Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 31 (2014) 413 – 422

Procedia Computer Science

2nd International Conference on Information Technology and Quantitative Management, ITQM 2014

Incentive Problem in Gas Transport Infrastructure Development on the Norwegian Continental Shelf

Katerina Shaton[a,]*

[a]*Molde University College – Specialized University in Logistics, Britveien 2, Molde, 6410, Norway*

Abstract

The objective of this paper is to propose an analytical structure to investigate the interaction between the tariff regulation and investment behavior in the Norwegian gas transport sector. A game theoretic approach is used to analyze the current tariff system, and consider its implications on the development of the transport network in the long run. A special position of the independent system operator as a common agent is discussed.

Keywords: Infrastructure; Regulation; Investment; Natural gas; Incentive problem

1. Introduction

Von Hirschhausen[1] claims that the existing models fail to provide unambiguous results regarding the effect of regulation on infrastructure investments; therefore, case-specific assessments are needed to derive policy recommendations for a certain country. The objective of this paper is to provide an analytical structure to understand and explain the regulatory choices regarding the gas transport infrastructure development on the Norwegian continental shelf (NCS).

Infrastructure investments will not be undertaken, if the regulatory regime does not ensure appropriate conditions for recovery of the invested capital. Therefore, one regulatory question is to define an appropriate rate base. In July 2013, the Norwegian Government reduced the expected rate of return on the existing gas infrastructure investments

* Corresponding author. Tel.: +47-90-774-920; fax: +47-71-21-41-00.
E-mail address: katsiaryna.shaton@himolde.no

doi:10.1016/j.procs.2014.05.285

from 7% down to 4%, raising a surge of discussion and discontentment among the investors. The research questions addressed in this study are: (1) How efficient is the current tariff regime to provide sufficient incentives for the development of the network? (2) What is the role of the independent system operator (ISO) in the incentive problem? (3) Which implications may the changes of the tariff regime have on the infrastructure development on the NCS in the long run?

In order to address these questions, the incentive structure and interaction between the parties upon the infrastructure development under the current regulatory regime are investigated by a game theoretic approach. Gas infrastructure development is analyzed through a static model, which might be a rather limited representation of the system in a constant change; however, the regulatory regime changes by discrete steps.

The paper is organized as follows. In Section 1, the game of infrastructure developments is presented. The analysis and implications of the model are discussed in Section 2. Section 3 concludes the paper.

2. The model

There are matured areas in the southern part of the NCS, with an extensive transport network. The major concern for this part is to ensure high utilization, which becomes an acute issue in light of expected drop of gas inflow in certain pipelines in coming years. The northern part of the shelf is much less matured, but exploration interests of petroleum companies move further to the North. Approximately 35% of undiscovered petroleum resources on the NCS are expected in the Barents Sea[2]. The only transport infrastructure in the Northern region available at the moment is the LNG (Liquefied Natural Gas) facility at Melkøya, with capacity around 20 MSm^3/day. The alternative is a pipeline solution. A formal discussion of this solution has begun in 2012, as a part of general study of infrastructure development on the NCS (NCS2020-study, Gassco). This plan motivates this paper and serves as a main empirical base for modelling interactions of the players under the changing market conditions.

Game-theoretic models are widely applied for the analysis of different aspects of the gas market. E.g., Egging and Gabriel[3] use a game-theoretic approach to analyze market power in the European natural gas market, discussing the importance of pipeline and storage capacity, however, infrastructure decisions were not incorporated into the model. Holz et al.[4] include investment issues in a game-theoretic complementarity model for the European market. Gasmi and Oviedo[5] use the a game theory framework to define optimal transport charges set by a regulator to maximize social welfare, taking into account the level of the downstream competition. Hagen et al.[6] derive the optimal tariffs for gas transportation on the NCS for domestic and international shippers. A model for infrastructure development on the NCS is presented by Xue and Haugen[7], as a game between the authorities and petroleum companies.

In this paper, decisions regarding the infrastructure development on the NCS are modelled as a sequential game of three players: the Government, the ISO and a gas company. Their strategies and objectives are discussed in the next section.

2.1. Players, Strategies, Objectives

2.1.1. The Government

In order to ensure the efficiency of the gas transport market, the Government simultaneously pursues two goals: (1) to ensure high utilization of the existing transport network and (2) to motivate further infrastructure development. In liberalized markets, the government cannot directly influence infrastructure investments, but can adjust incentive structure through the change of framework conditions for petroleum activities.

