Extended Abstract (Work in Progress)

Regulation of Natural Gas Pipeline Investments

- An Experimental Evaluation

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Abstract:

We conduct economic laboratory experiments in order to compare the performance of rate of return regulation and regulatory holiday regulation in providing incentives for an optimal expansion of natural gas pipeline capacity. We additionally evaluate in how far the introduction of long term financial transportation rights (LTFTR) in each of these two regulatory schemes affects overall performance of the schemes in general as well as the optimality of pipeline expansion decisions in particular. Preliminary findings suggest that regulatory holiday regulation does not provide adequate incentives for an optimal expansion of pipeline capacity as it performs significantly worse in our test-environment compared to rate of return regulation.

1. Introduction

Regulation of investments in network infrastructure has attracted and continues to attract a considerable degree of attention both from the academic community[1] as well from policy makers. On one side, the natural monopoly nature of many network industries necessitates access

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[1] Vogelsang 2005 provides a good overview of the relevant literature.

regulation which prevents the infrastructure-owner from charging significantly supra-competitive prices from network-access seeking parties. Conversely, the prospect of effective regulation in that sense decreases the expected profitability of building new network infrastructure for a potential investor, diminishing the chance to obtain a socially optimal level of investments in the first place. Furthermore, regulation intended to stipulate investments should also take into account how to compensate a potential investor for the ex-ante risk of stranded assets.

The European Regulators' Group for Energy and Gas (ERGEG) has initiated Gas Regional Initiatives (GRI) to determine characteristics of an environment which stipulates a sensible expansion of the gas-pipeline capacity between the member states. Clearly, the evaluation of the suitability of regulatory regimes to overcome the previously mentioned potential conflict of goals is essential for the success of this undertaking. This paper utilizes economic laboratory experiments to assess the properties of two regulatory regimes – rate of return regulation and regulatory holiday regulation – in this regard. To the best knowledge of the authors, this is the first time that Regulatory Holiday Regulation is subjected to tests using economic experiments. Both regulatory systems are tested with and without periodic markets for long term financial transportation rights (LTFTR). Sales of LTFTR might at least partially reduce the ex-ante risk of stranded assets and the volatility of income streams and might thus be seen as a suitable measure for enhancing both regulatory systems mentioned.

This paper proceeds as follows: The next section motivates our choice of regulatory regimes and our rationale for using economic laboratory experiments in order to evaluate them. The research questions of this paper will also be outlined. Section 3 details our experimental design while Section 4 provides results. Section 5 concludes and gives an outlook.

2. Regulatory Schemes and Economic Experiments

Regulation of network industries, be it telecommunications, energy or gas, has manifested itself in a considerable number of regulatory schemes. Cost-plus regulation, price-cap regulation as well as revenue caps come easily into mind, as well as rate of return (RoR) regulation. These represent arguably the most prevalent choices of regulatory schemes aiming at the regulation of existing network capacity. In fact, RoR-based regulation is used in some member states of the European Community (EC) to regulate gas pipelines. This circumstance (which ensures familiarity of the concept with participants of the GRI[2]) along with the fact that regulation of existing capacity and not stimulation of new investments is RoR regulation's primary goal turn it into a suitable benchmark for regulatory schemes which explicitly strive to address the potential investment issue hinted at in the previous section.

One category of these schemes are "regulatory holidays", as discussed by Gans & King 2003. Under Regulatory Holiday Regulation, a potential investor is exempted from access regulation for a pre-specified amount of time. This exemption is intended to address the following issue which potentially arises under the aforementioned regulatory regimes, such as RoR: If such regulation is applied and the investment turns out to be successful, an investor's profits are truncated by regulation. At the same time, if the investment turns out to be unsuccessful, the investor still has to bear the full costs of that failure. Thus, for a given level of ex-ante risk, an investor's expected profits from an investment under "conventional" regulation is lower than under regulatory holiday regulation. Consequently, a potential investor might either reduce its level of investment below the optimal level or not invest at all. Interestingly, the Second Gas Market Directive (2003/55/EC, Article 22) has provisions for granting something akin to a regulatory holiday for investors establishing new interconnector capacity, albeit under very strict

[2] A major part of this research effort is funded by the Dutch regulator (NMa) in the context of discussions within the GRI framework, hence a certain level of familiarity of the involved regulation to GRI participants was mandatory. We express our deep thanks to the NMa for the financial support.

conditions which have to be met. Hence, choosing regulatory holiday regulation for a comparative evaluation is a sensible decision.

