

The Macroeconomic Impacts of Increasing US LNG Exports



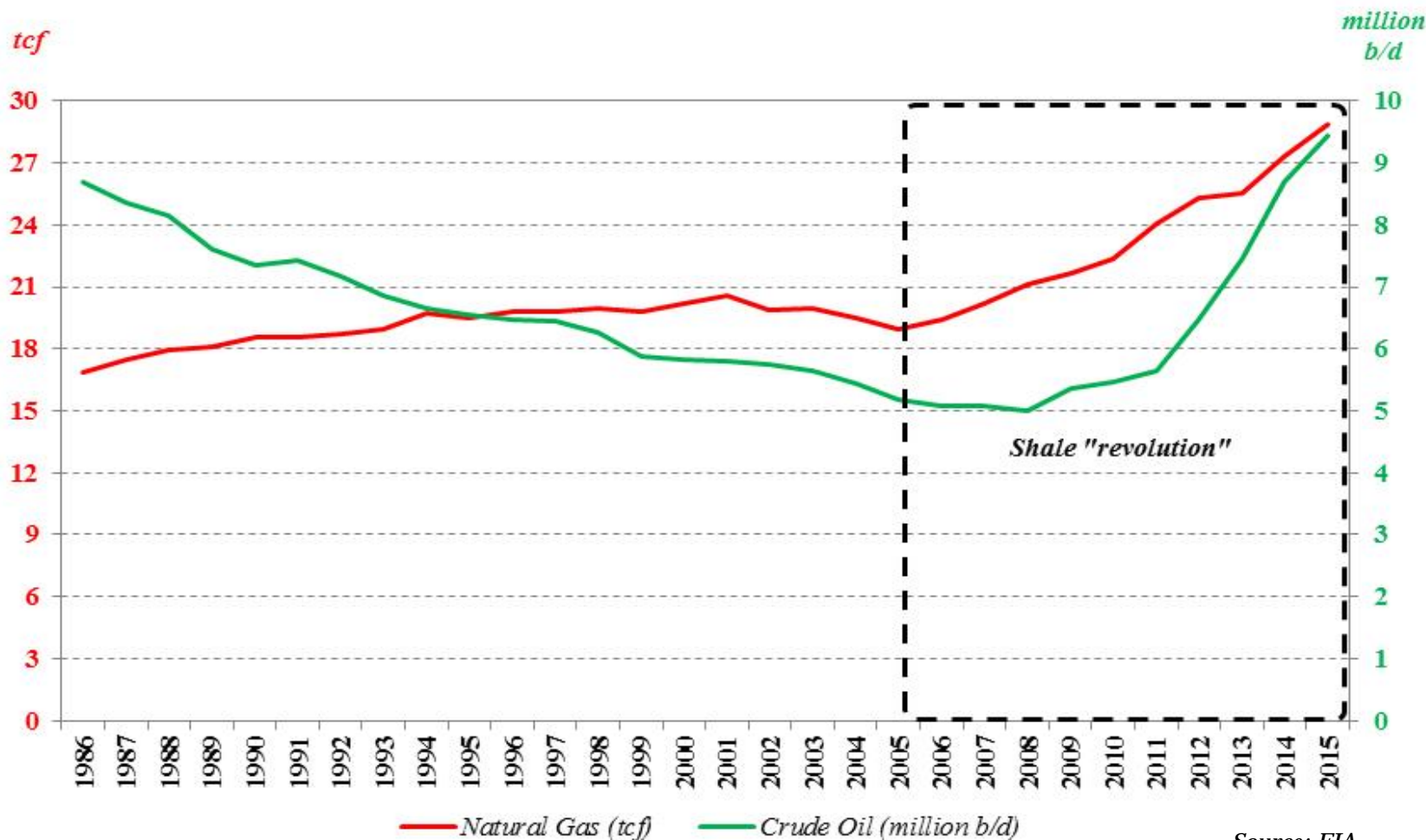
Kenneth B Medlock III, PhD

**James A Baker III and Susan G Baker Fellow in Energy and Resource Economics, and
Senior Director, Center for Energy Studies
Rice University's Baker Institute**

April 8, 2016

Shale drives significant change

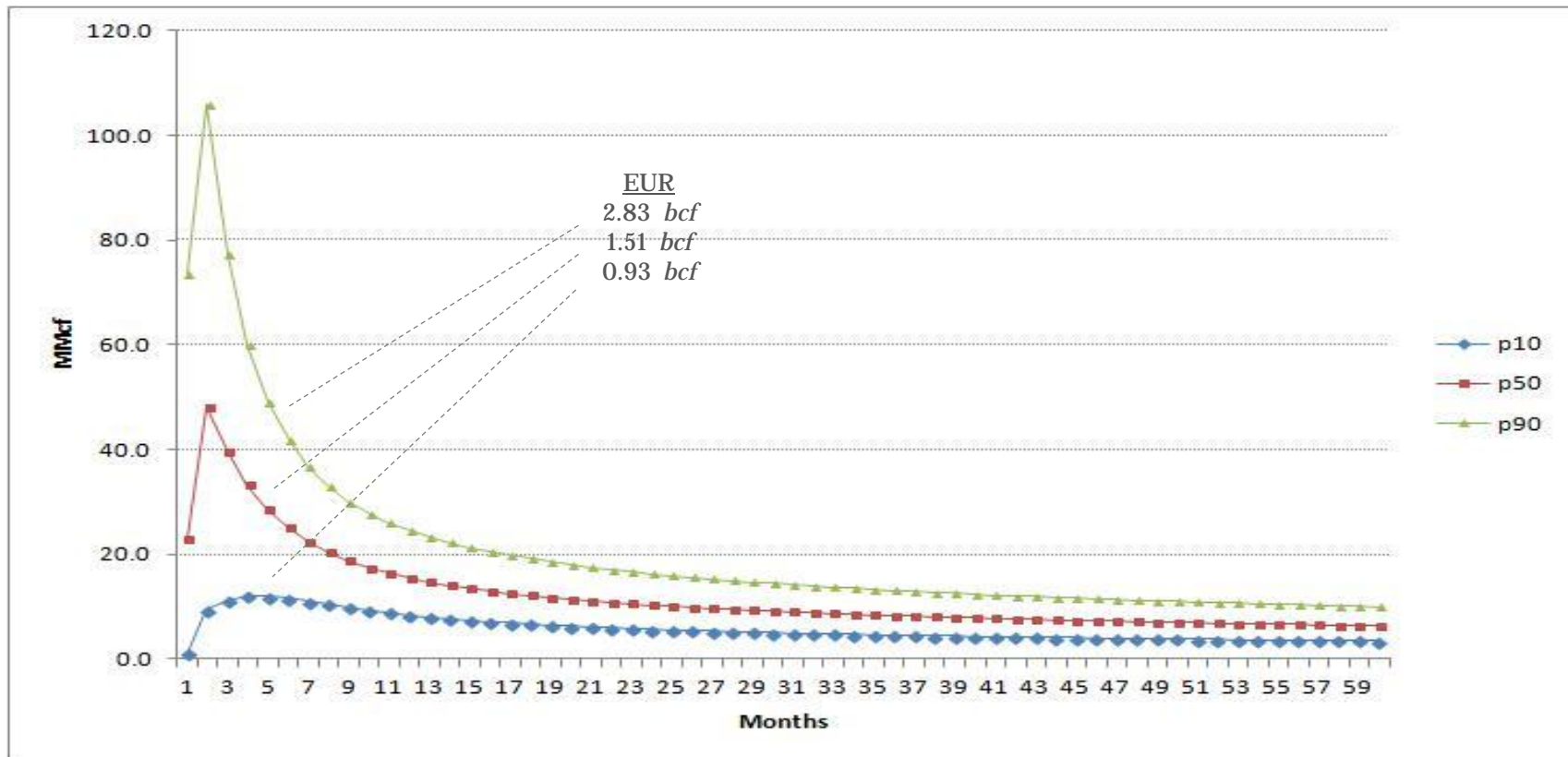
- The “Shale Revolution” has been paradigm shifting in the US upstream since 2005.



