UNIVERSITY OF CAMBRIDGE | Energy Policy Research Group

Strategic Eurasian Natural Gas Market Model for Energy Security and Policy Analysis

Application to South Stream investment and Ukraine's gas diversification policy

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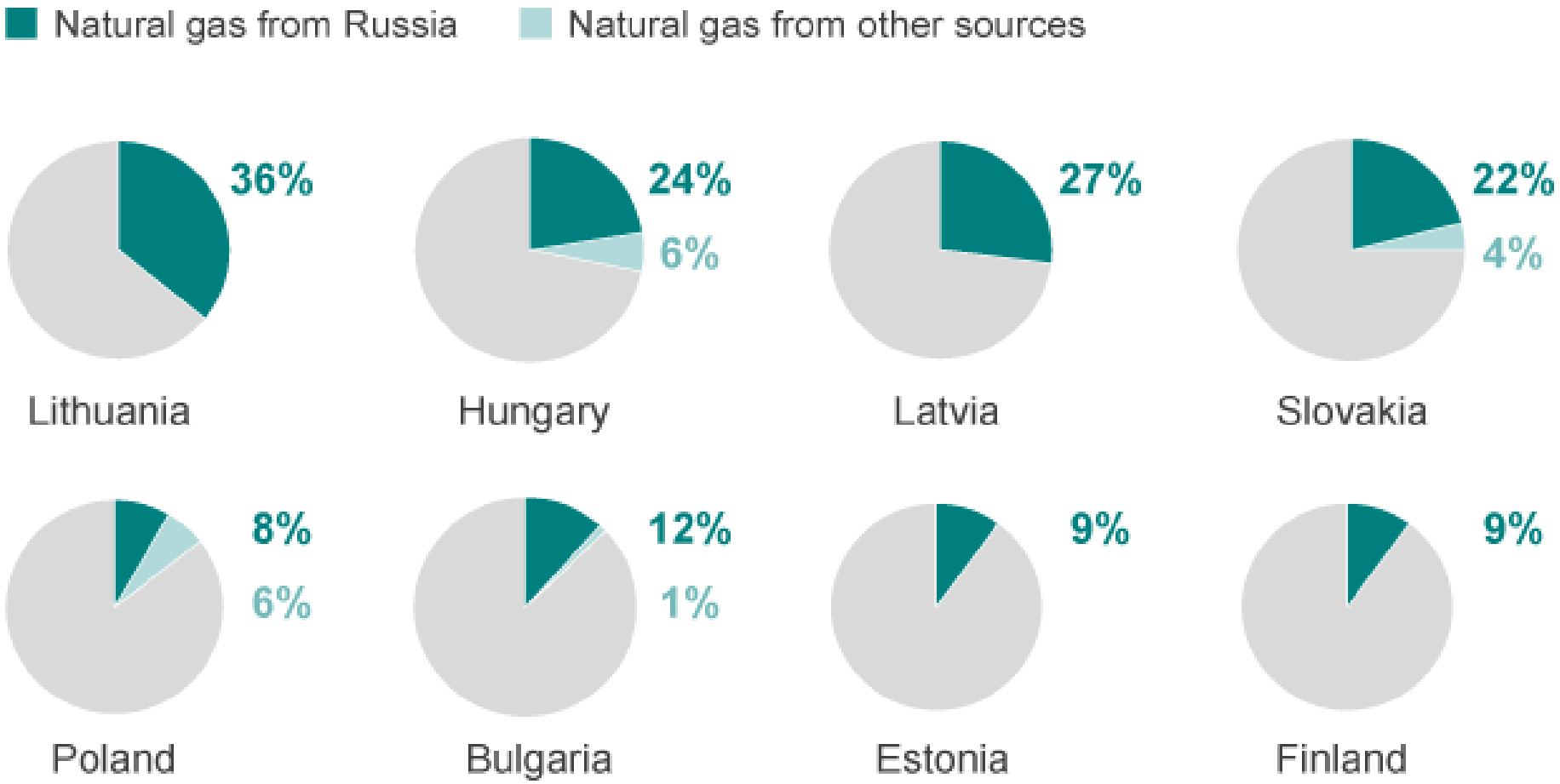
- The model
- Results – South Stream
- Results – Ukraine's gas diversification policy
- Conclusions