Regulatory holiday regulation grants unregulated profits to an investor in order to compensate it for an ex-ante risk of stranded assets[3]. A different approach towards at least partially overcoming a potential investor's reluctance to invest due to fear of stranded assets is by providing an investor with a source of reliable information on future demand for transportation capacity as well as a stable flow of income over that period. We choose periodic auctions of long term financial transportation rights (LTFTR) as means to achieve this. LTFTR are financial hedges which entitle their holders, in our case gas-shippers which are active in transportation capacity spot markets, to a share of the revenues an investor (which from now on we assume to be a Transportation System Operator, TSO) receives in these spot markets. There are several reasons for our decision to assess LTFTR within the context of the two aforementioned regulatory regimes. First, during their validity period, which spans over several spot market periods, they provide the potential investor with information on future demand. By choosing an appropriate level of investments given the aggregated demand information acquired in an LTFTR auction, a TSO can ensure that no assets will be stranded during that time and at least cost recovery is guaranteed. If risk of stranded assets was indeed a major obstacle for investments, the introduction of periodic LTFTR auctions in addition to spot market transportation capacity auctions would diminish that obstacle. Should such an effect exist, we can assess and compare it to the extent of the assumed positive effect on the level of investments triggered by implementing regulatory holiday regulation instead of RoR regulation. There is then clearly also the opportunity to identify any interactions between the regulatory schemes and the introduction of LTFTR.

[3] Initial discussions with Transportation System Operators (TSO) taking part in the GRI quoted the risk of stranded assets as the potentially most severe hindrance towards investments in interconnector capacity in an environment relying (solely) on competitive transportation capacity allocation. The involved regulatory authorities strive for competitive allocation of capacity to the largest extent possible.

Second, the income of the TSO is decoupled from potentially highly volatile spot market revenues: If a TSO covers all pipeline capacity with LTFTR sales, it will need its entire spot market income to compensate LTFTR holders (the shippers). The TSO instead derives its income solely from LTFTR sales, which are constant during the entire validity period of the LTFTR. Third, LTFTR are not only beneficial for a TSO but also for shippers, as acquiring LTFTR protects a shipper both against not obtaining capacity in the spot markets and against having to pay "too high" spot market prices. LTFTR achieve this by generating a payment for its holder which is independent from a successful acquisition of transportation capacity in the spot market.

Two additional aspects motivate our decision to contemporaneously assess LTFTR with RoR and regulatory holiday regulation schemes. First, the inclusion of LTFTR provides an excellent opportunity to assess in how far a TSO can make optimal investment decisions if it only relies on competitive spot market sales. Put differently, we want to seize the opportunity to assess in how far the addition of long term demand information contributes to an optimal pipeline capacity expansion and in how far this effect differs for the two types of regulation. Second, - and more of practical relevance - periodic LTFTR auctions provide a convenient and elegant way of implementing a regulatory holiday scheme. This will be outlined in the following section.

Our methodology of choice for the actual evaluation of the discussed regulatory schemes as well as the effect of introducing periodic LTFTR auctions are economic laboratory experiments, which have a successful record in assessing the properties of regulatory schemes intended for implementation in network industries. Please refer to Kiesling 2005 for an excellent summary of the work done in that regard. In short, the advantages of using laboratory experiments are the possibility to implement regulatory schemes both in environments which contain essential features of actual or hypothetical surroundings, the possibility to compare market outcomes to theoretical benchmarks and the possibility to do so at low costs and prior to the implementation of the actual regulatory scheme. However, arguably the most significant benefit of evaluating regulatory schemes by means of laboratory experiments is the opportunity to identify possibilities for strategic, efficiency decreasing behavior.