The tariff regime is one of the regulatory mechanisms used by the Government on the gas transport market. The tariff is stipulated by the Ministry of Petroleum and Energy and applies for all shippers, domestic and international. The tariff is constructed such that the transport service does not assume any profit; the capital element is stipulated in a way to ensure only a reasonable return on the capital invested, operating element is stipulated such that there are no profit or loss neither for the owner nor the operator. The current regulation prohibits tariff discrimination (neutral access requirement by the EEA Agreement), and reduces the ability of the Government to directly adjust the tariff. However, the Government can manipulate the construction of the capital and operation elements of the tariff. The

capital element in the tariff formula may be changed through the change of the discount rate or/and change of the length of a pay-back period. Formally, these changes lead to the increase/decrease of the tariff. Therefore, strategies of the Government are: to set up a tariff T_H with a larger capital element: a shorter pay-back period or/and higher discount rate, or to set up a tariff T_L with a longer payback period or/and lower discount rate. A lower tariff means lower transportation costs and possibility of price reduction, resulting in higher utilization of the existing network. On the other hand, a lower rate of return on investments raises incentive problem. A higher tariff works in the opposite way: gives incentives for infrastructure development, but reduces the utilization of the network.

The objective function of the Government is usually defined as long-term social welfare maximization, e.g. by Hagen et al[6]. In case of the gas transport sector this objective can be translated into maximization of revenue through taxation of petroleum activity on the NCS and share participation in production. For simplicity, it can be expressed as the maximization of the gas flow on the NCS (pipelines and LNG). This simplifying assumption, nevertheless, reflects both aspects of the state interest: the gas flow is maximized both as a result of utilization increase and new infrastructure development.

2.1.2. The Operator

The gas transport infrastructure on the NCS is a typical example of a natural monopoly. It is mostly owned by the Gassled joint venture, and operated by a single state-owned company Gassco. The relationship between the owners of the network and the ISO is determined by the Norwegian government. The position of an independent system operator means that Gassco acts in a neutral manner, ensuring an efficiently-run transport system to the benefit of owners, users and customers. In fact, the ISO is responsible both before the owners of the infrastructure and the Government. Two principals can be identified in Gassco's principal-agency relationships: the Norwegian government and the Gassled joint venture. According to the literature[8,9,10], Gassco can be regarded as a common agent for the two principals. A common agency is a situation when the actions chosen by the agent affects several other parties (the principals), whose preferences for the possible actions of the agent typically conflict[10].

Regarding the infrastructure development, Gassco's task is to assess the need for new transport solutions, recommend optimal routing and connections to existing facilities onshore and offshore. Planning of a particular facility is initiated by a petroleum company, usually as a part of a project for development of a new petroleum deposit. Development of new infrastructure is referred to Gassco's responsibilities on behalf of the Government; at the same time new infrastructure is funded by gas companies and, if the third party access is assumed, becomes a part of Gassled. Development of the transport network is a point, where the common agency nature of Gassco becomes apparent: it should follow the objective of the Government of providing sufficient transport capacity in order to ensure well-functioning of the gas market in the long-run, and present short-term (due to a high required rate of return in the sector) profit-maximizing interests of the investing companies.

There might be a supposition that Gassco would present authorities' interest rather than transport network owners in light of the fact that at least 50% of Gassled's shares belongs to the State through the fully state-owned company Petoro ($\approx$ 45% of shares) and the main gas producer, partially state-owned company Statoil (5%). One can raise a question whether owners of infrastructure should be considered as a principal. According to the definition, principals need not be of equal power; there is no requirement regarding the relative power of principals.

In the relevant literature[7], decisions of the ISO regarding the infrastructure development and long-term planning on the NCS are usually not distinguished from the actions of the Norwegian government. However, decisions of Gassco, as of a common agent, certainly influence payoffs of both principals and cannot be ignored in the model. Some models of the short-term market for gas transport treat Gassco as an independent player[11,12]. The set of actions for the ISO is then related to the routing of gas flows in the system and secondary market sales of available capacity. However, such models disregard long-term perspectives and investment decisions.

