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# U.S. natural gas exports and their global impacts ☆,☆☆

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## HIGHLIGHTS

- We evaluate potential global impacts of the U.S shale gas boom.
- We use a global economic model, CTEM to understand this timely policy issue.
- World economic activity is higher when U.S. natural gas exports rise.
- The magnitude of U.S. income gains depends on the rate and level of export changes.
- The effects on other countries vary with the scenarios and model parameter values.

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## ABSTRACT

We evaluate potential global impacts of increase in U.S. natural gas exports as a result of the shale gas boom. To our knowledge this is the first such analysis using a global economic model to understand this timely policy issue. Our primary conclusion is that world economic activity is higher through most of the simulation period [2014–2035] when U.S. natural gas exports rise. The overall U.S. results mirror the global ones, but the magnitude of income gains depends upon how the rate of increase and level of exports are determined, and the price elasticity of natural gas supply. The U.S. benefits more when export increases and levels depend on natural gas production rather than when they are pre-determined by assumption. The economic impacts on other natural gas importers and exporters can change as well based on how export levels are determined. The effects on natural gas prices, consumption, and production in individual countries vary with the scenarios and model parameter values.

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## 1. Introduction

The Natural Gas Act of 1938 requires U.S. Department of Energy (DOE) authorization to import or export natural gas to or from the United States. Although the U.S. has exported limited amounts of natural gas via pipeline to Canada and Mexico for many years, recent developments in U.S. natural gas production due to shale have changed the export picture considerably. As of September 2013 there have been 32 applications to export domestically produced liquefied natural gas (LNG). Twenty-five of these applicants have also requested approval to export to countries with which the U.S. does not have a free trade agreement (non-FTA countries), and four of the non-FTA applications have been approved.[2] The potential for further rises in U.S. natural gas exports has led to a robust debate about the economic costs and benefits of such trade.

In this paper we consider the economic impacts of various U.S. natural gas export scenarios. To our knowledge this is the first such analysis using a global economic model to understand this important policy issue. Our primary goal is to assess the potential costs and benefits for the U.S., natural gas importers, and natural gas exporters using a global framework. We also seek to perform a variety of sensitivities on key modeling choices to understand what is driving the magnitude and direction of the results. Although we do not use a model specific to the natural gas industry, we are able to consider global trade in all goods and services to evaluate the broader economic impact of U.S. natural gas export scenarios.

☆ The analysis and conclusions expressed here are those of the authors and not necessarily those of the EIA, CSIRO, or CAMA.

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[2] The Natural Gas Act of 1938 was amended in 1992 so that exports to countries with which the U.S. has an FTA are considered in the national interest and fast-tracked for approval. See http://energy.gov/fe/downloads/summary-lng-export-applications for details on LNG export applications and approvals.

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To date, the debate surrounding increased U.S. natural gas exports has focused on their consequences for domestic natural gas prices and economic activity. The consensus is that allowing more natural gas exports will lead to higher prices, and that these higher prices will depress economic activity in energy-sensitive sectors according to the Congressional Research Service (CRS) [1].[3] The disagreement revolves around whether the benefits of exports in terms of employment and investment are large enough to offset the losses from higher natural gas prices.[4] This is a quantitative issue that has been studied extensively in both model and non-model based reports (see the next section for a review).

Because of their specific nature, there have been four key aspects missing from most of the model-based reports: (i) an assessment of the global economic impacts of U.S. natural gas exports; (ii) consideration of how U.S. export levels are determined; (iii) scenarios that consider pipeline exports; and (iv) sensitivity analysis on key parameter values. We attempt to address each of these by using a global macroeconomic model under various scenarios and assumptions about exports and parameter values.

To allow for comparison, we begin by replicating U.S. LNG export scenarios based on the January 2012 report prepared for the DOE by the U.S. Energy Information Administration (EIA) [9]. We then consider alternatives that solely incorporate pipeline exports to Canada and Mexico. For each group of scenarios we vary our assumptions regarding the driver of U.S. natural gas export and the price elasticity of U.S. natural gas supply.[5] Results are presented for the U.S.; Japan, the EU25, and Mexico (natural gas importers); Canada, Russia, and OPEC (natural gas exporters); and (where applicable) the world.

The overall results show that the manner in which export levels are determined and assumptions about the price elasticity of U.S. natural gas supply are important ingredients in determining the magnitudes of world and U.S. income gains. For natural gas importers and exporters the results change sign depending upon these assumptions.