Our research questions are thus as follows:

- What is the relative performance of RoR and regulatory holiday regulation in an environment which reflects essential features of natural gas-transportation markets?
- How much does the inclusion of long term demand information by means of periodic LTFTR auctions affect overall performance of the aforementioned regulatory schemes?

The upcoming section discusses our experimental design, that is the actual implementation of the regulatory schemes as well as the experimental environment in which they are assed. Proceedings during the experiment are also discussed.

3. Experimental Design

As outlined, we intend to identify the properties of two regulatory schemes as well as their interactions with LTFTR auctions. Hence we devise a 2x2 design, yielding the four combinations of treatment variables (regulatory scheme and LTFTR respectively). So far, we have conducted two treatments: RoR without LTFTR and regulatory holiday with LTFTR.[4] The experiments were conducted at the CenterLab facilities at Tilburg University using the z-tree software (Fischbacher 2007). In both treatments, one subject takes on the role as TSO while four subjects take on roles as shippers. The roles are assigned based on the performance of the subjects in a quiz, which is used to ensure subjects' understanding of procedures. The subject exhibiting the best performance was assigned the role as TSO.

[4] These are the two treatments for which funding by the NMa was obtained, hence they were conducted first in order to meet GRI requirements. Only the proceedings in these treatments will be discussed in this extended abstract. We expect to have conducted the remaining two treatments by January 2010.

In both treatments, the subjects interact over two separate thirty period spot market cycles. Shippers learn their individual demand (valuation) for transportation capacity[5] in periods 1, 7, 13, 19 and 25 for the current and five subsequent periods with certainty. The functional form of inverse aggregated transportation capacity demand by the shippers is given by:

$$P_t(q_t) = a - \frac{b}{g_t} q_t \tag{I}$$

Where a and b are fixed parameters, q_t the amount of transportation capacity and g_t a growth parameter. $g_t = 1$ in the first period of each thirty period cycle and grows by approximately 6% per period until period 12. It remains constant from period 12 up to period 15 and declines by approximately 6% during periods 16 to 18. From period 19 onwards g_t increases again by approximately 6% per period. The subjects possess no information about this. The competitive equilibrium pipeline capacity is equal to 8 capacity units in period 1 and equal to about 19 units in period 30.

Subjects can, at the revelation of demand information (periods 1, 7, 13, 19 and 25), decide to raise part of their valuations by pre-specified amounts of experimental currency units for all spot market periods until the subsequent revelation of demand. If they do so, they incur a fixed cost in every period until the subsequent revelation of demand. This aspect captures potential must-serve demand obligations. In both treatments, the TSO can invest (expand pipeline capacity) every three periods, i.e. in periods 1, 4, 7, … We do only consider the case of a single pipeline. The expansion itself is costless, but a fixed cost per pipeline capacity unit is incurred in every period until the end of the thirty period cycle, regardless on whether it is actually used to provide transportation capacity or not.

[5] The following convention shall apply: "Transportation capacity" designates the amount of capacity on the pipeline that the shippers acquire during spot market auctions, whereas the term "pipeline capacity" is used to designate the actual physical size of the pipeline. A TSO's investment decision hence concerns the expansion of pipeline capacity. One unit of pipeline capacity is required for the provision of one unit of transportation capacity.

In the RoR / No LTFTR treatment (henceforth simply RoR treatment), a spot market auction for transportation capacity is conducted at the onset of every period. If the period is also an investment period (1, 4, 7, …) it is conducted after the TSO decides on the expansion of pipeline capacity. Shippers submit bids for transportation capacity which are aggregated and presented to the TSO, which then decides on the amount of pipeline capacity to be used for the provision of transportation capacity. The price for transportation capacity which all successful bidders have to pay is equal to the lowest accepted bid. A price cap is in place such that if the resulting price exceeds that cap, the TSO receives the capped price (and hence a pre-specified return) per unit of pipeline capacity actually used for providing transportation capacity. Hence, there is a "used and useful" rule in place which discourages the TSO from making wasteful investments in pipeline capacity. The difference between shipper payments and TSO spot market income in case of a binding spot market price cap constraint is kept by the experimenter[6]. The spot markets of each period are the only means for the TSO to offer transportation capacity to the shippers.