The task of the ISO in infrastructure planning is to ensure a system approach to the development of the network. Defining strategies of Gassco, I refer to the actual plan of infrastructure development in the Barents Sea. An LNG solution, associated with a certain field, does not provide any economy of scale. The pipeline solution, although coming on stream later and requiring significantly higher investment cost, has advantage in terms of significant economy of scale, which assumes low additional cost to establish overcapacity. Available excess capacity provides incentives for exploration in the region and reduces the cost threshold for development of fields along the pipeline.

Another benefit of the pipeline solution is utilization of the transport capacity in the North and the Norwegian Sea, which may become spare in the near future. Maintenance costs of these transport facilities will be shared between the larger volumes of transported gas, reducing unit costs. It provides incentives to develop marginal fields in the matured areas. If there are no new discoveries in the South, where excess capacity is expected after 2021, inflow of gas is needed from the North in order to maintain the same tariff level. The system approach to infrastructure development means planning sufficient excess capacity with regard to future discoveries in the area. To the purpose of this model, decisions of Gassco are narrowed to the determination of the capacity of the planned transport facility, particularly the size of the excess capacity.

Gassco is a non-commercial organization and does not receive any profit from its activity. This makes the task of objective function definition rather tricky. As an agent of the Government, the ISO should pursue long-term goal of social welfare maximization and prefer to plan optimal excess capacity with respect to the expected growth of production rate. As an agent of Gassled, Gassco should advocate short-term profit maximization and plan capacities as close to just needed for existing fields as possible.

The framework of the common agency theory assumes some reward schemes provided by principals to motivate agent acting in their interests. In case of Gassco, there is no explicit reward incentive. The main objective of Gassco is to minimize total costs of gas transportation on the NCS in the long run.

2.1.3. A Company

A group of companies, a licensee, initiate a new transport facility development and invests into the project. One company is appointed as an operator and acts on behalf of the licensee. To define a set of actions for the Company, I refer again to the Barents Sea infrastructure project. Statoil, the company holding a license for the field Snøhvit, plans to increase gas production on this field. The LNG facility at Melkøya may be expanded (plan TOG II with capacity expansion 20 MSm^3/day which is exactly needed for increased production on Snøhvit). This solution has advantages: market flexibility (no lock-in to the European market); better timing: this solution comes on stream 1-2 years earlier than the pipeline, which is an important issue for the company in light of high required rate of return in the sector; significantly lower than the pipeline investment costs and possibility of a step-wise expansion in the future. On the other hand, there is an option of a pipeline solution, which requires higher initial investments, lacks destination flexibility, but implies lower operation costs, and may be preferable in the long-run. This determines two strategies for the Company, defining the mode of transportation: a pipeline or an LNG solution. I do not consider an option for the Company not to invest, as a transport solution is an integrated part of a gas field development, and as a project is started, the company needs a solution for gas transportation, either an LNG or a pipeline. The Company's objective is profit maximization.

2.2. Game of infrastructure development

An assumption of the common agency theory is that the agent makes decisions based on the actions taken simultaneously by the principals[11]. The presented model deviates from the classical model. The Government moves first and sets up the tariff regime. In practice, a company initiates the planning process of a particular transport facility. Gassco is involved in the process from an early stage, giving recommendation regarding the routing, connection points and the capacity of a pipeline. The choice of a solution concept is made in a tight collaboration between the licensee and Gassco. In the model, the decision of Gassco is placed before the Company's to indicate that the final investment decision is made by the Company, which may decide to postpone the decision (this option is not considered in the model), or prefer an LNG, if the pipeline solution recommended by Gassco is unacceptable from a commercial point of view.

In the game, these decisions are represented by sequential moves: the Government sets up the tariff regime, Gassco decides upon the capacity, then, the Company makes a concept choice, see Fig.1.