Source: EIA

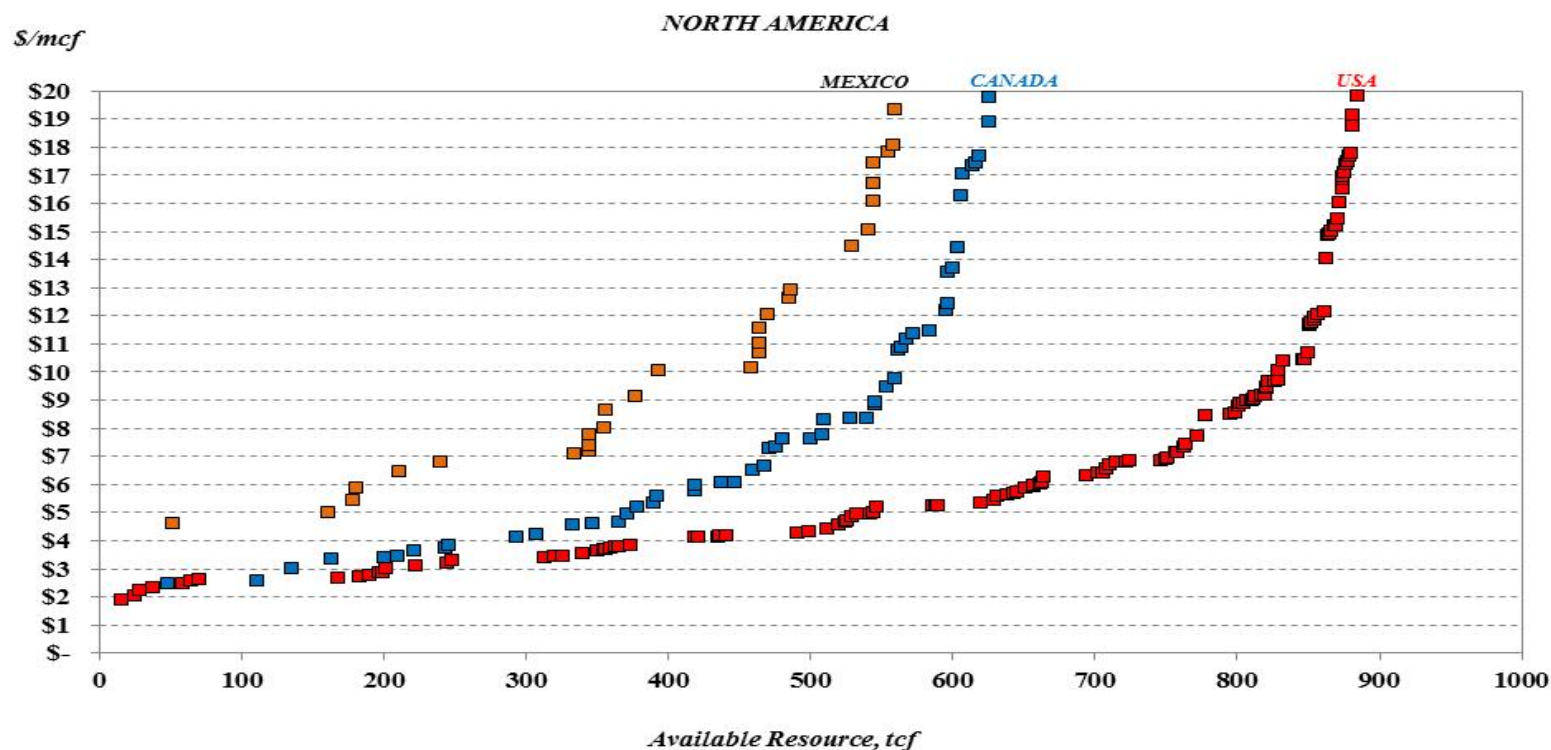
Shale well performance is very heterogeneous

- The Barnett experience translates to other shales. Depicted below are “type curves” based on empirical analysis of production history for over 16,000 wells in the Barnett shale.



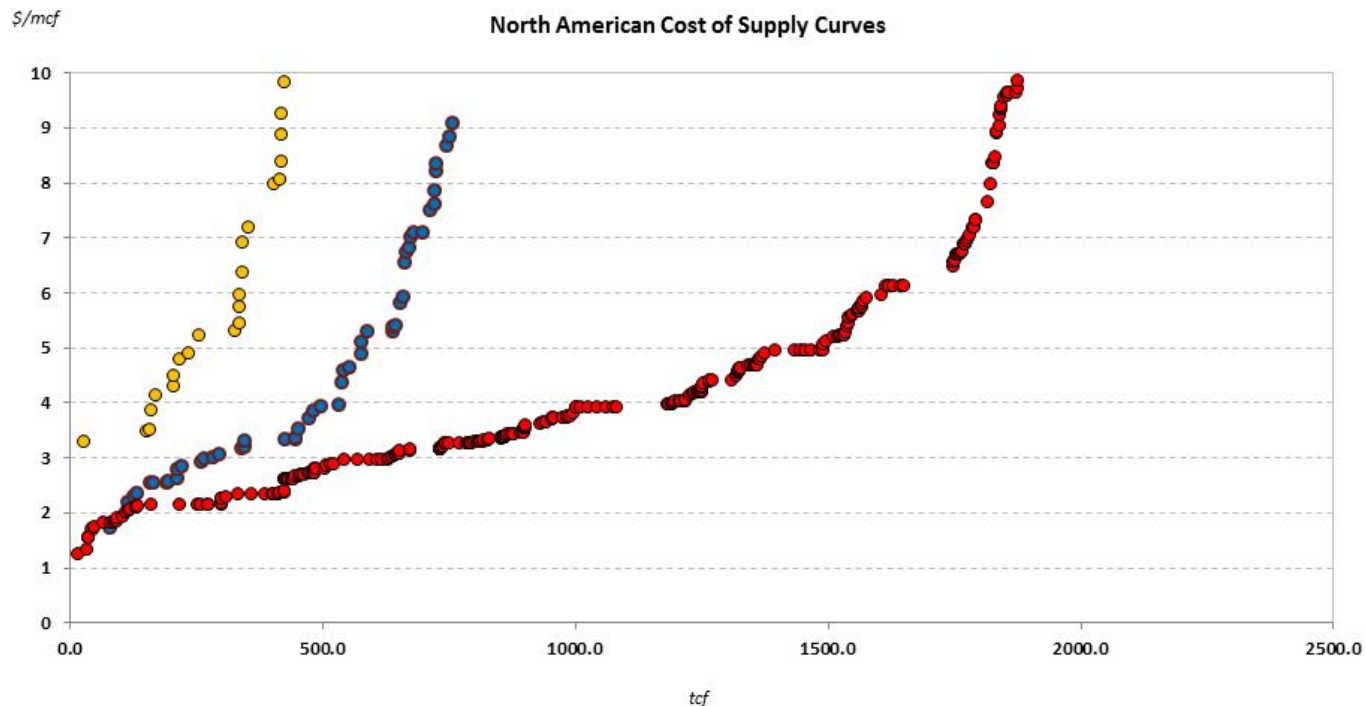
A Long Term Shale Gas Opportunity...

- About 1,400 tcf of shale gas at wellhead prices below \$6, making North America a driver of supply-side global gas developments for years to come.
- Importantly, sustained development will require lots of drilling activity.



... seated in a robust natural gas opportunity

- About 1,400 tcf of shale gas at wellhead prices below \$6, making North America a driver of supply-side global gas developments for years to come.
- Importantly, sustained development will require lots of drilling activity.