Proceedings in the regulatory holiday / LTFTR treatment (henceforth simply regulatory holiday treatment) are overall similar. A spot market for transportation capacity is conducted in every period and the TSO can invest in pipeline capacity every third period. In addition to the RoR treatment there is an LTFTR auction held in the periods in which individual transportation capacity demand is revealed to the shippers, that is in periods 1, 7, 13, 19 and 25. The proceedings are completely identical to the spot market auction for transportation capacity as discussed for the RoR treatment. There is one difference though: The TSO is required to offer as many LTFTR to cover its entire pipeline capacity which exists at the moment of the LTFTR auction, but is free to offer more. As in the spot market auction for transportation capacity, there is a price cap in place which limits the maximum payment per LTFTR unit the TSO can receive.

[6] We make no assumptions on the utilization of this amount, as it is mostly a political decision in reality. We do however clearly consider it when computing overall efficiency.

That cap is equal to the one implemented in the spot market auctions for transport capacity in the RoR treatment. Shippers which acquire LTFTR pay the resuling price for LTFTR in every period until the next LTFTR auctions. One LTFTR generates, in each period in which it is valid, a payment equal to the spot market price of one unit of transportation capacity.

In a period in which a LTFTR auction takes place, it is conducted prior to the TSO's opportunity to expand pipeline capacity and prior to that period's spot market for transportation capacity[7] in that period. This provides the TSO with the following options: First, if the TSO expands capacity such as to match the number of LTFTR sold in the LTFTR auction of the same period, it uses its entire income from the transportation capacity spot markets to compensate the holders of the LTFTR. The TSO then receives a constant income stream solely from the regulated sales of LTFTR. Alternatively, the TSO can install more pipeline capacity than LTFTR units sold in the most recent LTFTR auction. In that case, the TSO's income from the spot market sales of transportation capacity is at least as high as the necessary payments to LTFTR holders and, in case of transportation capacity prices larger than zero, higher. It is thus this additional pipeline capacity for which the TSO is exempted from regulation and allowed to make unregulated profit. However, this regulatory holiday for additional pipeline capacity expansions does only last until the next LTFTR auction as at that point in time the TSO is once more required to offer LTFTR for all pipeline capacity which exists at the onset of the LTFTR auction, and that includes the new pipeline capacity as well.

4. Results

Four sessions of each of the two treatments were conducted. Every subject took only part in one session. The statistical analysis is performed by means of a mixed effects model of the specification

[7] The rules are exactly the same as discussed for the spot markets in the RoR treatment, with only two exceptions: The TSO must offer its entire pipeline capacity and the resulting market price is unregulated, i.e. there is no cap in place.

$$Y_{it} = \alpha + \beta X_{it} + \upsilon_i + \varepsilon_{it} \qquad \text{(II)}$$

Y_{it} is the independent variable of interest, α a fixed intercept and the coefficient beta β represents the combined fixed effect of regulatory holiday regulation as well as LTFTR auctions. X_{it} is thus a one / zero dummy attaining a value of one in the regulatory holiday / LTFTR treatment. υ_i is a random intercept accounting for session effects (subscript i is used to designate the individual sessions). Finally, ε_{it} designates a random error term.

We report results from the second thirty period cycle, as by that time we can confidently assume that the subjects have fully accustomed themselves to the experimental procedures. We do not report the random session effects for reasons of brevity, but they are of course available on request, as are the statistical results of the first thirty periods.