Motivation

Gas supplies as proportion of total energy use



Source: Eurogas

NY Times, 10/31/2014

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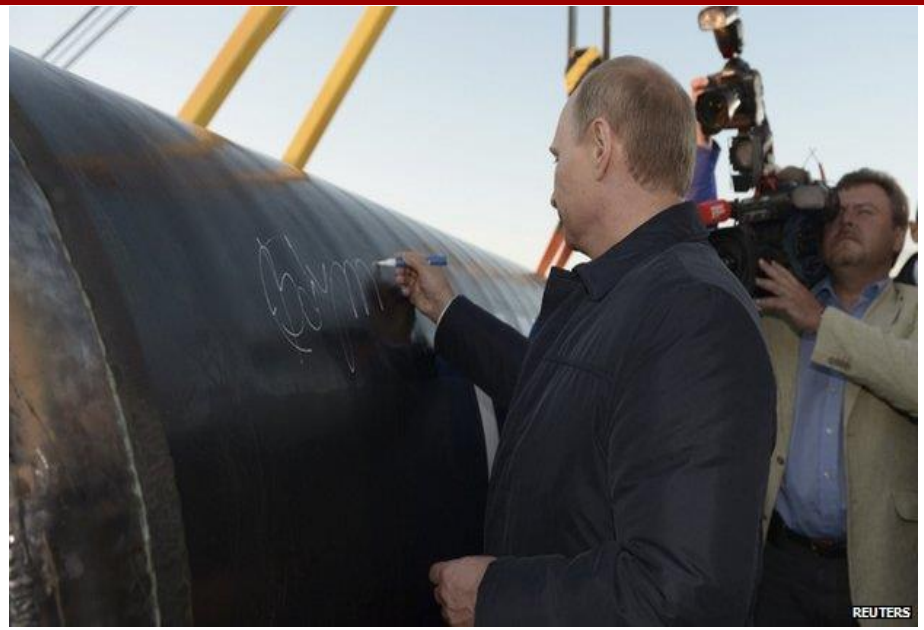

NY Times, 10/31/2014

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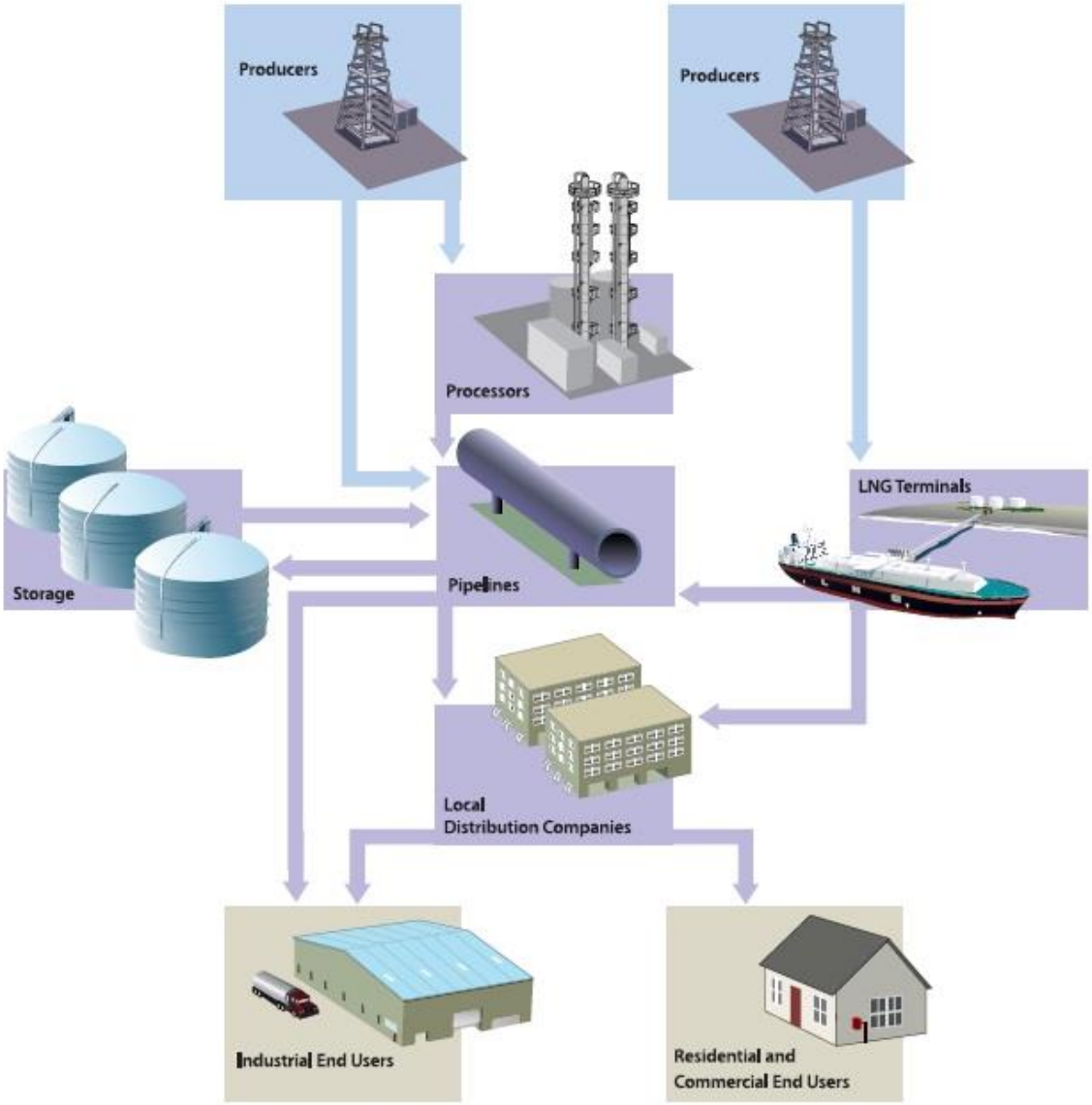
Model Description