Our primary conclusion is that world economic activity is higher through most of the simulation period [2014–2035] when the U.S. exports additional natural gas. U.S. national income rises through 2030 when either LNG or pipeline exports are exogenously specified, but falls below zero after this point. Under endogenously specified exports U.S. income changes are always positive, and the magnitude of U.S. national income increases is highest when natural gas supply has elastic responses to price changes. In contrast, when exports are exogenous the largest U.S. income gains occur under inelastic natural gas supply. With the exception of Mexico, natural gas importers are better-off under exogenous U.S. exports, while the results for natural gas exporters vary.

## 2. Literature review

Our paper fits into a relatively large research area that considers the interactions between energy and economic activity as in Sharma [14], energy market integration and economic growth as in Sheng and Shi [15], and how energy may constrain growth as in Nel and Zyl [16]. More specifically, we focus on the impact of natural gas on economic growth as in Apergis and Payne [17], although we use a model-based approach. In similar work, Wakamatsu and Aruga [18] consider how shale gas impacts natural gas markets, while Logan et al. [19] focus on how shale may influence the U.S. power sector. However, none of these papers consider the potential global economic impacts of U.S. natural gas exports. Paltsev et al. [20] do model such exports, but they concentrate on how the integration of international natural gas markets may or may not influence the volume of U.S. exports. Because this topic is a relatively new area of research, the majority of related analysis has been done by either government agencies or consulting firms, although the focus has U.S. centric.

The recent debate surrounding potential impacts of U.S. natural gas exports has seen the use of varying models and methods. EIA's January 2012 report, in response to a DOE request, considers four pre-selected scenarios of increased natural gas exports under different assumptions about U.S. natural gas supply and economic activity [9].[6] EIA uses the National Energy Modeling System (NEMS), which includes both a U.S. natural gas model as well as a U.S. economic model in generating its conclusions. The report concludes that U.S. natural gas prices will be higher under any of the export scenarios, but does not evaluate the corresponding domestic macroeconomic impacts. NERA Economic Consulting followed-on with a report using a computable general equilibrium (CGE) macroeconomic model alongside a world natural gas model that does evaluate the economic impacts on the United States [10]. Using the same natural gas export scenarios as EIA, NERA finds that increasing natural gas exports will lead to small net economic benefits for the U.S. economy.[7]

Charles River Associates (CRA) challenged these results in a February 2013 study [7].[8] Using a non model-based approach, they argue that greater exports will lead to higher natural gas prices, and these prices will have a negative impact on the U.S. manufacturing sector and overall economic activity. This view was supported by Sarica and Tyner [8], who use the MARKAL-Macro model to show that permitting additional natural gas exports can cause small reductions in U.S. GDP. ICF International counter this view using another model-based approach, finding that greater U.S. natural gas exports will lead to positive employment and GDP impacts in the U.S. [5].[9] None of the three aforementioned studies use the DOE export scenarios.

To simplify, proponents of allowing increased U.S. natural gas exports argue that the economic benefits to energy and related industries outweigh the costs, while opponents counter that both American firms and households will be hurt by higher natural gas prices.

## 3. Model, scenarios, and calibration

This section begins by reviewing the model used in our analysis, including a detailed description of its unique features. It then outlines the U.S. natural gas export scenarios used to generate simulation results and describes the variations. The section concludes by explaining the calibration procedure for each of the scenarios.

[3] Darmstadter [2], Deloitte [3], Ebinger et al. [4], ICF [5], and Medlock [6], among others, argue that the price impacts of additional U.S. natural gas exports will be small-to-moderate, while CRA [7] and Sarica and Tyner [8] take the opposite view. EIA [9] and NERA [10] occupy a middle ground.

[4] How natural gas prices affect the U.S. economy is a different question that has not seen extensive empirical study. However, the results in Kliesen [11] and Arora et al. [12] suggest that the impact may not be large, even in energy-intensive industries. Additionally, the analysis in Arora and Lieskovsky [13] indicates that the response of natural gas production to exports will have the largest influence on subsequent U.S. economic activity.

[5] Other sensitivities that include changing how natural gas exports are implemented in the model and varying the degree of substitutability of natural gas in trade between regions (Armington elasticities) have also been performed. They do not change the main results of the paper and so are not shown for brevity.

[6] See http://www.fossil.energy.gov/programs/gasregulation/reports/fe_eia_lng.pdf.

[7] See http://www.fossil.energy.gov/programs/gasregulation/reports/nera_lng_report.pdf.

[8] See http://www.crai.com/uploadedFiles/Publications/CRA_LNG_Study_Feb2013.pdf.

[9] See http://www.api.org//media/Files/Policy/LNG-Exports/API-LNG-Export-Report-by-ICF.pdf.