Table 1: Development of pipeline capacity, transportation capacity spot price and efficiency

	$K_{it} - K_{it}^{comp}$			$p_{it}^{spot} - p_{it}^{spot\_comp}$			$\Pi_{it} / \Pi_{it}^{comp}$		
	Coef..	Std. Err.	$p >\mid z\mid$	Coef..	Std. Err.	$p >\mid z\mid$	Coef..	Std. Err.	$p >\mid z\mid$
$\alpha(cons)$	-2.575	0.455	0.000	14.758	4.191	0.000	0.945	0.017	0.000
β	-2.025	0.644	0.002	30.717	5.926	0.000	-0.176	0.024	0.000

K designates installed pipeline capacity, p the spot market price of transportation capacity and Π the sum of profits of the TSO, the shippers and the auction authority. The superscript $comp$ indicates competitive equilibrium outcomes obtained under the assumption of a benevolent social planner which optimizes over the entire 30 period with full information on aggregate demand.

We find that in the regulatory holiday treatment, the difference between optimal pipeline capacity and actually installed pipeline capacity is significantly higher. That is the capacity in the regulatory holiday treatment falls significantly short of both the optimal level of pipeline capacity and the level of pipeline capacity realized in the RoR treatment. As a result, the difference between actual and competitive equilibrium spot market prices for transportation capacity is significantly higher in the regulatory holiday treatment as compared to the RoR treatment. Finally, efficiency is significantly lower in the regulatory holiday treatment. We will discuss likely explanations for this in the next section. By using the same statistical test procedures, we find that the TSO earns significantly more profits under regulatory holiday regulation than under RoR regulation, while shippers in aggregate earn significantly less.

Figure 1: Averages Pipeline Capacity

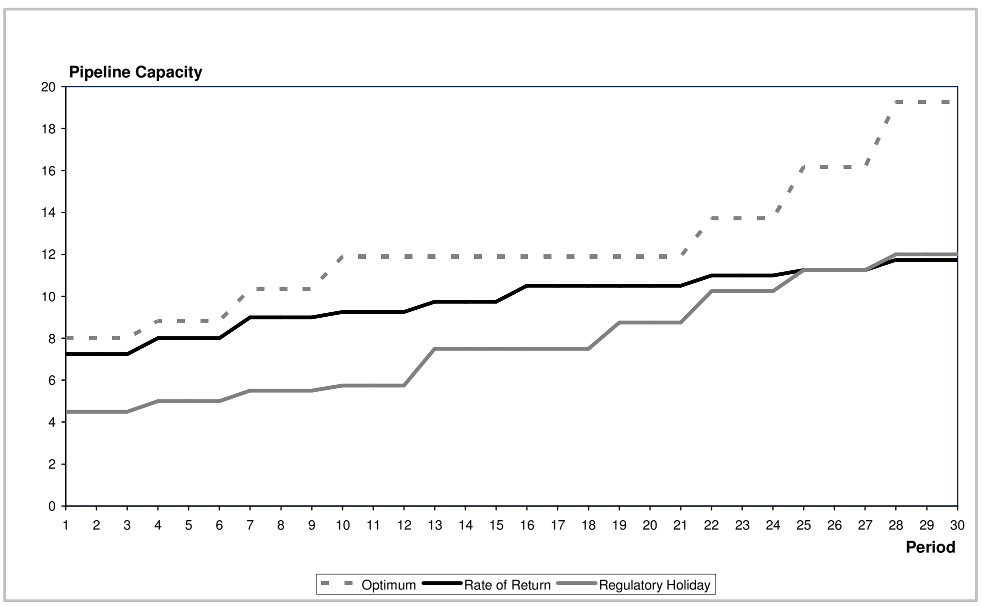


Figure 1 reveals the pattern of pipeline capacity expansion. Until the stagnation and subsequent drop in demand for transportation capacity (occurring during periods 12-15 and 16-18 respectively), pipeline capacity is much faster expanded in the RoR treatment. From period 12 onwards, the rate of capacity expansion under regulatory holiday regulation is higher and the overall pattern of pipeline capacity expansion is more persistent.