- Model foundations:
  - Microeconomics
  - Game Theory
- Purpose:
  - Analyse energy policy questions such as economic justification for energy security projects
- Features:
  - Each player: MAX profit s.t. constraints
  - Includes gaming in the upstream gas market by large producers, or perfect competition
  - Flexible and generalizable under various market assumptions and data inputs
- Details are in Chyong and Hobbs, *Energy Economics,* (2014)

Model Description



- Capture the full gas value chain:
  - Producers
  - Traders
  - Pipeline transmission operators
  - LNG terminal operators
  - LNG shipping
  - Storage operators
  - Final markets

Model Description
Representing market power in the gas supply chain

- Producers anticipate traders' reaction (Asymmetric/Leader-Follower game)

- Traders and Producers: Cournot Game (i.e., game in quantities) → each player believes that if it changes gas sales, competitors maintain sales by cutting or raising their prices

- Consumers are represented by aggregate inverse demand functions in each market

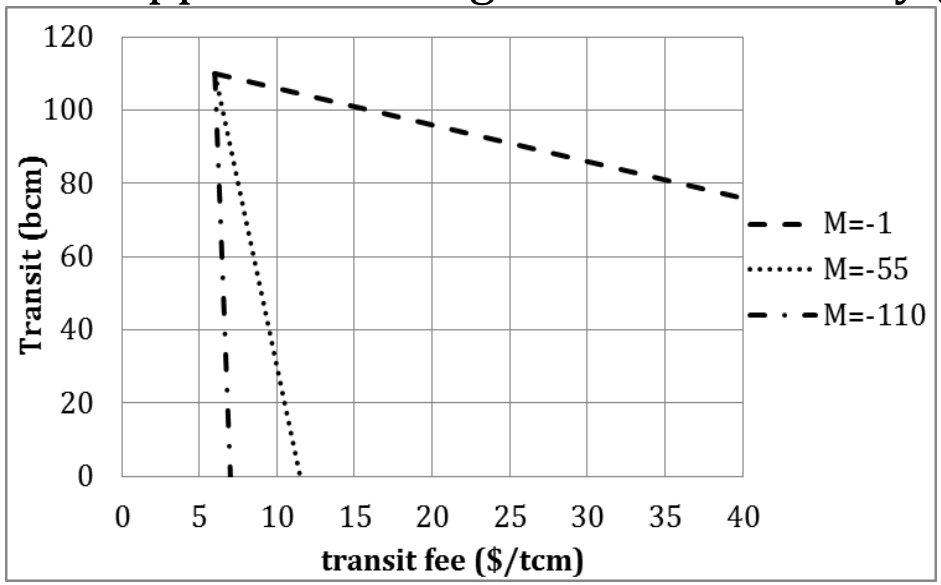
- These are standard in other equilibrium models, such as: WGM (Gabriel et al.), DIW Gas Market Model (Holz et al.), GASTALE (Boots, Rijkers, Hobbs), EWI COLUMBUS Global Gas Model etc.

Modelling market power of large gas transporters (e.g., Ukraine)

- New: Market power of large gas transporters
- Transit market power represented by the conjectured transit demand curve. Large transit countries (e.g., Ukraine, Belarus) believe that they face a declining effective demand curve for their services with an assumed slope $\boldsymbol{M}$ (exogenous parameter):

$$(\boldsymbol{x} - \boldsymbol{x}^*) - \boldsymbol{M}(\boldsymbol{tf} - \boldsymbol{tf}^*) = \boldsymbol{0}, \qquad \boldsymbol{M} < \boldsymbol{0}$$

where *(x-x*)* is change in demand for transit that the transit country conjectures will happen if it changes its transit fee by *(tf-tf*)*



Model Outputs

- Consumer P's, Q's
- P's for gas transmission services, LNG services
- Gas trade Q between contracted parties
- Production Q at each production field
- Storage withdrawal/injection Q
- Gas flows for both LNG and pipelines
- Investment in gas infrastructure facilities (production, pipeline, LNG, storage)

