***OPTIMAL CAPACITY AND TWO-PART PRICING FOR NATURAL GAS PIPELINES UNDER ALTERNATIVE REGULATORY CONSTRAINTS***

Matthew E. Oliver, Georgia Institute of Technology, 404-894-0491, matthew.oliver@econ.gatech.edu

David Finnoff, University of Wyoming, 307-766-5773, finnoff@uwyo.edu

Charles F. Mason, University of Wyoming, 307-766-5336, bambuzlr@uwyo.edu

## Overview

## Natural gas continues to play an increasingly prominent role as a primary energy resource, particularly in the United States. Domestic supplies have increased dramatically over recent years due to advances in extraction technology, and demand has steadily risen as electrical plant managers shift toward natural gas in response to increased public concern over carbon emissions from coal-fired electricity generation. However, the ability of the natural gas market to link supply and demand centers is fundamentally limited by the capacity of the natural gas pipeline transmission network. Insufficient capacity over certain routes results in the emergence of bottlenecks and network congestion, which are known to have systematic and measurable effects on transportation costs. Increased transportation cost drives apart the natural gas spot prices at any two nodes on the network, indicating reduced market integration and, more importantly, potential negative welfare effects. Furthermore, federal regulation of interstate natural gas pipelines, while having moved considerably toward a more liberalized restructuring over the past two decades, maintains some important controls over rate-setting behavior. This paper’s broad intent is to illuminate potential interactions between this regulatory framework, the pipeline capacity and transportation markets, and the natural gas spot market. Our results suggest that these interactions may result in suppressed investment in pipeline capacity—a situation that exacerbates congestion issues and undermines efficiency.

## In the U.S., the market for natural gas pipeline transmission is comprised of two distinct tiers. The primary market, in which pipelines sell ‘firm’ capacity contracts using a two-part tariff structure, is subject to rate-of-return regulation. In the secondary market for transportation services, owners of firm contracts may either utilize their contracted capacity or release it to other shippers. Both secondary market activities are transacted at decentralized market-based prices, potentially earning firm contract owners scarcity rents. Previous research has raised concerns that this regulatory dichotomy – i.e. price controls in the primary market and market-based prices in the secondary market – diverts scarcity rents away from the pipeline to the firm contract holders. This diversion negatively impacts a pipeline’s incentives to install sufficient capacity where needed, which exacerbates congestion problems. To examine this issue, this paper extends a rich literature on optimal capacity and pricing to account for these key structural features of the natural gas pipeline market, deriving and solving the optimization rules for a pipeline’s two-part tariff and capacity under alternative regulatory regimes. Importantly, we assume that demand for shipping services in the secondary market is stochastic. The key implication of our work is that under certain conditions the tandem effects of congestion, secondary market uncertainty, and tariff structure rigidity can suppress primary market demand for capacity. As a result, we find that the optimal installed capacity of the pipeline under rate-of-return regulation is only a slight improvement over the unregulated monopoly optimum capacity, and falls well short of the socially optimal level. This, in turn, has the potential to generate large wealth transfers from the pipeline to the primary contract holders, who are able to capture the scarcity rents accruing to excessively constrained transport capacity.

## Methods

## We consider a simple network model with two hubs connected by one pipeline. That is, the pipeline is assumed to be a local monopoly over the transport route in question. For comparison, the analytical model derives optimality conditions under three alternative regulatory regimes – unregulated monopoly, a Ramsey second-best solution (i.e. constrained welfare maximization), and rate-of-return regulation. As the optimality conditions that obtain under each regulatory alternative are too complex to solve analytically, we parameterize and numerically solve each set of conditions. To examine the effect of secondary market demand uncertainty, we compute the solution under each regulatory alternative for a series of different scenarios regarding the distribution of secondary market demand. More specifically, we parameterize the variation in each individual firm capacity owner’s secondary market demand such that it has 1) a low variance and a low correlation with the other firm capacity owners’ secondary market demands, 2) a low variance and a high correlation with the other firm capacity owners’ secondary market demands, 3) a high variance and a low correlation with the other firm capacity owners’ secondary market demands, or 4) a high variance and a high correlation with the other firm capacity owners’ secondary market demands. For each solution, we compute the key endogenous variables (i.e. the optimal two-part tariff and capacity of the pipeline), as well as several other important network variables, including the spot price differential and total economic welfare.

## Results

## Results indicate that in each of the four distributional scenarios, optimal capacity under rate-of-return regulation exceeds the unregulated monopoly level, but is less than what would occur under a Ramsey second-best solution. So, while our results are consistent with the classic Averch-Johnson hypothesis that a rate-of-return regulated firm will employ a greater capital stock relative to the unregulated optimum, the result that the pipeline’s optimal capacity under rate-of-return is less than the Ramsey second-best socially optimal level implies that under-investment in pipeline capacity may indeed exacerbate congestion issues. Calculations of social welfare under each regulatory regime show that total economic welfare is sub-optimal under rate-of-return regulation in each distributional scenario. An important aspect of the problem is that the Ramsey solution accounts for the external effect of capacity on spot prices – and thus on the consumer and producer surpluses in the markets connected by the pipeline – whereas rate-of-return regulation does not. Furthermore, we find that it is the variances of the individual firm capacity owners’ uncertain secondary market demands that are the centrally important parameters in influencing the pipeline’s optimal capacity. When uncertainty in the secondary market is high (i.e. distributional scenarios 3 and 4 above), the pipeline’s optimal capacity under rate-of-return regulation is scarcely greater than in the unregulated monopoly optimum. In other words, uncertainty leads to an attenuation of the Averch-Johnson effect, and causes rate-of-return to perform more poorly relative to the second-best solution. Finally, we find evidence that high secondary market demand uncertainty is associated with significant wealth transfers from the pipeline to the firm capacity owners under rate-of-return regulation that do not occur in the Ramsey second-best outcome.

## Conclusions

## In the market for natural gas pipeline capacity (primary) and transportation (secondary), uncertainty in the secondary market plays a central role in the capacity reservation decisions of primary firm customers. The key implication of rate-of-return pricing for pipelines is the real potential of severely distorted optimality conditions that determine a pipeline’s pricing structure and maximum capacity. This problem is especially relevant given that constrained capacity results in negative external effects on the economic welfare of producers and consumers at the hubs connected by the pipeline. With this in mind, our analysis demostrates that even when uncertainty in the secondary market is relatively low, rate-of-return regulation constricts maximum capacity – and consequently overall economic welfare – relative to what would occur under a Ramsey second-best socially optimal rule. This finding emanates primarily from the fact that a rate-of-return pricing rule for pipelines does not force the pipeline to internalize the aforementioned external costs. Furthermore, we show that under rate-of-return regulation, a high degree of uncertainty regarding daily fluctuations in secondary market transportation demand strongly suppresses reservation demand in the primary capacity market relative to the second-best outcome, greatly reducing the optimal capacity of the pipeline. Based on our results, we argue that rate-of-return regulation is likely to be a poor choice for pipeline routes characterized by a high degree of stochasticity of demand in the secondary market for transportation services.