Long-Run Productivity Models of Oil and Gas for Energy and Climate Policy: A Stable Equilibrium or Inherent Volatility?

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Overview

Studies on the economics of long-run climate and energy policy extend beyond the frontiers of today's knowledge, requiring a consideration of potential developments in future oil and gas production techniques. To address uncertainties in this context, the global change research community uses a hypothesis developed by Rogner (1997) to understand the economics of future hydrocarbon resources, where an autonomous compounding learning-by-doing effect improves the productivity of all upstream expenditures in a permanent equilibrium for securing investment. However, there are presently no studies that empirically calibrate this learning parameter or assess its efficacy. We examine the suitability of this learning-driven productivity model by analyzing trends in industry productivity data, highlighting cyclical and structural elements of upstream performance since the late 1970s. This approach provides empirical constraints for the resource economics applied by the Global Change Asessment Model (GCAM) to scenarios of international climate policy targets, projected mitigation costs and the role of oil, gas and coal in a low carbon global energy future.

Methods

We draw from time-series data of major oil and gas producer performance profiles to test for evidence of pure endogenous learning in upstream costs for oil and gas production through extending a method proposed by Nordhaus (2009). These data calibrate the full century geologic supply curve of oil and gas resources used by the GCAM partial equilibrium model of global energy markets. GCAM is then applied to solve for developments in the global energy system through the year 2100, providing the decarbonization scenarios it develops with empirically calibrated productivity trends for underlying carbon-intensive resources.

Results

This work finds that the learning model approach proposed by Rogner (1997) has accurately described trends in industry operational expenditures. However, development expenditures did not show productivity gains as anticipated. Our analysis of empirically consistent industry productivity rates more accurately captures the effect of industry cycles, moderating the effect of compounded productivity gains in multi-decade studies. Slight changes in GCAM's chosen learning rate produces scenarios of radically different conventional and unconventional oil production, indicating the need for more research that calibrates energy industry productivity in studies of climate and energy policy.

Conclusions

While the original Rogner (1997) theory provides a compelling description of dynamic industry productivity for use in long-term studies, evidence from the last few decades provides reason to develop a more refined assesment. The effect of industry investment cycles have yet to find plausible representation in integrated assessments of climate and energy policy. This can have a significant influence on how the future of the oil and gas is framed in these studies.

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