Data Input

INFORMATION	AVAILABILITY	SOURCE
Production capacities	✓	IEA Natural Gas Information 2013
Pipeline transport capacities	✓	IEA, EIA, and various other sources
LNG regasification capacity	✓	IEA Natural Gas Information 2013
Liquefaction and shipping capacities	✓	IEA Natural Gas Information 2013; Bloomberg
Storage withdrawal capacity	✓	IEA Natural Gas Information 2013
Injection capacity	✓	IEA Natural Gas Information 2013
Working volume capacities	✓	IEA Natural Gas Information 2013
Reference prices	✓	IEA Natural Gas Information 2013
Consumption levels	✓	IEA Natural Gas Information 2013
Price elasticities	✓	Various academic papers
Pipeline transport costs	✓	EPRG Pipeline Costing Model
LNG liquefaction costs	✓	US DOE, IEA and various industry reports
Regasification and shipping costs	✓	Academic papers, US DOE, IEA and various industry reports
Storage withdrawal costs	✓	Academic papers, US DOE, IEA and various industry reports
Injection and working volume costs	✓	Academic papers, US DOE, IEA and various industry reports
Production costs	✓	EPRG Production Costing Model

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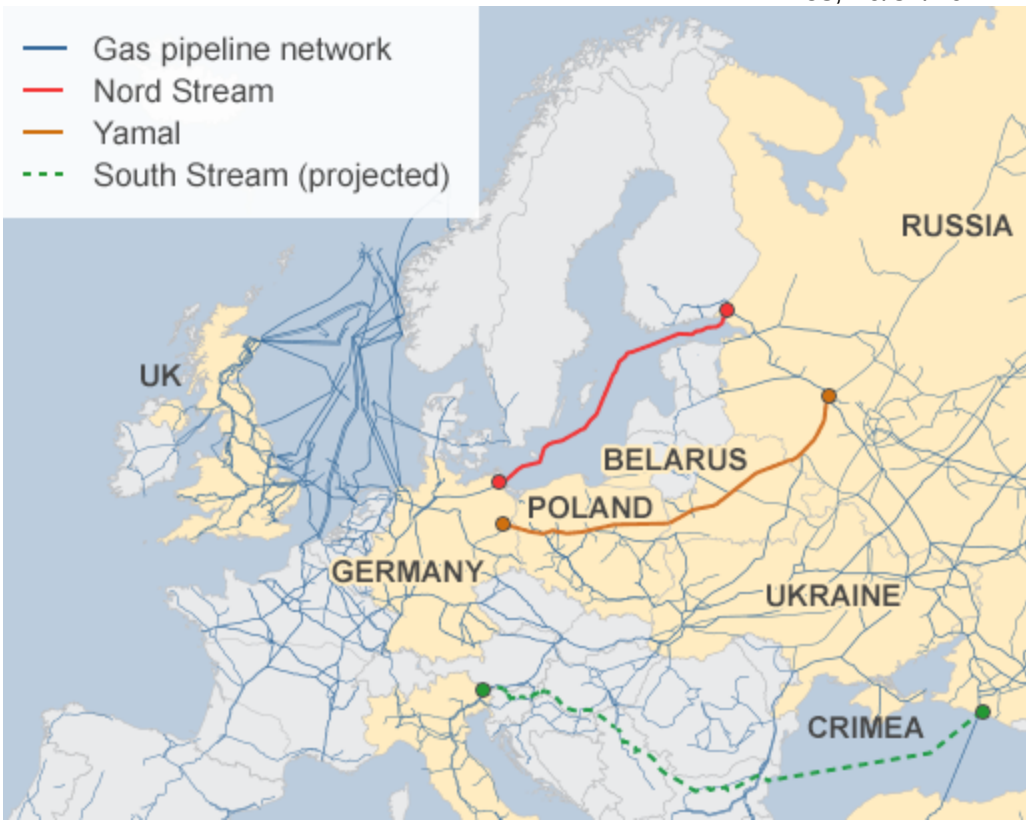
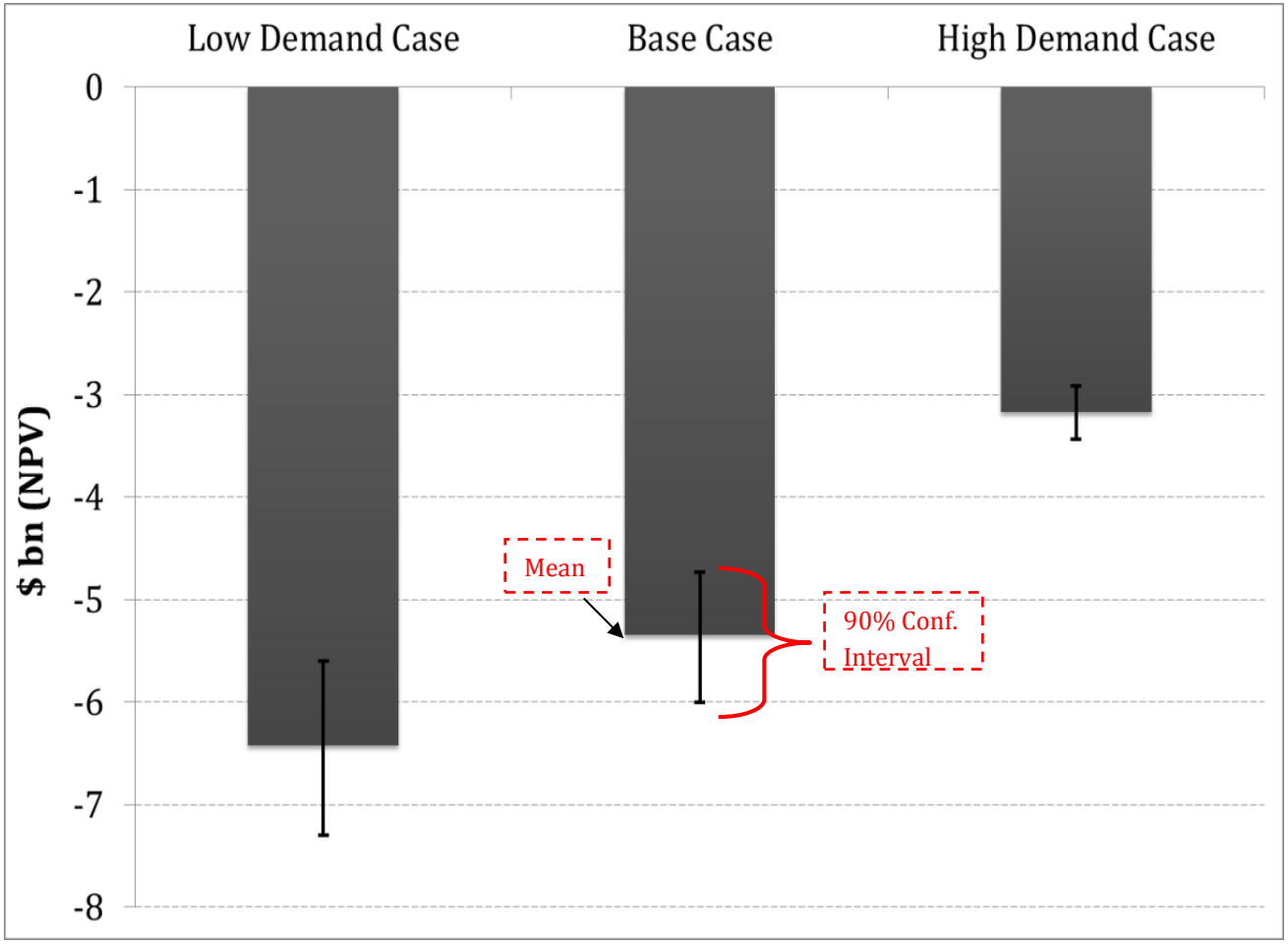