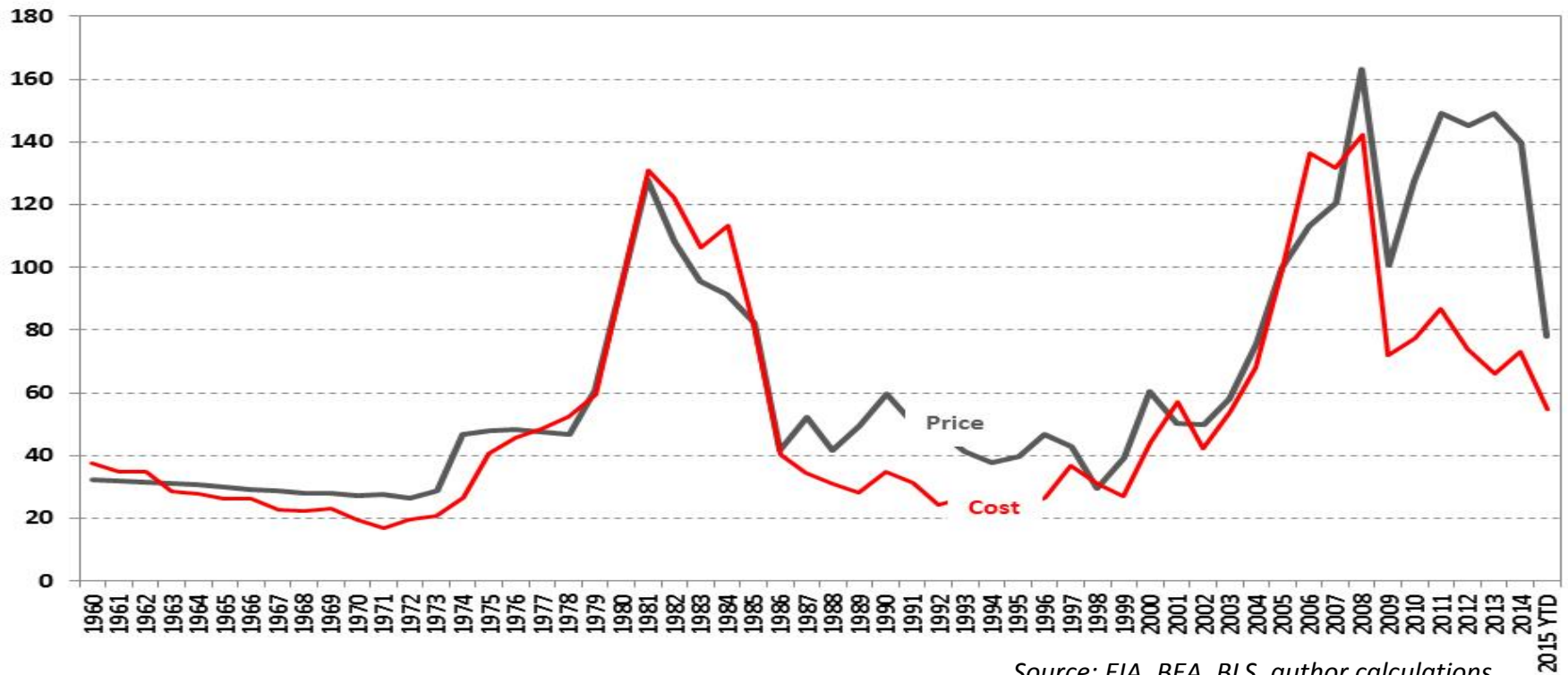


Comment: The Long Run Cost Environment

Oil Price versus Cost (Real, \$/b vs \$/b)

- Today's cost environment is below the mid-trend cycle due to underutilization and productivity improvement. So, price should rise, all else equal, as activity increases.

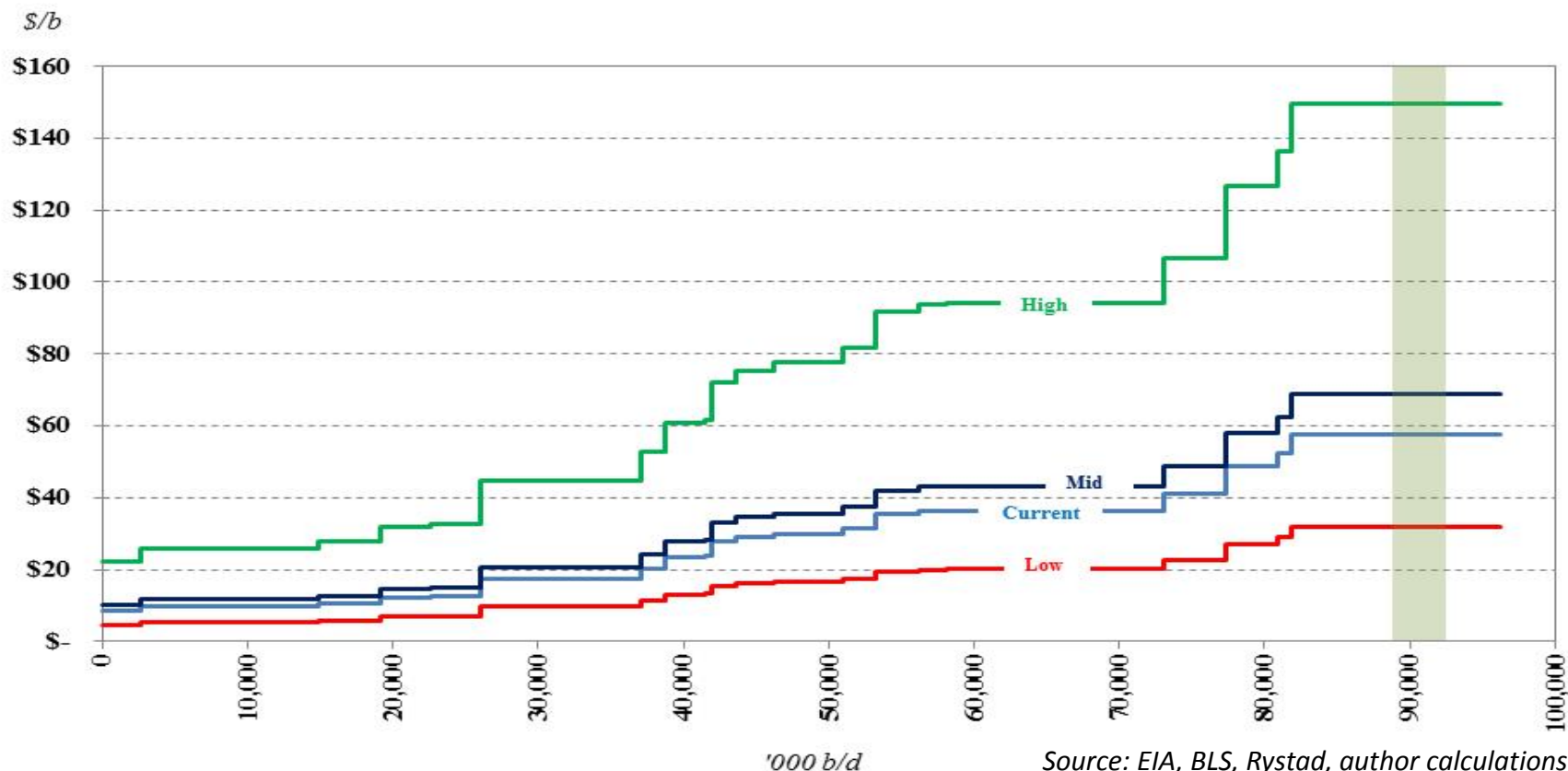
Index,
2005=100



Source: EIA, BEA, BLS, author calculations

Comment: Dynamic Long Run Costs

- Supply-demand imbalances trigger investment cycles that react to price.
- Cost pressures mount when demand exceeds current production capacity.
- The mid-trend is consistent with a real oil price of about \$65/b, but productivity gains can reduce this.