Figure 2: Averages Spot Market Price for Transportation Capacity

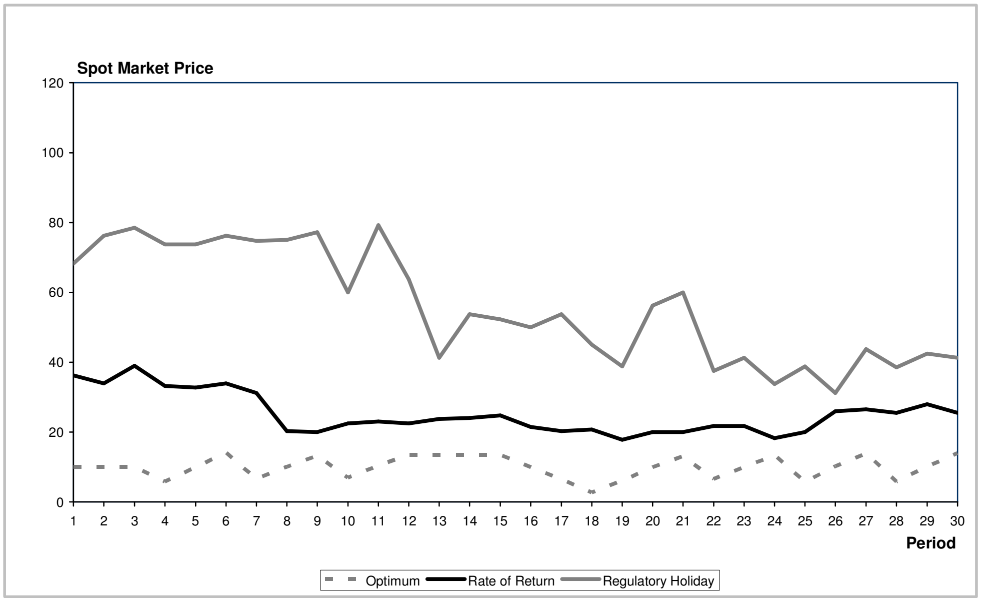
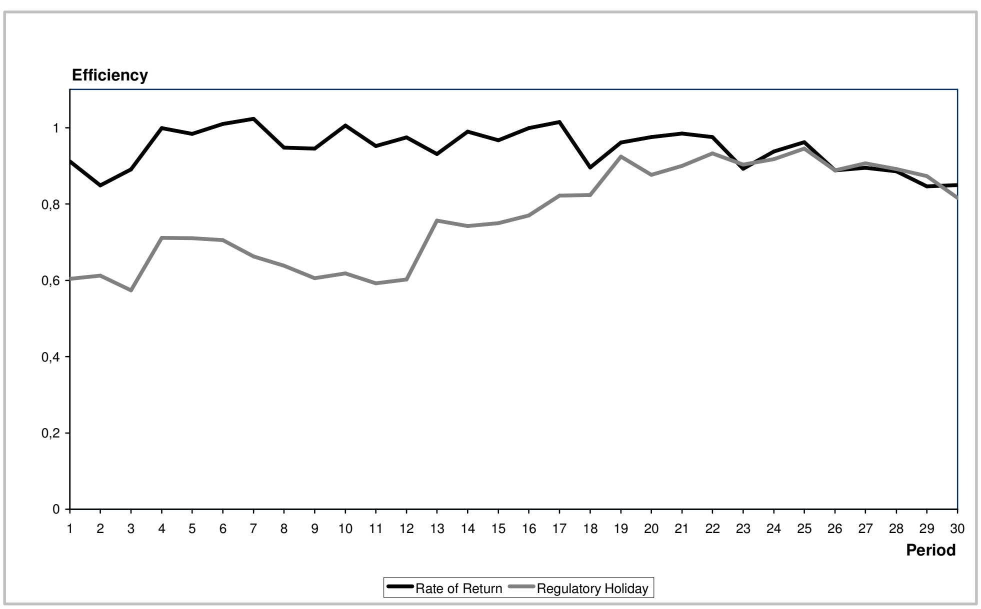


Figure 2 reveals the development of transportation capacity spot prices. As both table 1 and figure 1 already suggest, the prices are significantly higher under regulatory holiday regulation, especially over the first two thirds of the cycle.