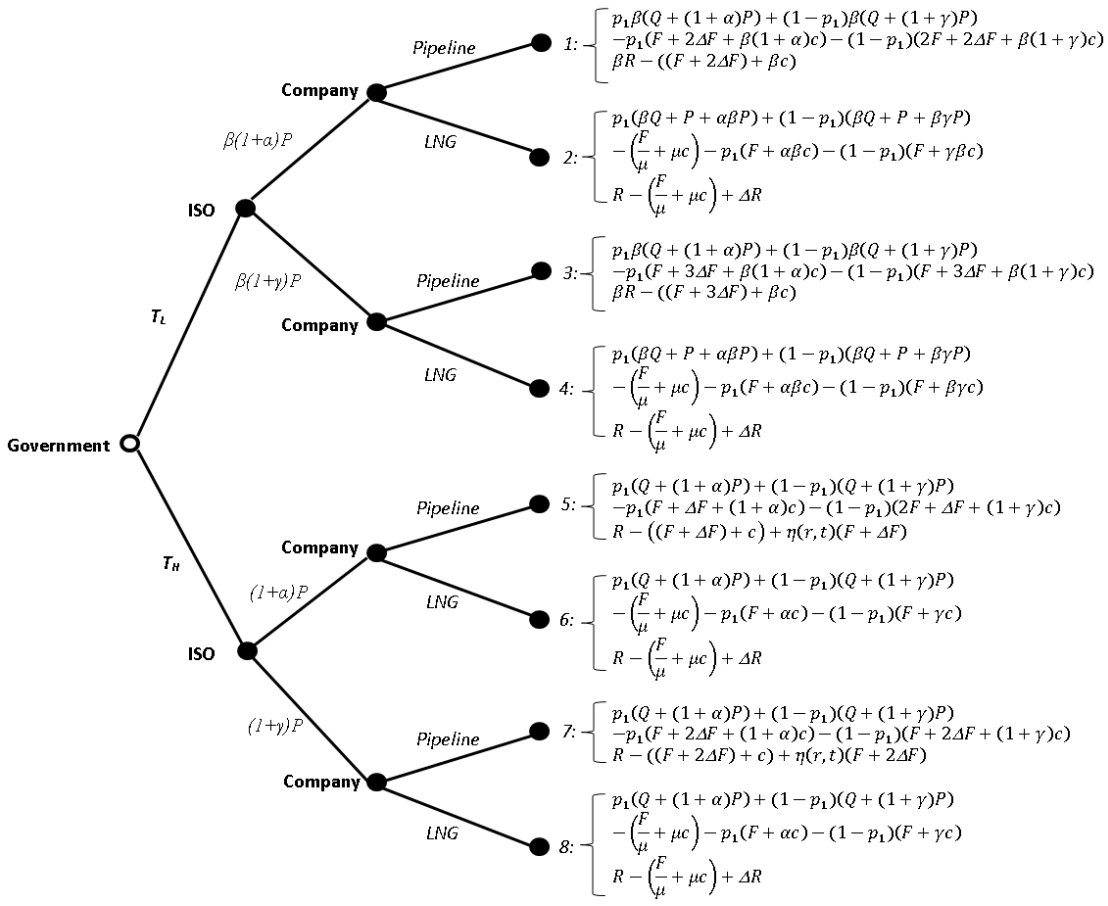

Fig.1. The game tree (the payoffs: 1.Government; 2.ISO; 3.Company)

Parameters used in the model are listed in Table 1.

Table 1. Parameters of the model.

Notation	Meaning
P	Production rate of the field under consideration
Q	Throughput of the existing transport system
F	Fixed cost of a pipeline of capacity P
ΔF	Fixed costs to establish overcapacity of a size of αP or βP, to establish overcapacity γP costs $2\Delta F$;
c	Total operating cost of a pipeline of capacity P during the whole operation period
R	Total revenue of the petroleum company from the field under consideration
ΔR	Additional revenue of the petroleum company due to destination flexibility of LNG
α	Expected exploration success in the area of the field under consideration in case of scenario Low, $0 \geq \alpha > 1$
β	Increase of production rate on the NCS due to low tariff, $\beta > 1$
γ	Expected exploration success in the area of the field under consideration in case of scenario High, $0 > \gamma \geq 1$, $\gamma >> \alpha$
μ	Cost ratio of LNG and pipeline transport solutions, $\mu > 1$
$\eta(r,t)$	Fraction of fixed cost recovered, a function of time and discount rate
p_1	Probability of the resource scenario Low

It is assumed that: (1) demand is always sufficient for all produced gas; (2) set up cost for an LNG solution is F/μ, variable costs are proportionally higher: μc; (3) if established capacity is not sufficient, then a new pipeline is built, at a cost F, and it suffices to transport $\alpha\beta P$ or $\beta\gamma P$ of gas and does not assume overcapacity.