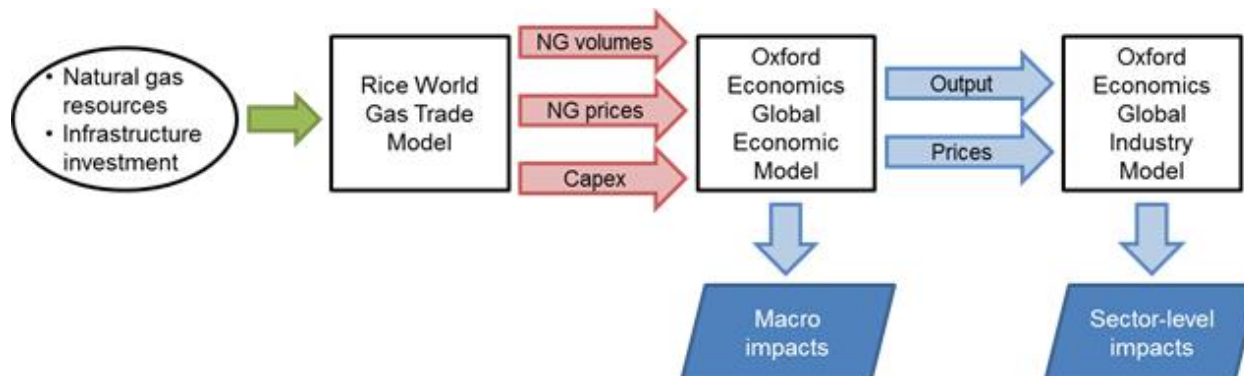
Detail on the study

“The Macroeconomic Impacts of Increased US LNG Exports”

**completed for the US Department of Energy by
the Center for Energy Studies at Rice
University's Baker Institute and Oxford
Economics**

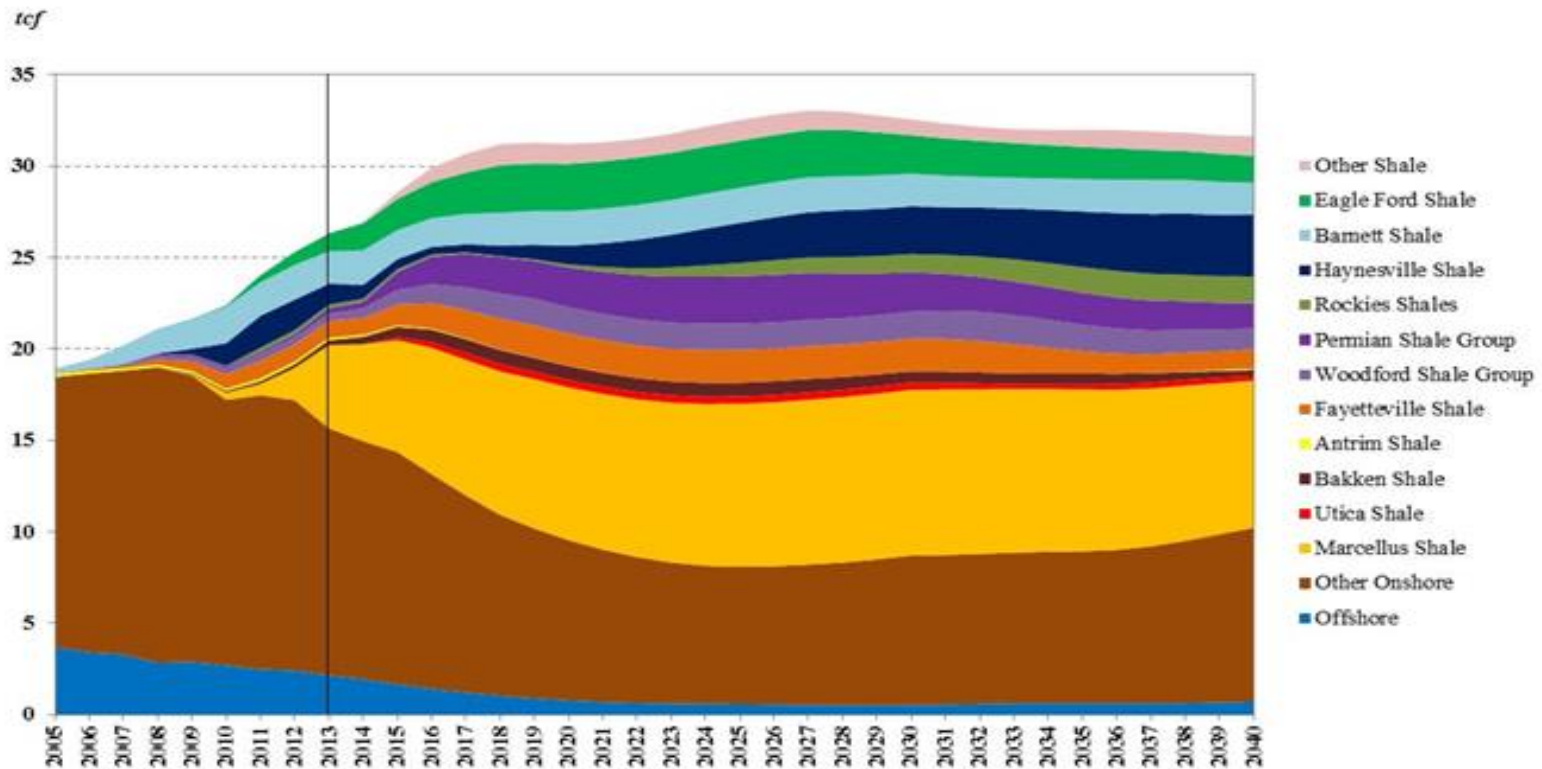
Modelling Approach

- The goal is to assess the impact of US LNG exports in excess of 12 Bcf/d in cases where international demand pull supports up to 20 Bcf/d of US LNG exports.
- We use a highly specialized, multi-stage modelling approach.
 - The Center for Energy Studies at Rice University's Baker Institute used its Rice World Gas Trade Model (RWGTM) to simulate alternative futures for the global gas market.
 - The RWGTM output data were then input into the Oxford Economics Global Economic Model (GEM) and Global Industry Model (GIM) to simulate broad macroeconomic and sectoral impacts of the various alternative paths.



US Natural Gas Production*

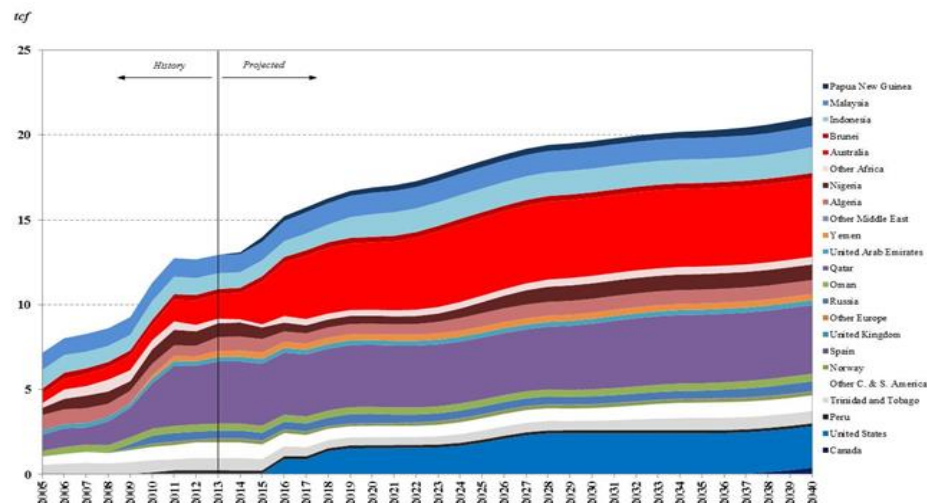
- A shale dominated picture emerges, highlighting a need for infrastructure development as well as opportunities for deeper North American integrations.



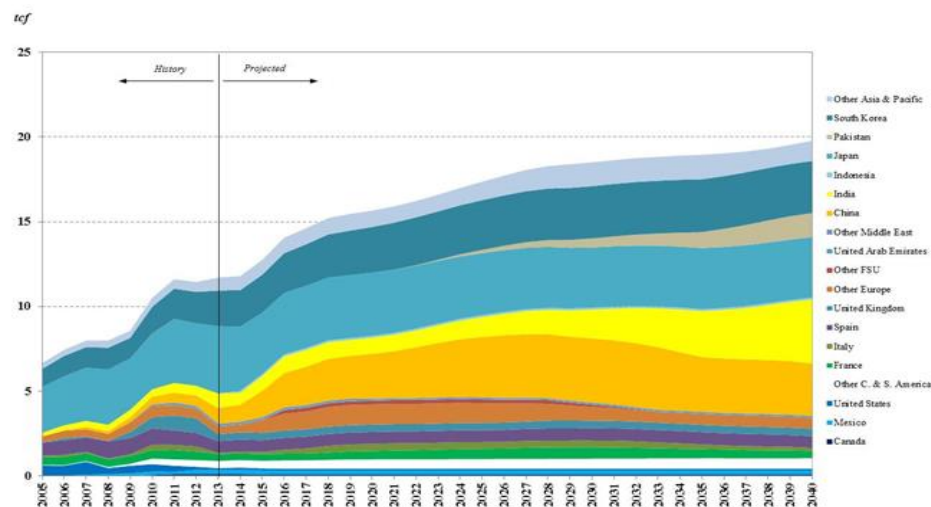
* The results are from the Rice World Gas Trade Model (RWGTM). The RWGTM was developed by Kenneth B Medlock III and Peter Hartley at Rice University using the MarketBuilder software platform provided through a research license with Deloitte MarketPoint, Inc. The architecture of the RWGTM, the data inputs, and modeled political dimensions are distinct to Rice and its researchers. Data depicted are from the recent CES/Oxford study completed for the US DOE, "The Macroeconomic Impacts of Increased US LNG Exports."