Figure 3: Averages Efficiency



Finally, Figure 3 indicates the level of efficiency over time. It is evident that again over approximately two thirds of the cycle efficiency under RoR is significantly higher than under regulatory holiday regulation but as capacity catches up the gap closes. The next section discusses these results, concludes and gives and outlook.

5. Conclusions & Outlook

Clearly, with only the results from two treatments, there is no way of giving a fully qualified answer to the research questions at this stage. However some qualified interpretations can be made. The most striking observation is clearly that RoR regulation without LTFTR clearly outperforms regulatory holiday regulation with LTFTR. The results seem to indicate that regulatory holiday regulation is most likely inappropriate to trigger an optimal level of investments in an environment like ours in which the investor is able to repeatedly make significant expansions to pipeline capacity over time. A sensible argument is as follows: Under regulatory holiday regulation, with any current expansion of the pipeline, be it an expansion which is regulated (if the TSO chooses to offer LTFTR for the expansion immediately) or an unregulated one, the TSO decreases its chances to obtain potentially very high unregulated profits in the future. Hence, the experiments reveal that the optimal strategy for the TSO turns out to be the following under regulatory holiday regulation: The TSO only offers the amount of LTFTR it is required to offer, i.e. the amount needed to cover the currently installed pipeline capacity. It then uses the LTFTR auction for obtaining information on future aggregated demand for transportation capacity. If that demand turns out to be relatively high compared to the currently available pipeline capacity (which is actually the case in our environment especially in early periods), a minor expansion of pipeline capacity generates huge unregulated profits for the TSO while at the same time the potential to obtain significant unregulated profits in the future is only slightly decreased. The pattern shown in figure one as well as data on LTFTR sales and actual pipeline capacity expansions support this argument.

"Ironically", the additional demand information provided by LTFTR auctions seems to have contributed to the bad performance of the regulatory holiday scheme. Again, there is no way to provide a definitive answer until the remaining treatments have been conducted, but it is once more the pattern in figure 1 which gives some indications. It is evident that with the beginning of the temporary demand stagnation / demand drop in period 12, pipeline capacity expansion in the RoR treatment continues at a much slower pace than under regulatory holiday information. One way to explain this is with the superior information on future demand provided by the additional LTFTR auctions in the regulatory holiday treatment as compared to the information a TSO can obtain when solely relying on spot market sales as in the tested RoR treatment. By means of the information conveyed by the aggregated bids for LTFTR the TSO was able to determine that although demand was decreasing, there was still plenty of "headroom" for continuing with relatively minor expansions in order to maximize its profit as described previously. It is this very continuation of the expansion pattern under regulatory holiday regulation (with LTFTR) during and after the drop in aggregated transportation capacity demand together with the relative slowdown of pipeline capacity expansion under RoR regulation (without LTFTR) during the same timeframe which suggests that periodic LTFTR auctions serve their intended purpose well to provide the TSO with information on future demand. However, under the incentive structure of the regulatory holiday scheme this information enables the TSO to behave anti-competitively as outlined above.

Provided that the two arguments given have merit, we should observe that a RoR regulatory scheme combined with periodic LTFTR schemes performs well, exceeding the performance of both schemes tested so far. We will use this as an additional working hypothesis. It should also be mentioned that in an environment with more volatile aggregate demand for transportation capacity, any scheme that lacks dedicated mechanisms to transfer long term demand information from the shippers to the TSO is likely to exhibit significant efficiency losses.

In such an environment the performance gap between the two schemes already subjected to testing is arguably lower than what we observe from our results.

We intend to proceed with the conduction of the remaining two treatments in order confirm or refute the tentative explanations given for the observed results and to provide definitive answers to our research questions.

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