According to its architect role, Gassco is not likely to plan capacity of a pipeline exactly equal to production rate P of the field under consideration, but will take into account possible discoveries in the area and recommend solutions with pre-investments: pipeline of capacity either $(1 + \alpha)P$ or $(1 + \gamma)P$, $0 \leq \alpha < 1$ and $0 < \gamma \leq 1$, where α and γ can be regarded as expected growth of production rates due to exploration success in the area (lower bound for α is set equal to 0, allowing the possibility of zero expectation over future discoveries in the area). Uncertainty over future discoveries is represented by Gassco's estimates of probability of Low (p_1) or High ($1 - p_1$) resource scenarios to occur. As the perfect information game is assumed, Gassco observes the action of the Government and adjusts its plans in accordance to the tariff regime. The low tariff T_L means lower total costs, resulting in general increase of gas production on the NCS to β. Therefore, in case of T_L, Gassco plans either $\beta(1 + \alpha)P$ or $\beta(1 + \gamma)P$. When Gassco has recommended the capacity of the pipeline, the Company decides whether to accept the recommended pipeline investment or establish an LNG solution.

2.3. Payoffs

Government. The gas flow in the transport system is a sum of the throughput in the existing network (representing the first "sub goal"– high utilization of existing network), the gas flow in the newly built pipeline (the second "sub goal" – network development) and the volume transported as LNG, weighted upon the probabilities of the resource scenarios. Under the high tariff, if the capacity of the established pipeline is not sufficient, then another pipeline is to be built at a cost F. If the low resource scenario occurs and excess capacity γ was established, then, there is underutilized capacity in the network. If the Company decides to build an LNG, without excess capacity and opportunity for the third party access, the infrastructure needed by the other companies (LNG or pipelines) is to be built by other companies. All the gas that is needed to be transported will be transported, therefore, the payoff for the Government is the same for nodes 5 – 8. For the low tariff case, the payoffs are constructed in the same manner, with the difference in the market response to tariff reduction β: volumes of gas transported as LNG are not affected by tariff reduction (nodes 2 and 4).

ISO. The payoff of the operator is the sum of investment and operating costs, weighted upon the probabilities of resource scenarios. If the Government sets up T_L, the Company decides to build a pipeline and the resource scenario Low occurs, then investment cost is $F + 2\Delta F$, variable cost is $\beta(1 + \alpha)c$. If scenario High occurs, the established capacity is not sufficient and a new pipeline is needed, resulting in fixed cost equal to $2F + 2\Delta F$. The variable cost in this case is $\beta(1 + \gamma)c$. If Gassco recommends larger capacity $\beta(1 + \gamma)P$, investment cost is $F + 3\Delta F$ for both scenarios, variable costs are $\beta(1 + \alpha)c$ and $\beta(1 + \gamma)c$ for Low and High scenarios respectively. If the Company decides to use an LNG solution, then a pipeline of capacity P with investment cost F is built by other companies to transport the volume $\alpha\beta P$ or $\beta\gamma P$ of gas from their discoveries in the area with corresponding variable costs. For the lower branch of the tree, the payoffs are constructed in the same manner.

Company. The payoffs for the Company are defined as a difference between the revenue R and total costs, assuming option premium for destination flexibility of an LNG solution ΔR. In the lower branch of the game tree, the Company pays total investment costs to build a pipeline of capacity either $(1 + \alpha)P$ or $(1 + \gamma)P$, but uses only P, having variable cost c in both cases. In the upper branch, the Company pays full cost to establish a pipeline capacity $\beta(1 + \alpha)P$ or $\beta(1 + \gamma)P$, but uses only βP with the associated variable cost βc, and receives an increased revenue βR.

The lower branch of the game depicts the tariff regime with a higher rate of return. These conditions allow the Company to consider investment costs as partially recoverable. A part of fixed costs $\eta(r,t)F$ is subtracted from total costs in the outcomes 5 and 7. The rationale behind this is the availability of the second-hand market for the infrastructure investments: shares in Gassled can be sold. Increased rate of return expands this second-hand market, giving opportunity for the Company to recover costs of pipeline easier. Certainly, this second-hand market exists under both tariff regimes, for simplicity $\eta(r,t)F$ is introduced only under the high tariff, underlining considerably higher willingness to buy Gassled shares. The outcomes for the nodes 2, 4, 6 and 8 are the same, meaning that a lower tariff for the pipeline transportation does not affect Company's revenue if it chooses the LNG option.