LNG Trade*

- LNG exports increase in multiple locations, with the US emerging as the 3rd largest LNG exporter in the world behind Australia and Qatar, and...



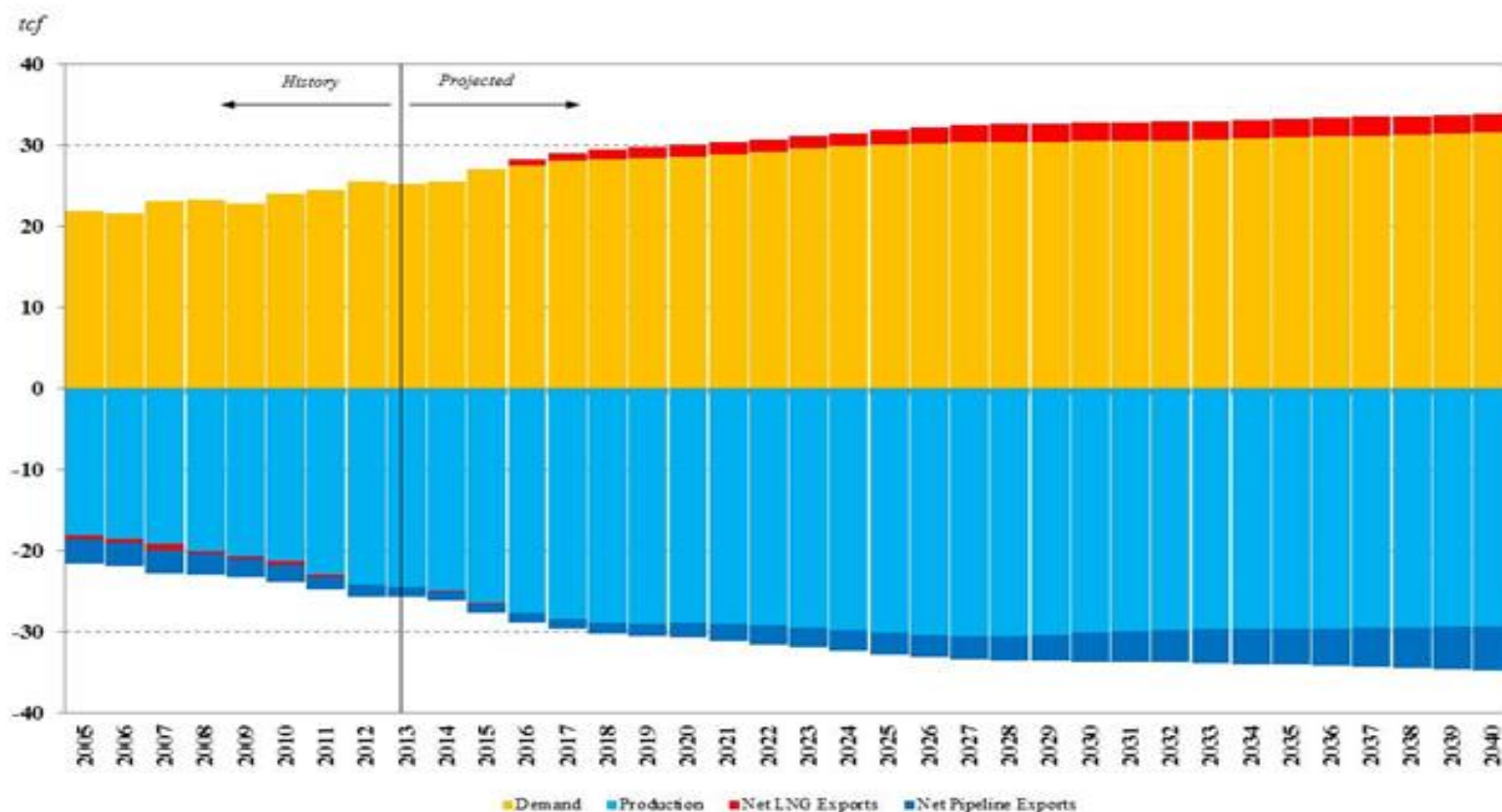
- ... new consumers enter the market as global demands increase.



* Data depicted are from the recent CES/Oxford study completed for the US DOE, "The Macroeconomic Impacts of Increased US LNG Exports."