South Stream economics

- South stream is not a profitable project under 'normal' circumstances, in absence of Ukraine transit market power



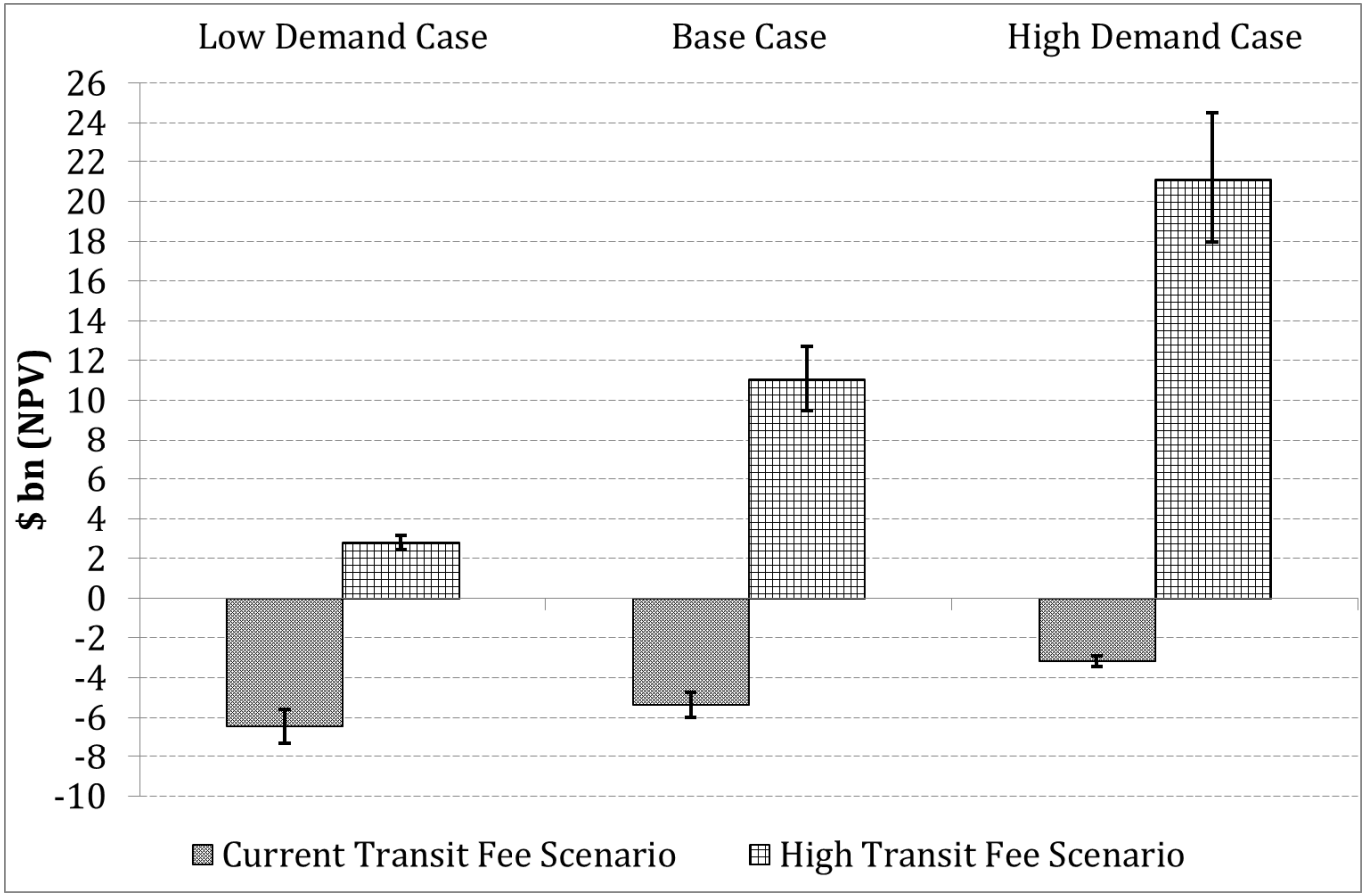
South Stream economics

- Nor is South Stream profitable project under gas transit disruptions through Ukraine as well, unless project developers (Gazprom) are very risk averse

	NPV, $ bn		
	No Disruption	Moderate Disruption	Severe Disruption