2.4. Outcomes and findings

The petroleum companies, Gassled stakeholders, have a twofold nature, acting both as shippers and as investors. As shippers, the companies would definitely prefer low transport tariffs. As investors, they are interested in higher tariffs, meaning higher rate of return on investments.

The dominant strategy of the Government is to follow the path of a low tariff. Under this tariff regime, the company considers infrastructure development only from the position of a shipper, considering pipeline alternative as a large fixed cost of a field development. As an investor, it observes a low rate of return on investments and relatively little opportunity to recover the cost in the short run. The question of excess capacity becomes rather sensitive, as the company needs transport facility of the capacity βP, and Gassco plans some overcapacity with regard to future connections. Here the incentive problem comes into play: companies have no incentives to invest into capacity higher than needed for their fields. Under the low tariff, investment in excess capacity means only tied-up capital. The choice between nodes 1 and 2 depends on the company's estimates of value of flexibility of LNG, ΔR:

$$\Delta R < (\beta - 1)R - \left(\left(1 - \frac{1}{\mu}\right)F + 2\Delta F\right) - (\beta - \mu)c \tag{1}$$

If condition (1) is satisfied, gains from increased revenue due to low pipeline transportation costs and savings on variable costs minus losses on investment costs exceeds premium for the destination flexibility of LNG. Then, the Company chooses the pipeline solution and the game ends up at node 1. If Gassco expects high growth in the area and suggest excess capacity γ, the estimate for the value of LNG flexibility should be very low for the Company to decide in favor of the pipeline, actually excluding node 3 from the set of possible outcomes. Coming back to the Barents Sea infrastructure project, rather high estimate of ΔR can be observed, determining the strong tendency for the game to end up with an LNG solution, which is less preferred from the socio-economic standpoint (lost βP in the payoffs for the Government).

A solution to the incentive problem is found in the lower branch of the game tree. If the Government decides to follow the path of higher tariffs, it bears the loss of reduced utilization of the existing capacity (lost β), but motivates the Company to act not only as a shipper, but also as an investor. The shorter is the determined payback period and the higher the discount rate, the larger fraction of the investment costs, $\eta(r,t)$ is considered as recoverable.

In case of relatively high rate of return, the Company takes into account second-hand market for pipeline investments and makes the decision both from the point of view of a shipper and of an investor. If Gassco recommends access capacity α, the Company has an incentive to invest into this overcapacity if

$$\eta(r,t) > 1 - \frac{1}{\mu}\frac{F}{(F + \Delta F)} - \frac{(\mu - 1)c}{F + \Delta F} + \frac{\Delta R}{F + \Delta F} \tag{2}$$

If this condition (2) is satisfied, incentive problem is solved, the Company invests into the pipeline of the capacity $(1 + \alpha)P$, the game ends up at node 5.

If Gassco defines the capacity of the pipeline as $(1 + \gamma)P$, for the Company to go for it, the share of recoverable costs should be:

$$\eta(r,t) > 1 - \frac{1}{\mu}\frac{F}{(F + 2\Delta F)} - \frac{(\mu - 1)c}{F + 2\Delta F} + \frac{\Delta R}{F + 2\Delta F} \tag{3}$$

If condition (3) is satisfied, the game ends up at node 7, where the pipeline capacity is $(1 + \gamma)P$.

The objective of Gassco, as an ISO, was defined as minimization of total transportation costs. Following this objective as it is, the choice of the dominant strategy is based on expectations of Low and High scenarios to occur. From the point of view of cost minimization, LNG solution can also be preferred under certain relationship between variable and fixed costs. The common agency position of the entity and assigned tasks makes its decision process more complex. System approach for infrastructure development, first of all, assumes planning of possibilities for future connections, thereby providing incentives for exploration in regions with available transport solutions. In this regard, an LNG solution is not efficient because of low economies of scale and high operation costs.

