T's profits is adjusted for the national ownership share. These effects on national profits have to be divided by the shadow price v in order to make it commensurable with the social value of profits in the transportation company.

We can interpret the last two terms in the numerator on the left hand side of (15) and (16) as the marginal social costs due to the price effects assessed at the national level of shipping an additional unit of gas for company N and T, respectively. The optimal social mark-ups on these marginal social costs are $\frac{1}{1-\frac{v-(1+\beta k)}{v}\frac{1}{\varepsilon_N}}$ and $\frac{1}{1-\frac{v-\alpha}{v}\frac{1}{\varepsilon_T}}$ for the two tariffs, respectively. Clearly, if the two companies have solely private and national owners, i.e., $\alpha = 1$, $\beta = 0$, then pricing according to marginal social costs is socially optimal if $v = 1$ and the transportation capacity is not scarce. On the other hand, if T is owned solely by foreigners, then monopoly pricing of transportation allocated to that company would be optimal regardless of whether the profit constraint is binding or not. In the present model the monopoly profit in the transportation company will accrue to the owners of the domestically owned company through reduced tariffs.[7]

One may think of the profit margin in relation to marginal social costs implicit in the transportation tariffs as an indirect tax on the use of transport capacity in order to finance fixed costs for the infrastructure. With equal price elasticities in the demand for transport and a positive public ownership in the gas company N, the optimal indirect tax rate (as a percentage of the tariff rate) will be larger for company T with solely private owners if there is an extra premium $k > 0$ on public revenue. The reason for this is that the indirect tax on N reduces the producer surplus and hence the profits accruing to the government. Thus, part of the excess burden from this indirect tax is born by the tax payers. In this respect one gets a sort of double taxation; partly because of the efficiency loss due to reduced profits and partly because it leads to increased distorting taxation in the rest of the economy. With foreign ownership in T part of the excess burden of financing the fixed costs through a tariff on that firm is born by foreigners. This strengthens the arguments for tariff discrimination in favour of N.

[7]One might imagine that this could lead to $\tau_N < \partial c_N^t/\partial x_N + \partial c_T^t/\partial x_N$, which may violate regulation against cross subsidies.

We consider a numerical example:

Assume that $\varepsilon_N = \varepsilon_T = 1.5$ and cross elasticities are zero, $v = 2$, $k = 0.5$, $\beta = 0.5$, and $\alpha = 1$, so that both companies have only national owners. Optimal mark-ups will in this case be 1.33 and 1.5 for N and T, respectively. With $\alpha = 0$, the optimal mark-up on T increases to 3, which is a 200% increase of the marginal transportation costs.

2.2.2 Equal tariff rates

We now assume that the regulatory agency is imposing a requirement of equal treatment as to the conditions for access to the transportation network irrespective of the shipper's ownership structure. Equal treatment is here assumed to require equal tariff rates related both to private versus public and domestic versus foreign ownership of the shipping companies. We retain the assumption that the transportation company is subject to a rate of return regulation, which in the static case is equivalent with a budget constraint.

Observing that all terms with $\partial p/\partial x_N$ and $\partial q/\partial x_T$ vanish by the envelope property of profit maxima, the first order condition for an optimal tariff rate can now be written as

$$\frac{\tau - \frac{\partial C^t}{\partial x_N} + \frac{\alpha x_T \partial q/\partial x_N}{v}}{\tau} \frac{dx_N}{d\tau} + \frac{\tau - \frac{\partial C^t}{\partial x_T} + \frac{(1+\beta k) x_N \partial p/\partial x_T}{v}}{\tau} \frac{dx_T}{d\tau} \tag{17}$$
$$= \left(\frac{v - (1+\beta k)}{v} \frac{1}{\varepsilon_N} \right) \frac{dx_N}{d\tau} + \left(\frac{v - \alpha}{v} \frac{1}{\varepsilon_T} \right) \frac{dx_T}{d\tau}.$$

The left hand side of condition (17) is a weighted average of the relative marginal social profit margins in the two companies, with the marginal capacity demand reactions with respect to changes in the tariff rate as weights, while the right hand side is a weighted sum of the inverse of the direct price elasticities.