	[1]	[2]	[3]
Low Demand Case	-6.43	-6.39	-6.18
Base Case	-5.36	-5.19	-4.46
High Demand Case	-3.17	-2.93	-1.91

South Stream economics

- South Stream profitable only if Ukraine increases transport cost; i.e., exerts its transit market power



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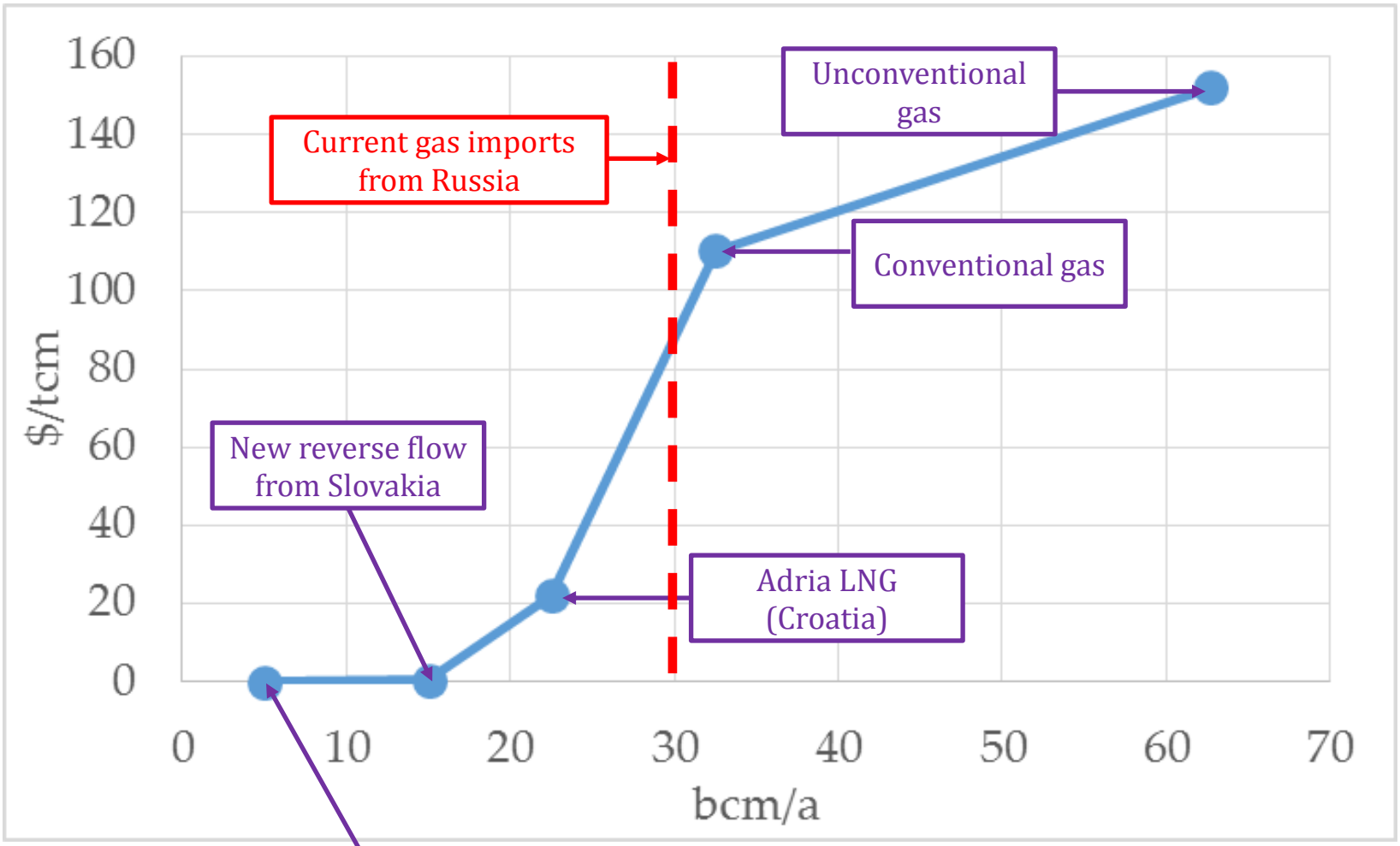
"Diversification" the buzzword of the month in EU energy policies