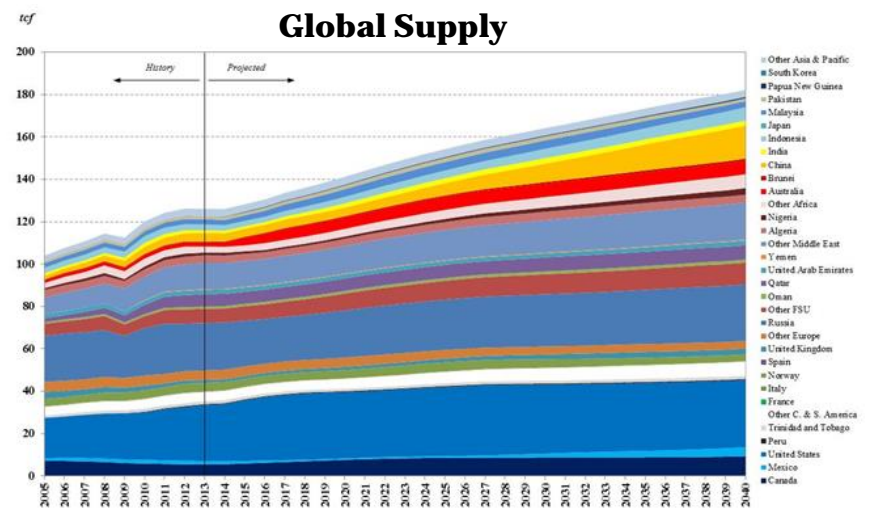
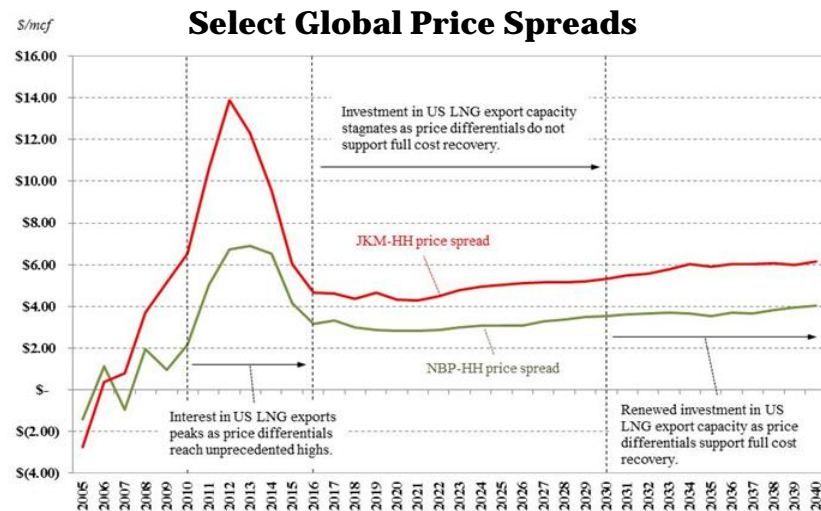
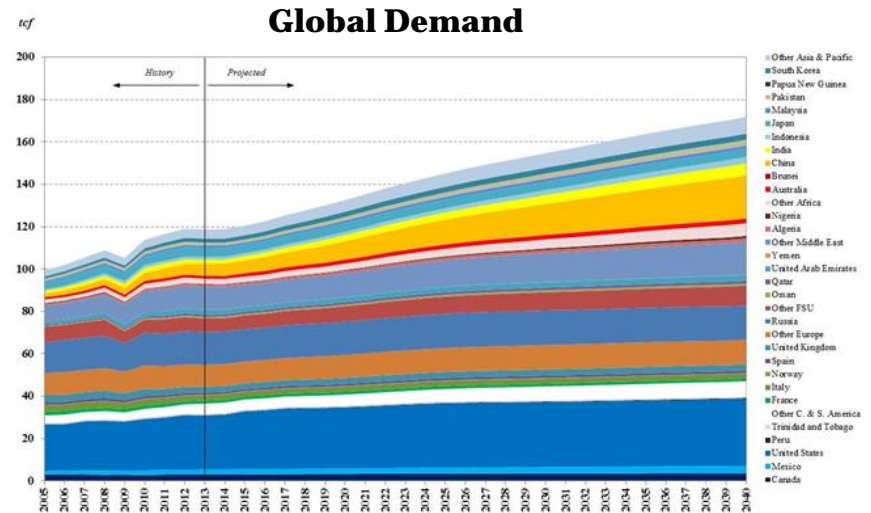
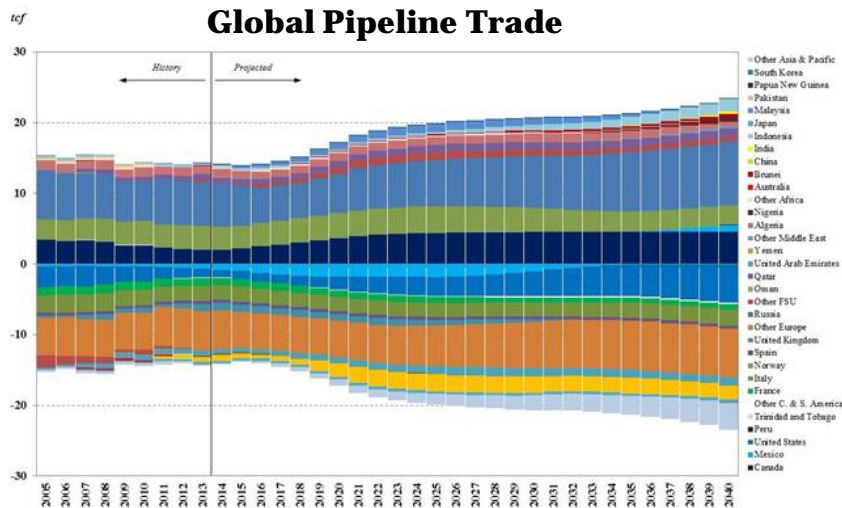
US Market Balance*

- US production responds positively to new demands for North American gas, but so does production in Canada... the North American market is deeply integrated!



* Data are from the CES/Oxford study completed for the US DOE, "The Macroeconomic Impacts of Increased US LNG Exports."

Other Indicators*

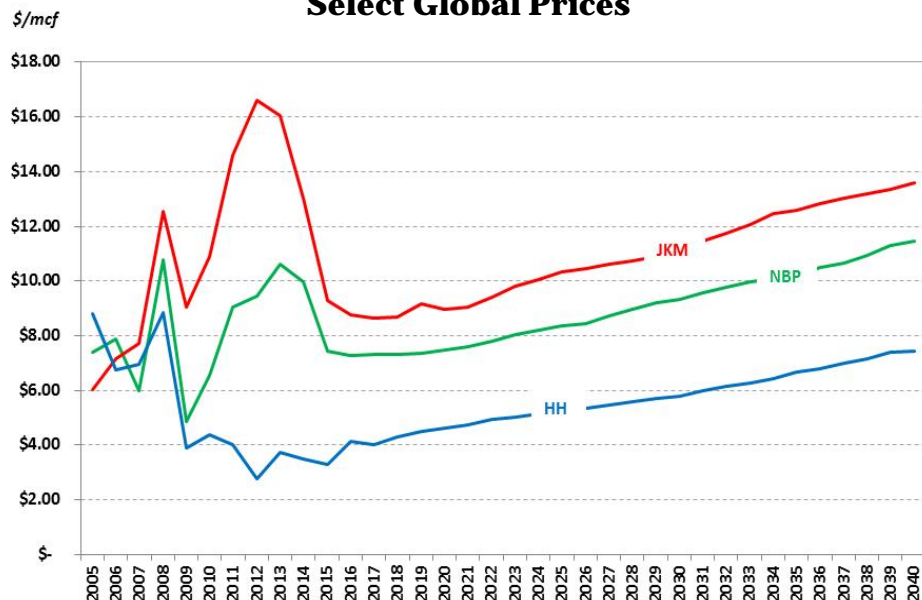


* Data are from the CES/Oxford study completed for the US DOE, "The Macroeconomic Impacts of Increased US LNG Exports."

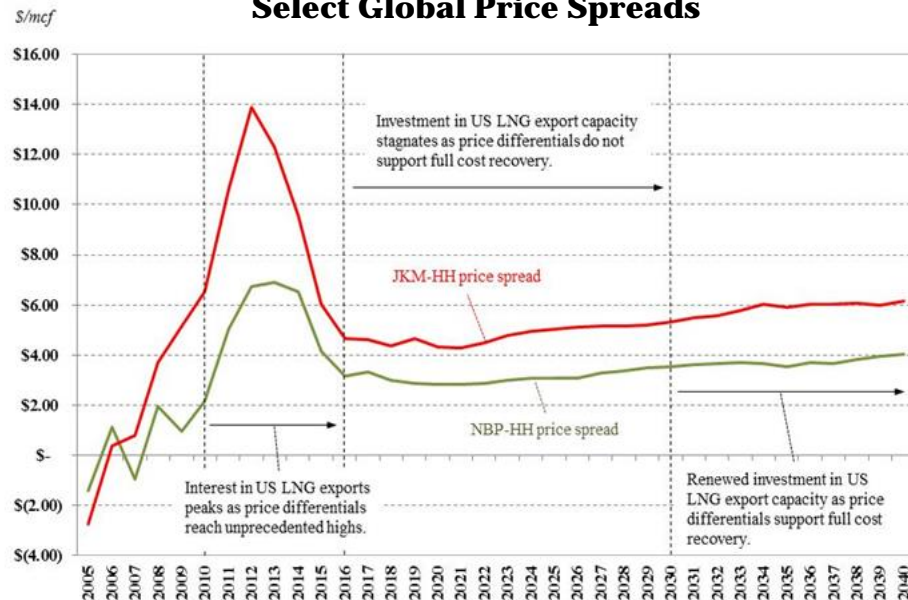
Prices*

- US price remains among the lowest in the world.
- Note, the long run price in the Ref-Ref case is contingent upon the long run cost environment. Costs are currently below this level, exacerbated by lower rig activity and weak global demand, some of which is seasonal.
- Scenario analysis was conducted for lower global demand cases, but in none of them was there sufficient pull on US LNG, so the price impact was negligible.

Select Global Prices



Select Global Price Spreads



* Data are from the CES/Oxford study completed for the US DOE, "The Macroeconomic Impacts of Increased US LNG Exports."

Scenario Development

- A comprehensive set of scenarios were prepared to evaluate the impact of higher US LNG exports under a range of circumstances and to establish conclusions that are not dependent on any particular set of starting conditions.
- We consider five international market cases across four domestic market settings.
- For reference conditions (Ref_Ref), the model sees 6.4 Bcf/d of U.S. LNG exports.