Under the low tariff, the game has a strong tendency to end at node 2 or 4, with an LNG solution. However, condition (1) can still be satisfied if economies of scale of the pipeline overcome the time and flexibility advantages of the LNG. The choice of pipeline capacity can be obvious if the probability of the resource scenario High is low: Gassco recommends solution with excess capacity α, which is acceptable for the Company. If expectation over the exploration success is high, then the common agency position of Gassco becomes explicit. In this situation, the solution with excess capacity γ is cost efficient and goes in line with the objective of the Government – gas flow maximization in the long run due to increased incentives for exploration in the region. However, the only feasible solution is the one with the excess capacity α; Gassco should adjust its strategy and comply with another principal – the Company. This solution is second best both for Gassco and for the Government, but it is the only way to incentivize establishment of a pipeline, ensuring efficient development of the system in the long run.

If the Government sets up a high tariff, the Company receives incentives as an investor and a pipeline solution becomes more attractive than an LNG. As a result, incentive problem as such loosens, but Gassco has to balance between the principals if the Company's willingness to invest does not correspond to the expected need for excess capacity. If condition (2) is satisfied, Gassco's choice of strategy $(1 + \alpha)P$ goes in line with interests of the Company, while the choice of $(1 + \gamma)P$ does not, and the system is again inclined to end up with an LNG solution. Only if the tariff regime makes $\eta(r,t)$ large enough to satisfy condition (3), then there is no conflict of interests between the principals, and Gassco can choose strategy $(1 + \gamma)P$ without balancing between the principals. From the social welfare perspective, the outcome of node 7 is the most preferred one, when the rate of return is high enough to provide incentives to invest into sufficient excess capacity. The main drawback of this solution is that the Government loses on the existing system utilization because of high tariff for the shippers.

There is a trade-off for the regulators to establish tariff low enough for shippers, and high enough for investors. This twofold objective of the Government reduces efficiency of tariff regulation in relation to the incentive problem. There arises a need for an additional coordination device in the infrastructure planning. The system operator, acting as a common agency, bears this responsibility. Observing actions of the Government, Gassco evaluates investment incentives and suggests solutions that are both feasible for the investor and beneficial for the Norwegian state. The position of the common agent is to ensure an efficient interaction between the regulatory framework and market-based incentives, and reconcile conflicting interests of the principals.

3. Model implications and discussion

The focus variable in the presented model is the share of recoverable investment costs. Reasoning behind this variable is the existence of a second-hand market for pipeline investments, represented by shares in the Gassled joint venture. This conclusion is supported by the dynamics of Gassled composition. Until 2010, the ownership in the Gassled gave preferential access rights on the primary market for transportation services. When these benefits were abolished, petroleum companies decided to redirect the capital to their core activities, as exploration and production. Several gas producers partially or totally sold their shares to investment vehicles. The interest to such acquisitions by the investment funds suggests that Gassled shares were generally considered as secure and rather profitable investments. An important implication of these changes in Gassled is the separation of infrastructure owners from users. 45.8% of shares now belong to the State (through a fully state-owned company Petoro), 42% – to investment vehicles and only 7.2% – to upstream companies, i.e. the main owners are not the users of the infrastructure anymore. Entities not directly involved into gas production have no such investment incentive as a need for transport solution. It may cause the problem of underinvestment in the long-run.

The interpretation of the game for the state of the Norwegian gas transport market before the tariff reduction suggests that the Government kept rather high tariff, prioritizing the infrastructure development goal. However,

according to the model, Low tariff was the dominant strategy of the Government, which found its reflection in the tariff reduction in July 2013. This decision was motivated by the prioritization of the existing system utilization.

The changes of July 2013 relate only to the existing infrastructure, not covering the newly built infrastructure. The Government can ensure high rate of return on new projects, having a lower one for the existing infrastructure. Such a strategy may have different implications. On one hand, lower tariffs in the southern part of the network give incentives for petroleum activities in the north, even if the transport tariff in the newly built facilities is high. E.g. the new pipeline, Polarled (planning start-up in 2016), will connect the fields in the Norwegian Sea to the processing facilities onshore at Nyhamna and export transport system to Easington (the Langeled pipelines). According to the new tariff regime, the tariff for Langeled will be close to short-term marginal costs, while the tariff for Polarled will be based on long-term marginal costs, and therefore, significantly higher. However, total transportation costs for gas produced up north will not be as high as they could have been under the old tariff regime. On the other hand, such a solution may have a distortion effect on the utilization of the newly built facilities: the route of the Polarled pipeline will partially go along the existing Åsgard Transport pipeline, which is fully utilized at the moment, but is expected to have spare capacity after 2020. If the tariff for transportation service via Polarled is considerably higher than via Åsgard, companies may prefer to postpone field development until there is spare capacity at the latter one, leaving Polarled underutilized.