Ukraine's gas diversification strategy:

- interconnection Central Europe ("Reverse flow")
- LNG project in southern Ukraine
- Equity participation in LNG projects in Poland and Croatia
- Develop indigenous gas production, including shale

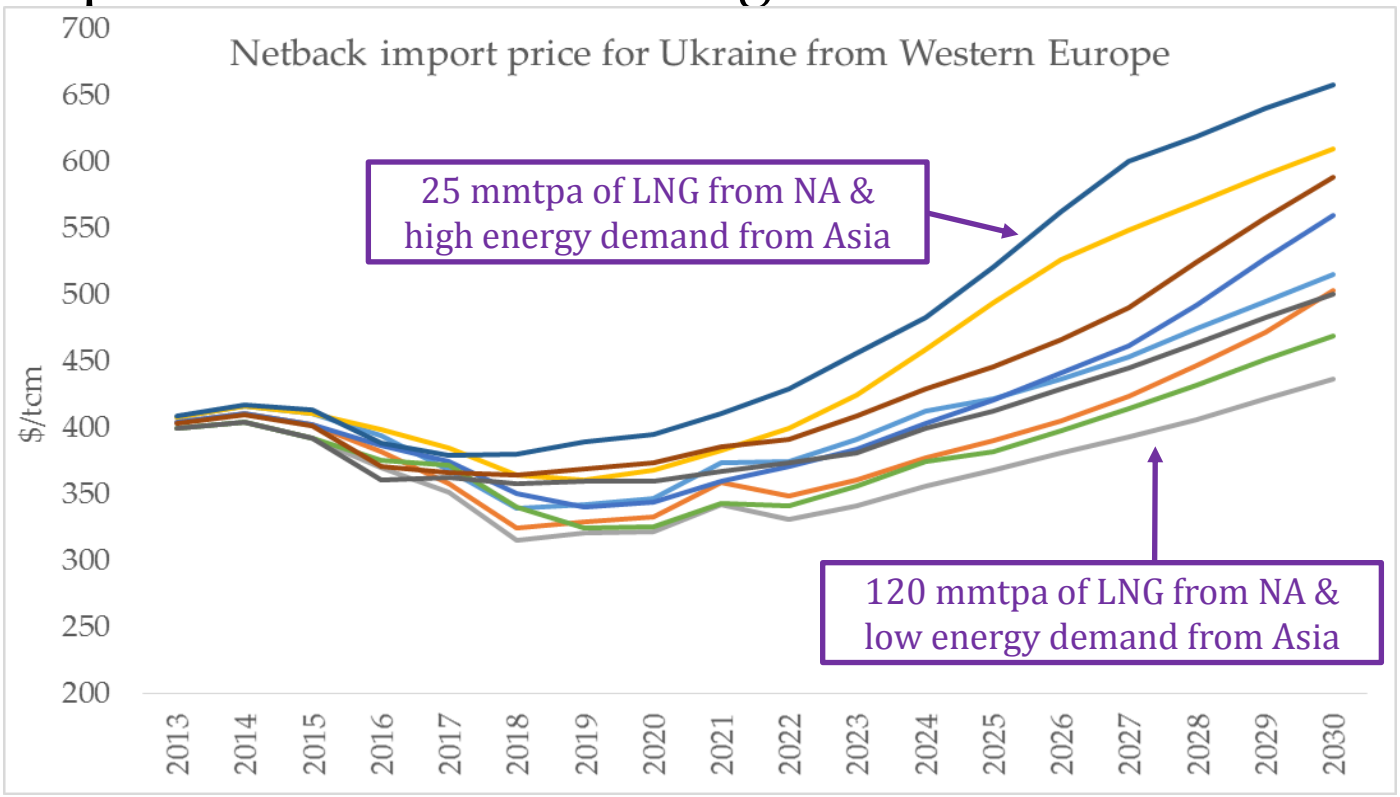
Potential non-Russian supply options for Ukraine – Fixed cost