Scenario matrix		Domestic Scenarios			
International Demand Scenarios		Reference	High Resource Recovery	Low Resource Recovery	High Natural Gas Demand
Reference		Ref_Ref	Ref_HRR	Ref_LRR	Ref_Hi-D
Global Demand for U.S. LNG supports 12 Bcf/d		LNG12_Ref	LNG12_HRR	LNG12_LRR	LNG12_Hi-D
Global Demand for U.S. LNG supports 20 Bcf/d	US LNG Exports 12 Bcf/d	LNG20_Ref12	LNG20_HRR12	LNG20_LRR12	LNG20_Hi-D12
	US LNG Exports 20 Bcf/d	LNG20_Ref20	LNG20_HRR20	LNG20_LRR20	LNG20_Hi-D20
	US LNG Exports Endogenous	LNG20_Ref	LNG20_HRR	LNG20_LRR	LNG20_Hi-D

Scenario Development (cont.)

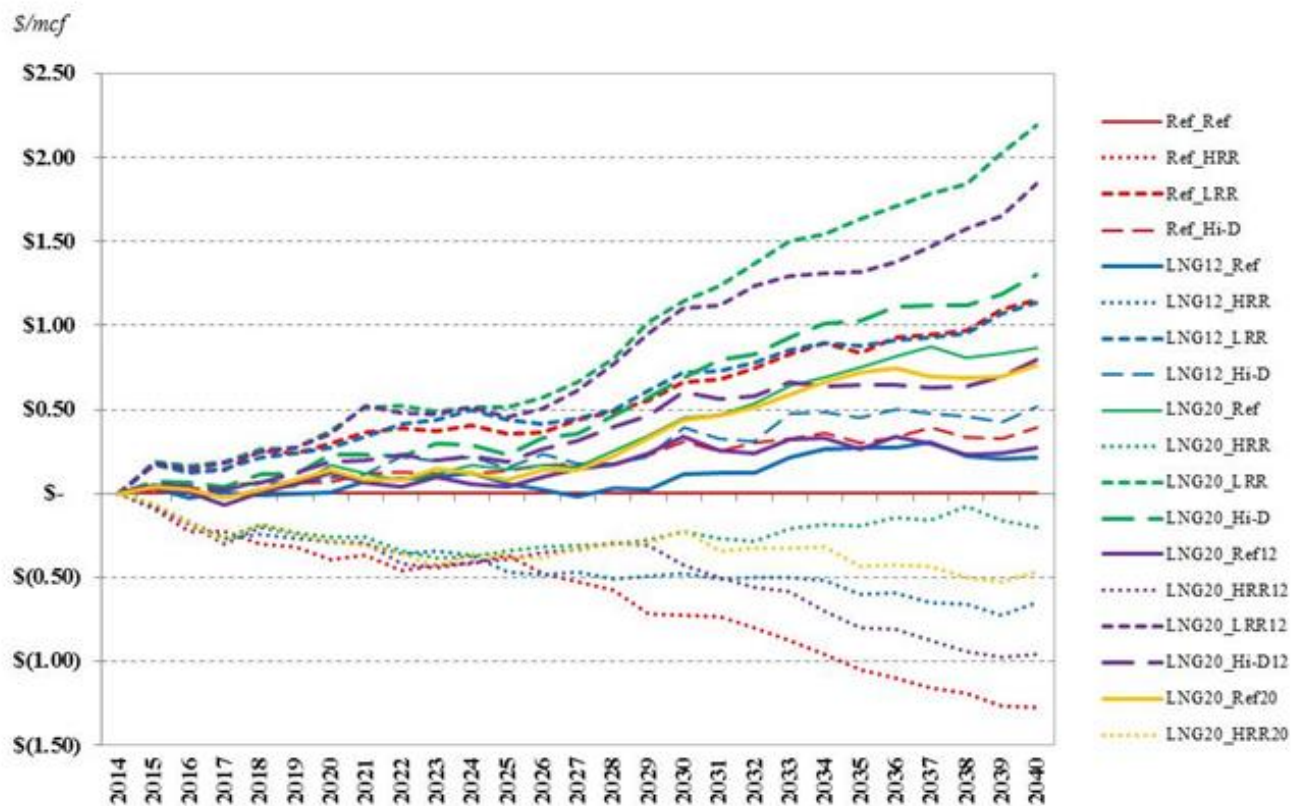
- Domestic cases:
 - The reference domestic case (Ref) assumes existing energy policy in the US continues and resource endowment assumptions are consistent with EIAs.
 - Alternative domestic cases assume (i) higher gas resource recovery (HRR) in the US, (ii) lower gas resource recovery (LRR) in the US, and (iii) higher US natural gas demand (Hi-D).
- International demand cases:
 - The reference international case assumes that current energy policies around the world are unchanged – including those setting domestic prices, dictating exports/imports, and/or addressing the environment – while the macroeconomic outlook is drawn from the Oxford Global Economic Model.
 - We then consider circumstances that result in different international demand pull for US LNG exports. The core scenarios examined allow international conditions that are sufficient to support up to 20 Bcf/d of US LNG exports.
 - When demand pull supports 20 Bcf/d of US LNG exports, we consider three export levels: 12 Bcf/d, 20 Bcf/d, and market-determined (endogenous) level.

Scenario Development (cont.)

		Reference	LNG12	LNG20
Accessible Shale Resource (tcf)	World	8,407	6,500	3,542
	Africa	1,918	1,918	0
	Asia and Pacific	2,107	1,075	90
	<i>China</i>	1,285	390	0
	<i>Australia</i>	529	529	90
	Europe	444	0	0
	South America	1,786	1,786	1,260
	North America	1,839	1,839	1,839
	<i>US</i>	829	829	829
	<i>Canada</i>	498	498	498
	<i>Mexico</i>	513	513	513
	Rest of World	314	86	64
LNG New Build Capability		No Limits	Limited expansion capabilities in selected locations	Only US has expansion capability beyond 2020
Pipeline New Build Capability		No Limits	No future expansions of Central Asian pipelines to China	LNG12 plus existing Russia-China pipeline supply agreements dissolve
Demand		In all scenarios, a CO2 trading platform is in place in Europe and the US is assumed to retire 61 GWs of coal by 2030	Chinese gas demand rises in response to policies to limit coal use; Japanese Nukes remain offline	LNG12 case plus CO2 reduction protocols targeting coal use in India, Indonesia, South Korea and a handful of other smaller coal consuming nations

