# *MODELING CO2 PIPELINE SYSTEMS: AN ANALYTICAL LENS FOR CCS REGULATORS*

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**Overview**

Carbon Capture and Storage (CCS) is regularly depicted as a crucial technology to reduce the social cost of achieving carbon neutrality. However, its deployment critically depends on the installation of $CO_2$ infrastructures. As the regulatory procedures governing their provision are yet to be clarified, the purpose of this paper is to assess the social and environmental impacts of such regulations. We show how the engineering equations of a $CO_2$ pipeline implicitly define a Cobb-Douglas production function. We then infer that the resulting cost function exhibits economies of scale and verifies the technological condition for a natural monopoly. As the possible exertion of market power is a concern, we evaluate the social distortion of the unregulated monopoly and the average-cost pricing solution, which we compare to the outcomes of the welfare-maximizing solution. While the deadweight loss obtained under average-cost pricing remains lower than 5% compared to the first-best solution, our findings indicate that allocative efficiency is an issue, with more than a quarter of the $CO_2$ emissions not being transported. By providing the first analytically determined cost function of a $CO_2$ pipeline, this analysis will usefully inform the emerging regulatory policy debates on CCS.

**Method**

This paper adapts the theoretical lens of engineering economics applied to natural gas pipelines, which shows the substitution effects between capital and energy (Perrotton and Massol 2018; Massol 2011; Yépez 2008; Chenery 1949). Through this technical representation, we describe the microeconomic behavior of a $CO_2$ pipeline operator that transports the emissions through a single point-to-point pipeline system. By assuming a cost-minimizing operator, we quantify the impact of regulation on the level of capital investment analytically, the quantity of $CO_2$ that the pipeline operator agrees to transport – i.e., the supply for the transportation service – the pipeline operator's profit, and the social welfare.

**Results**

We show that the technology of a point-to-point $CO_2$ trunk pipeline system can be represented using a Cobb-Douglas production function with two inputs: capital and energy. We prove that this system exhibits pronounced economies of scale, that the long-run total cost function is subadditive, and that it thus verifies the theoretical condition for a natural monopoly. This finding has important policy implications, as it suggests that some form of regulatory intervention may be necessary to attenuate the adverse effects resulting from the exertion of monopolistic power. We show how this could create an underutilization of the CCS transportation system, thus undermining eventual environmental objectives. Following these results, we discuss some assumptions of our model and suggest future avenues of research.

**Conclusions**

The existing regulatory frameworks imposed on $CO_2$ pipelining remain unclear and vary greatly from one region to another. Our study questions whether regulators have truly grasped the monopolistic character of these infrastructures, and the risk that the exhibition of market power can represent. Since part of the difficulty in regulating lies in the information asymmetry between the pipeline operator and the regulator, our paper aims at reducing this gap by determining the cost function of the former.

We propose a new representation of $CO_2$ pipeline systems that captures their essential engineering features: a Cobb-Douglas production function that allows substitution between two inputs (capital and energy), which verifies the technological condition of a natural monopoly. Our representation analytically validates the widely accepted – but rarely demonstrated – hypothesis that the $CO_2$ pipeline system exhibits economies of scale. We believe that this representation provides an observable and simple analytical understanding of the $CO_2$ pipeline system for policymakers, thus reducing the informational asymmetry between the regulator and the regulated firm. In practice, regulators most likely do not have full information on the pipeline operator's cost function as these infrastructures are still emerging. Our model thus provides a framework for analyzing their economics and should thus prove useful to academics, regulators, and policymakers interested in their deployment.

**References**


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