Methane and Markets: Firm Incentives to Emit *

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Abstract

As the primary component of natural gas, methane is both a powerful greenhouse gas and a valuable commodity. We explore the economic factors that influence firms' decisions to emit rather than to sell the gas that they produce. Using novel data on methane emissions from the Permian Basin, we provide empirical evidence that emissions respond to high-frequency price variation. In particular, emissions are positively correlated with capacity constraints in natural gas processing and pipelines, as captured by the Henry-Waha Hub price spread. To rationalize these dynamics, we present a model of the natural gas industry in which firms make production and emissions decisions in response to oil and gas prices, as well as the cost of capturing and transporting gas. The model implies a substantial social cost to insufficient processing and transmission capacity. With the model, we estimate the impact of taxing methane emissions assuming different levels of capacity constraints.

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1 Introduction

Methane is a powerful greenhouse gas, 80 times more potent than CO_2 in its first 20 years. However, as the primary component of natural gas, it is also a valuable commodity. About a quarter of U.S. methane emissions are from the oil and natural gas sector. If a greater share of this methane were captured and sold rather than emitted, the U.S. would be well on its way toward achieving its commitments under the Global Methane Pledge.

Because of methane's dual nature, it would be natural to think that emissions should decrease when the price of natural gas increases. Indeed, firms have more incentive to abate emissions when the reward for doing so increases. However, gas supply decisions are not only a function of price. For one, gas is a byproduct of oil production. As a result, gas production is determined in conjunction with oil production. For another, transporting gas is difficult. Pipelines are the only cost-effective way to move natural gas long distances, without first liquefying the gas (an expensive, energy-intensive process). When pipelines are full, producers are unable to bring their gas to market even if they would very much like to.

In this project, we explore the relationship between methane emissions, natural gas prices, and pipeline capacity constraints. We focus on the Permian Basin, an area of rich natural resource deposits located in West Texas and the southeastern corner of New Mexico. The Permian is a natural setting for our investigation because it is an area of intense oil and natural gas production. The area accounts for 17% of U.S. natural gas extraction, and over 40% of its oil (Federal Reserve Bank of Dallas, n.d.). It is also a region where pipelines have frequently hit capacity limits. We make use of recent advances in methane monitoring technology to analyze how emissions respond to these capacity constraints and other economic factors. Until recently, it has been impossible to accurately track methane emissions at any time scale, let alone at high frequency. New methods (Varon et al., 2022) use satellite measurements and atmospheric inversion techniques to produce weekly measurements of methane emissions over the Permian Basin.

Using the differential between the local (Waha) hub price and the benchmark (Henry) hub price as a proxy for pipeline capacity constraints, we find that Permian methane emissions and flaring are both significantly and positively correlated with capacity constraints. Together, our estimates suggest that during periods of constrained capacity, producers flare gas that cannot be sold rather than reducing production. Because flaring is imperfect, increased flaring releases additional methane directly into the atmosphere. These correlations are strongest in areas of the Permian where production is tilted more towards oil, a pattern implying that producers whose profits are less dependent on gas sales are also less likely to restrict gas production in the face of capacity constraints.

To rationalize our reduced-form estimates, we build a static model of firm emission decisions. In this model, firms decide on a level of oil and gas production to maximize profits at prevailing prices. Concurrently, they decide what share of the gas they produce to emit rather than capture and sell, given that both capture and transmission to customers are costly. We estimate this model using data on emissions, gas and oil prices, and gas flows through the Permian Basin. Key to our estimation strategy is a dataset on pipeline outages due to unplanned maintenance events, which provides us with exogenous shocks to pipeline capacity.

Our estimates allow us to calculate the marginal social benefit of additional pipeline capacity. We also model the emissions impact of a tax on methane (as has been proposed in the US), assuming different baseline levels of capacity. We find that when capacity constraints bind at baseline, methane taxes have little to no impact on emissions. Conversely, when capacity constraints are slack, methane taxes effectively reduce producers' methane emissions while increasing the amount of natural gas brought to market.

With this research, we bring new persepctives to the policy conversation around methane emissions, which until now has focused exclusively on increasing the price of emitting. Our conclusions highlight the importance of non-price market mechanisms in determining emissions, and the possibility for alternate policies (changes in pipeline permitting, new regulations around well drilling, etc.) in addressing this important issue. In future work, we plan to build a dynamic model of pipeline investment decisions to better understand how market structure and regulation contribute to pipeline capacity frequently undershooting natural gas production.