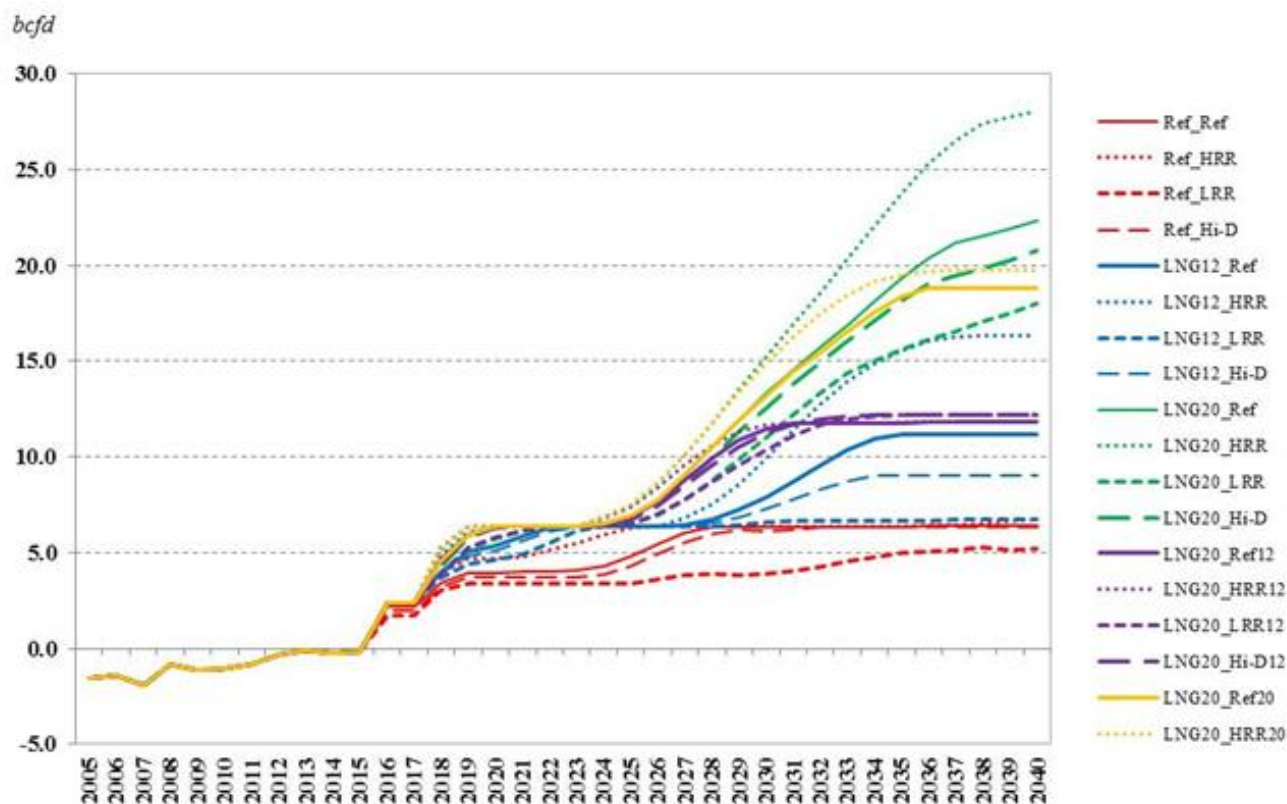
Cross Case Highlights

Change in Henry Hub Across Scenarios Relative to Ref_Ref



Cross Case Highlights (cont.)

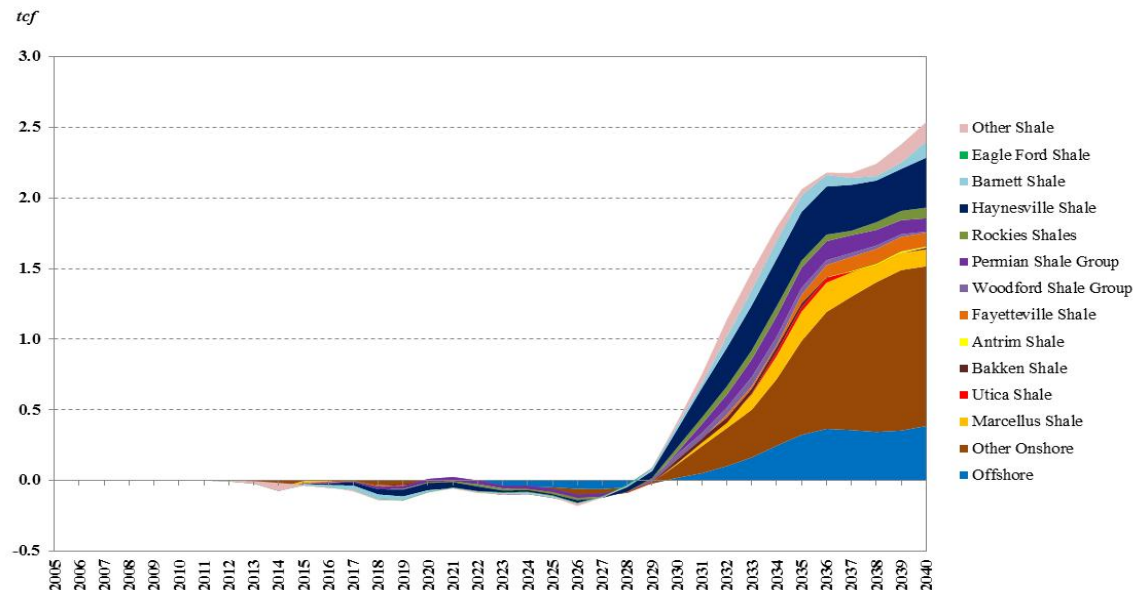
US LNG Exports Across Scenarios



Natural Gas Market Impacts

- Scenario analysis indicates that domestic production continues to increase as LNG export volumes expand to 20 Bcf/d. This contrasts to when exports do not exceed 12 Bcf/d and domestic production declines slightly in the 2030s.
- In moving from 12 to 20 Bcf/d, the majority of the increase in LNG exports is accommodated by expanded domestic production rather than reductions in domestic demand, reflecting very elastic long run North American supply (see figure).

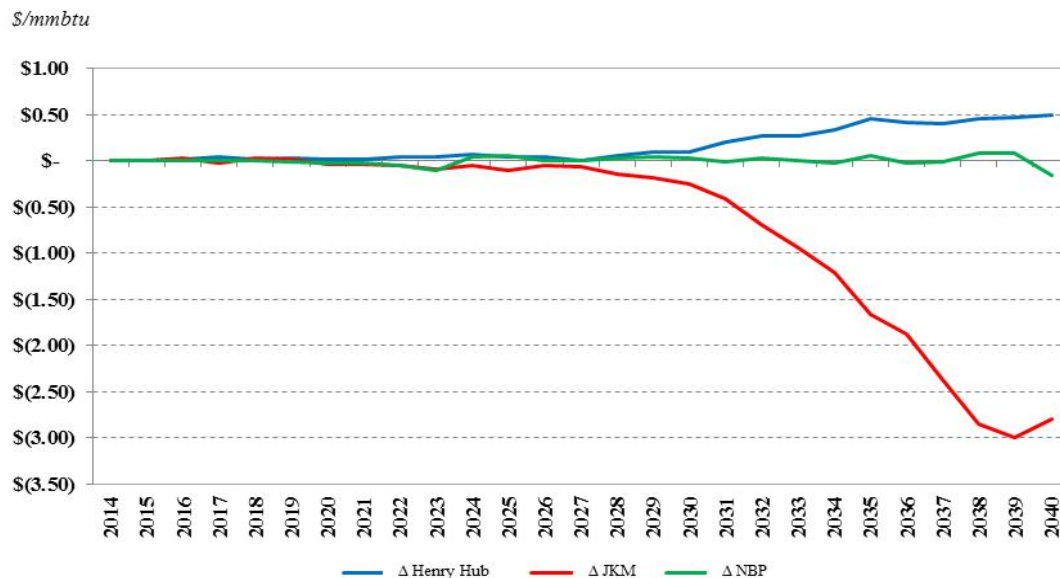
**Change in US production,
20Bcf/d vs 12Bcf/d LNG
exports in the Reference
domestic scenario**



Natural Gas Market Impacts (cont.)

- Increased US exports help alleviate a constrained international supply situation, although supplies from other regions also play a role when allowed by the scenario. Price changes are most significant abroad, with the greatest impact in Asia.
- Altogether, the spread between Henry Hub and international marker prices narrows with greater US LNG exports but is large enough to support trade. Across scenarios, when US LNG exports are determined endogenously, meaning they can exceed 20 Bcf/d, price spreads are narrowest thereby reflecting full capture of the US LNG arbitrage opportunity.

**Change in global prices,
20Bcf/d vs 12Bcf/d LNG
exports in the Reference
domestic scenario**



Concluding Remarks on Study

- The macroeconomic impacts to the US of LNG exports are marginally positive.
 - When US LNG exports increase from 12 Bcf/d in an international market environment that supports 20 Bcf/d of US LNG exports, the overall gain to the US economy is between 0.03% and 0.07% of GDP over the period 2026-40 or between US\$7 billion and US\$21 billion annually in today's prices.
- The main positive impact channel when US LNG exports rise is increased production and greater investment in the upstream. This exceeds the negative impact of higher domestic natural gas prices.
 - Over the period 2026-40, the incremental capital investment needed to increase US gas production and LNG exports is between 0.06% and 0.14% of GDP, while Henry Hub prices are between 2.6% and 7.5% higher compared to when LNG exports are 12 Bcf/d.
- Similar to previous studies, the results suggest an increase in US LNG exports will generate small declines for the energy-intensive, trade-exposed industries.
 - The sectors that appear most exposed are cement, concrete and glass but the estimated impact on sector output are very small compared to expected sector growth to 2040.
 - Growth in the domestic gas sector benefits industries that supply the gas sector, including energy intensive sectors such as cement.
 - Output losses in the energy intensive sectors in the higher LNG export cases are small relative to the baseline growth projected in those sectors over the forecast horizon.

center for
ENERGY
STUDIES

Rice University's Baker Institute