One would expect the optimal common tariff to be in between the optimally differentiated tariffs. In order to examine this presumption we make the simplifying assumption that the marginal transportation costs are the same for the two shippers, and that cross price effects between the two gas markets are zero. Letting $dX/d\tau = dx_N/d\tau + dx_T/d\tau$ denote total reduction in demand for transport induced by a marginal increase in the tariff rate, and letting MC^t denote the common marginal transportation cost, condition (17) simplifies to

$$\frac{\tau - MC'}{\tau} = \left(\frac{v - (1+\beta k)}{v} \frac{1}{\varepsilon_N} \right) \frac{dx_N/d\tau}{dX/d\tau} + \left(\frac{v - \alpha}{v} \frac{1}{\varepsilon_T} \right) \frac{dx_T/d\tau}{dX/d\tau} \tag{18}$$

If the price elasticities of demand are not too different from what they were in the case with optimal tariff discrimination, we see that the optimum profit margin relative to tariff rate in the transportation company is a weighted average of the corresponding margin rates in the case with rate discrimination. With a common tariff rate it will be less attractive to tax the foreign owners in company T through the tariff rate as parts of the efficiency costs are imposed on the domestically owned company with public ownership. In that sense part of the excess burden from taxing foreign owners through the tariff is born by domestic tax payers.

We consider a numerical example.

We return to the former example and assume that company N accounts for a share δ of the total response in the demand for transportation capacity to a marginal increase in the tariff rate, and company T for $(1 - \delta)$. As before, we assume that $\varepsilon_N = \varepsilon_T = 1.5$, $v = 2$, $k = 0.5$, $\beta = 0.5$, and α is 1 or 0. Solving (18) with respect to τ yields $\tau = \frac{MC^t}{0.67+0.08\delta}$ for $\alpha = 1$ and $\tau = \frac{MC^t}{0.33+0.42\delta}$ for $\alpha = 0$. In both cases the optimal common tariff rate will be in between the optimum company-specific tariff rates in the case with third degree price discrimination, and the size of this common monopoly mark-up depends on N's share in the total demand response. The larger N's response, the smaller the optimal mark-up on marginal transportation costs. With $\alpha = 1$ the optimal mark-up is 1.33 for $\delta = 1$ and 1.5 for $\delta = 0$, which are the optimum tariff rates with tariff discrimination.

3 Conclusion and Discussion

In the present paper we have discussed optimal tariffs from a national perspective for transportation of natural gas for gas shippers without own transport facilities in a setting where the national gas production in its entirety is exported to end-user markets abroad. An underlying assumption for the analysis is that the national appropriation of the resource rent through national taxation is incomplete and the issue is to what extent it would be optimal to harvest some of the rents through the tariff rates for gas transport. In the situation where the transportation network is owned by an integrated national gas producer, it is shown that the optimal tariff depends on the ownership structure in the integrated transportation company as well as in the non-facility based gas company. More precisely, there are two features of ownership that are decisive for the optimal tariff. One is the public ownership share in the integrated transport company which in the case of a premium on public revenue calls for a tariff in excess of the marginal transportation costs. This is due to the fact that a unit of profit has a higher social value in the network company than in the privately owned company. The other is the foreign ownership share in the privately owned company that depends on access to the network for its gas transport. A mark up on transportation cost is in that case an indirect way of appropriating rents accruing to foreigners. Indeed, the optimal tariff approaches the monopoly tariff as the foreign ownership share approaches 100%.

An integrated national gas producer controlling the transportation network and exerting monopoly power in the pricing of third party access is certainly not in accordance with EU's gas market directive laying down conditions conducive to a more competitive gas market. One step in that direction is to debundle the transportation activity from the producing and selling activities. Accordingly, we have examined optimal tariffs in a scenario were the network is run as a separate entity subject to a rate of return regulation. Again, for the above mentioned reasons it is optimal to discriminate the optimal tariff between the fully domestically owned shipper with a public share and a fully privately owned shipper with possibly some foreign owner interests. In that case the optimal tariffs may be seen as Ramsey prices and the mark-ups as indirect taxes that are used to finance fixed costs for maintaining and operating the network (inclusive of regulated profits). If non-discriminatory terms for the access of third parties to the network are to be interpreted as equal tariffs for all shippers, the optimal tariffs will be in between the optimally differentiated tariffs. This regulation of course will mean a welfare loss to the gas exporting country as a larger part of the excess burden has to be born by nationals in the capacity of tax payers as well as recipients of profits from the gas sector.

The above analysis is partial in that it has been conducted from the point of view of producer interests. Consumer interests have been taken into account only indirectly through their role as tax payers. In a setting where the gas is also consumed domestically, consumer interests have to be taken into account more directly. However, it is well known that the difference between Ramsey prices and monopoly prices is primarily with respect to the price level while relative prices are the same. Thus, including consumer interests is not likely to change the structure of the optimal tariffs derived in the various scenarios. The model is partial in other respects as well. Most notably, we have considered the transportation system as a separate activity rather than as an integral part of the total value chain. In the long run transportation tariffs might affect both optimum depletion policies and gas market strategies. We have also abstracted from uncertainty both related to upstream activities and downstream demand.

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