An important question is whether the current system provides sufficient perspectives for investment cost recovery, even with the high rate of return on new projects. At the moment, the existence of the second-hand market for infrastructure investments is under question; e.g. investment funds are reluctant to overtake the Polarled investments. If the secondary market will not be recovered, the investments will not find demand, or gas companies will have to sell them for a lower price in order to recover the capital. If this price is too low for a company, it may prefer to keep the investments; then, the share of shippers in Gassled will increase in the long run. The incentive problem may be resolved by a larger participation of the State in the investment projects, through Petoro, by funding the excess capacity to incentivize companies for exploration and development of the marginal fields along the pipeline. In this case, the share of Petoro will grow together with the investments, making the system inclined to become state-owned.

4. Conclusion

The paper uses a game theoretic approach to understand the interplay between the regulatory regime and investment behavior in the Norwegian gas transport sector. The model contains a set of rather strong simplifications (regarding the actions and payoffs of the players, relations between the costs of the pipeline and LNG facilities, etc.) and does not pretend for an exhaustive explanation of complicated interactions on the gas transport market, but nevertheless, outlines its main features and provides an analytical structure to address important regulatory issues.

In a liberalized market, development of transport network is left for market powers to communicate investment incentives for gas companies. An efficient governmental regulation is needed to ensure that the incentive structure assures adequacy of the transport infrastructure to the petroleum resources and demand in the long run. The Government aims at welfare maximization from all petroleum activities on the NCS. This objective has two dimensions: maximization of utilization of existing network and new infrastructure development. The tariff regime works in opposite directions for these two dimensions. This ambiguity reduces efficiency of the tariff regime in investment incentives provision. The actions of the common agent, the ISO, can mitigate the conflict of interests between the long-term planning of the State and short-term profit maximization of commercial companies. Gassco observes actions of the Government and incentives for gas companies in order to suggest a solution feasible for both principals. Intervention of the system operator is necessary to coordinate the infrastructure planning process and ensure well-functioning of the gas sector in the long run.

References

1. Hirschhausen Ch. Infrastructure, regulation, investment and security of supply: A case study of the restructured US natural gas market. *Utilities Policy* 2008;16: 1-10.

2. Norwegian Petroleum Directorate. Ressursrapporten petroleumsressursene på Norsk kontinentalsokkel. Stavanger: 2013.
3. Egging, RG, Gabriel SA. Examining market power in the European natural gas market. *Energy Policy* 2006; 34(17): 2762-78.
4. Holz F, Hirschhausen C, Kemfert C. A Strategic Model of European Gas Supply (GASMOD). *Energy Economics* 2008; 30: 766-88.
5. Gasmi F, Oviedo JD. Investment in transport infrastructure, regulation, and gas–gas competition. *Energy Economics* 2010; 32(3): 726-36.
6. Hagen KP, Kind HJ, Sannarnes JG. Network ownership and optimal tariffs for natural gas transport. Discussion paper / Norwegian School of Economics and Business Administration, Department of Economics; 2004:27.
7. Xu Y, Haugen K. A game of upstream natural gas pipeline development. 10th IAEE European Conference: Energy, Policies and Technologies for Sustainable Economies; 2008.
8. Dixit A, Grossman G, Helpman E. Common Agency and Coordination: General Theory and Application to Government Policy Making. *Journal of Political Economy* 1997; 105: 752-69.
9. Peters M. Common agency and the revelation principle. *Econometrica* 2001; 69: 1349-72.
10. Bernheim BD, Whinston MD. Common agency. *Econometrica* 1986; 54: 923-942.
11. Midthun KT. Optimization models for liberalized natural gas markets. Ph.D. thesis; Norwegian University of Science and Technology; Norway; 2007.
12. Rømo F, Tomasgard A, Hellemo L, Fodstad M, Eidesen BH, Pedersen B. Optimizing the Norwegian natural gas production and transport. *Interfaces* 2009; 39(1): 46-56.