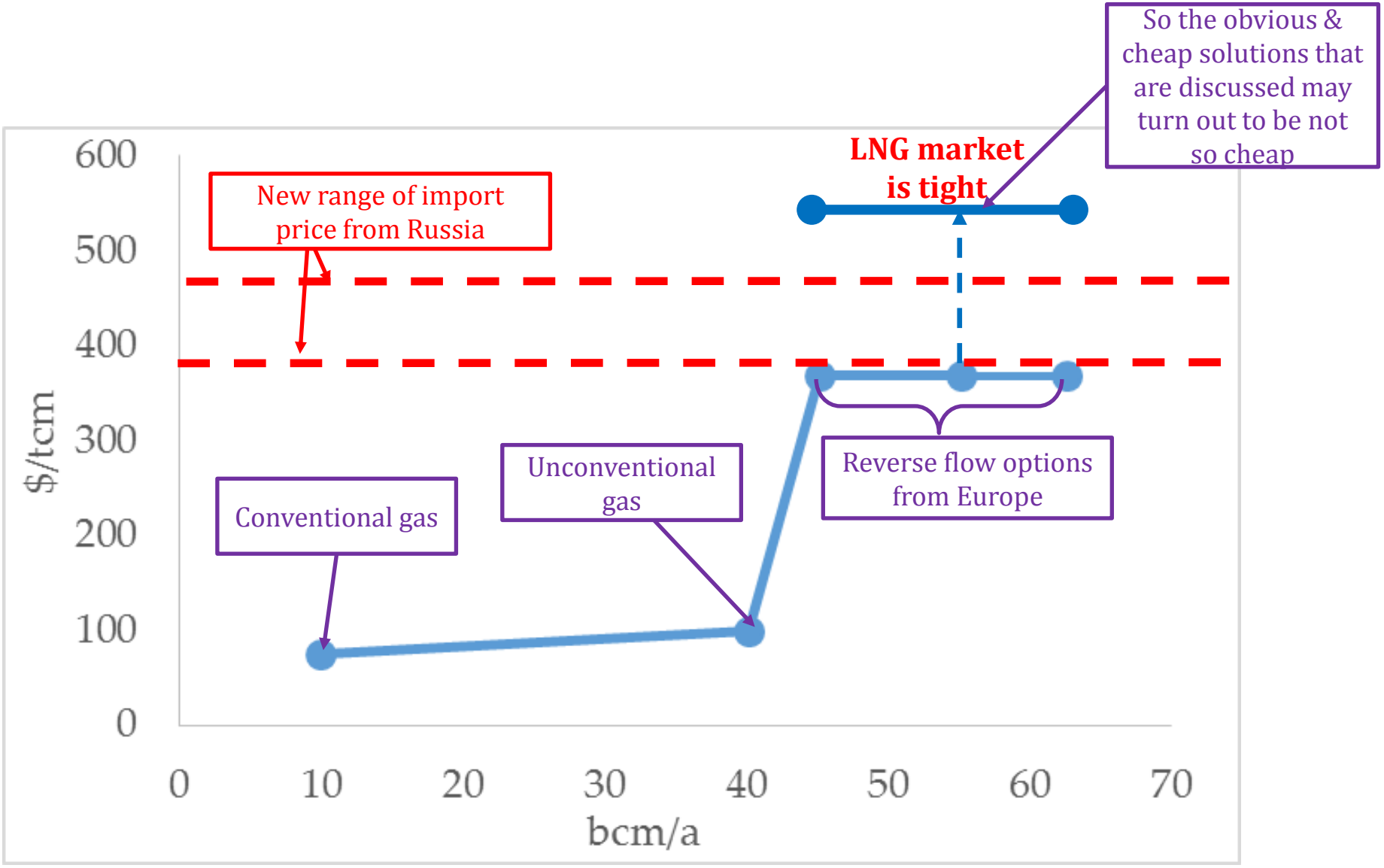
Potential non-Russian supply options for Ukraine

- How much diversification does Ukraine need?
  - How much gas would Ukraine receive from Europe?
  - At what P?

This depends on international gas markets



Variable costs for non-Russian supply options



Conclusions

- Equilibrium models useful to support rational, rigorous analysis of investment (South Stream) & policy

- Increasing energy costs & their effects on EU competitiveness

  → we need better models for rigorous analysis of economic impact of energy security policies and regulations on EU energy markets & economies

- EPECs needed to evaluate security of supply regulations
  - Where regulators are Stackelberg leaders who set rules which must be followed by all market participants
  - Two-stage games result in EPECs

NY Times, 10/31/2014

Thank you for your attention

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