

# Arbitrage in Natural Gas Markets?

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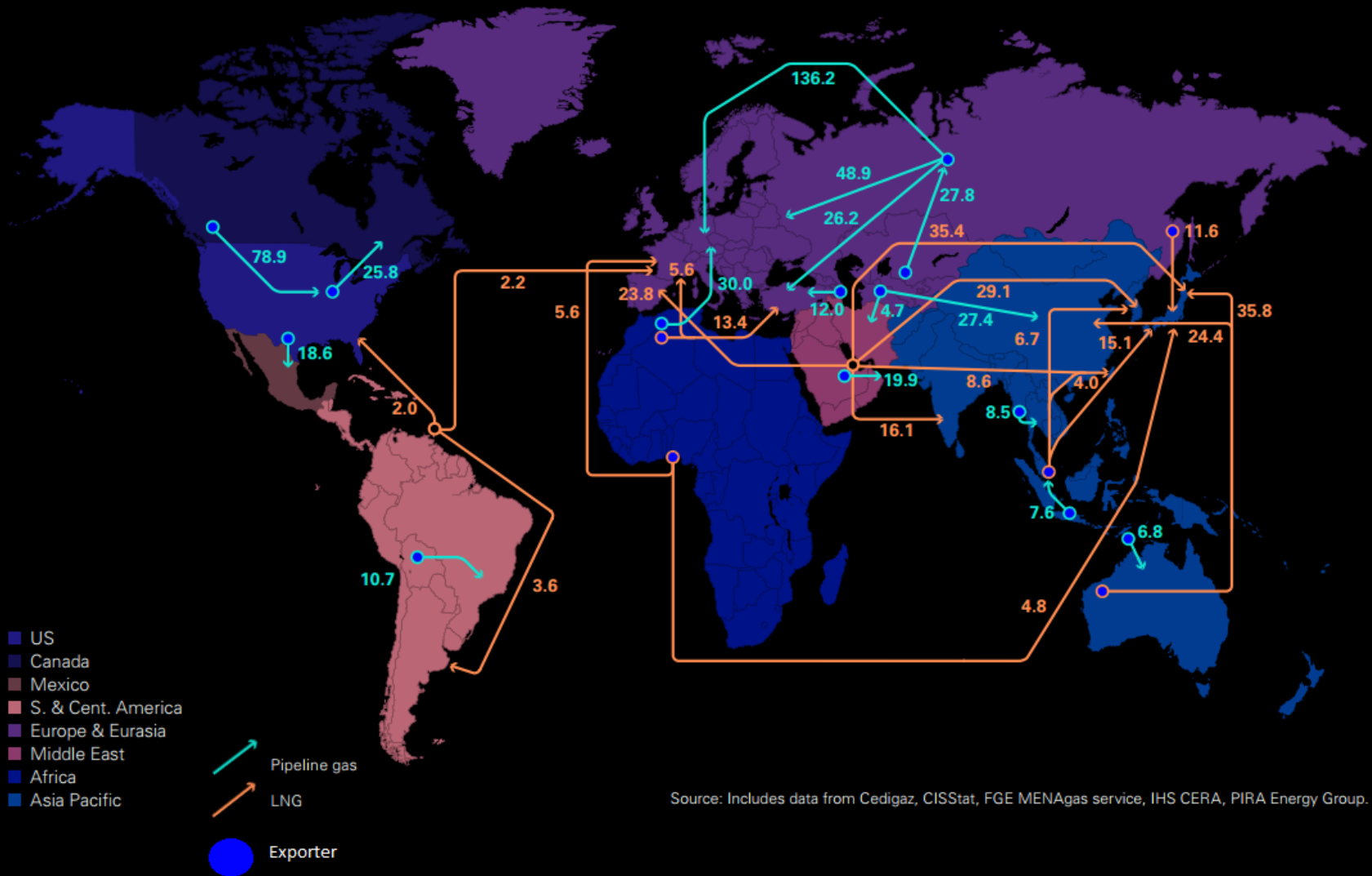
*April 13<sup>th</sup>, 2016, 16:30- 18:30*

Based on article with J.Dehnavi and F.Wirl in Intern. J. Energy & Statistics



# Major trade movements 2013

Trade flows worldwide (billion cubic metres)



Source: Includes data from Cedigaz, CISStat, FGE MENAgas service, IHS CERA, PIRA Energy Group.

# Abstract

- Regional liquefied natural gas (LNG) markets are characterized by substantial price differences since 2009. These regional differentials in prices suggest arbitrage possibilities which are incompatible with market equilibrium theory; this creates a puzzle. This paper tries to explain this puzzle by investigating potential explanations ranging from transport costs, bottlenecks in network (liquefaction, shipping and regasification), and restrictions arising from contracts. Only the past and current constraints on US liquefaction capacity has some explanatory power. This cannot be the entire story because US gas producers can engage in intertemporal speculation, i.e., keep their gas in the ground. Further explanations are needed. They can be linked to potential US government interventions. High and irreversible investment costs and rational expectations (i.e., others will exploit this opportunity, too, which will move regional prices closer) further add to keeping investments low. Summarizing, these factors combined can explain the price differences of the past and their persistence, albeit at a lower level, in the future.

# Content

- Natural gas markets are characterized by large spreads in liquefied natural gas (LNG) prices across locations, in particular the low prices in the United States (Henry hub) compared with Europe or Japan.
- Reasons can include
  - Constraints: *Transport, LNG facilities, contracts*
  - Investment costs & delays
  - Legal
- The objective of this paper is to explain the differences between regional natural gas prices and thus the puzzle of how markets can allow for such, at least at first sight, large arbitrage.

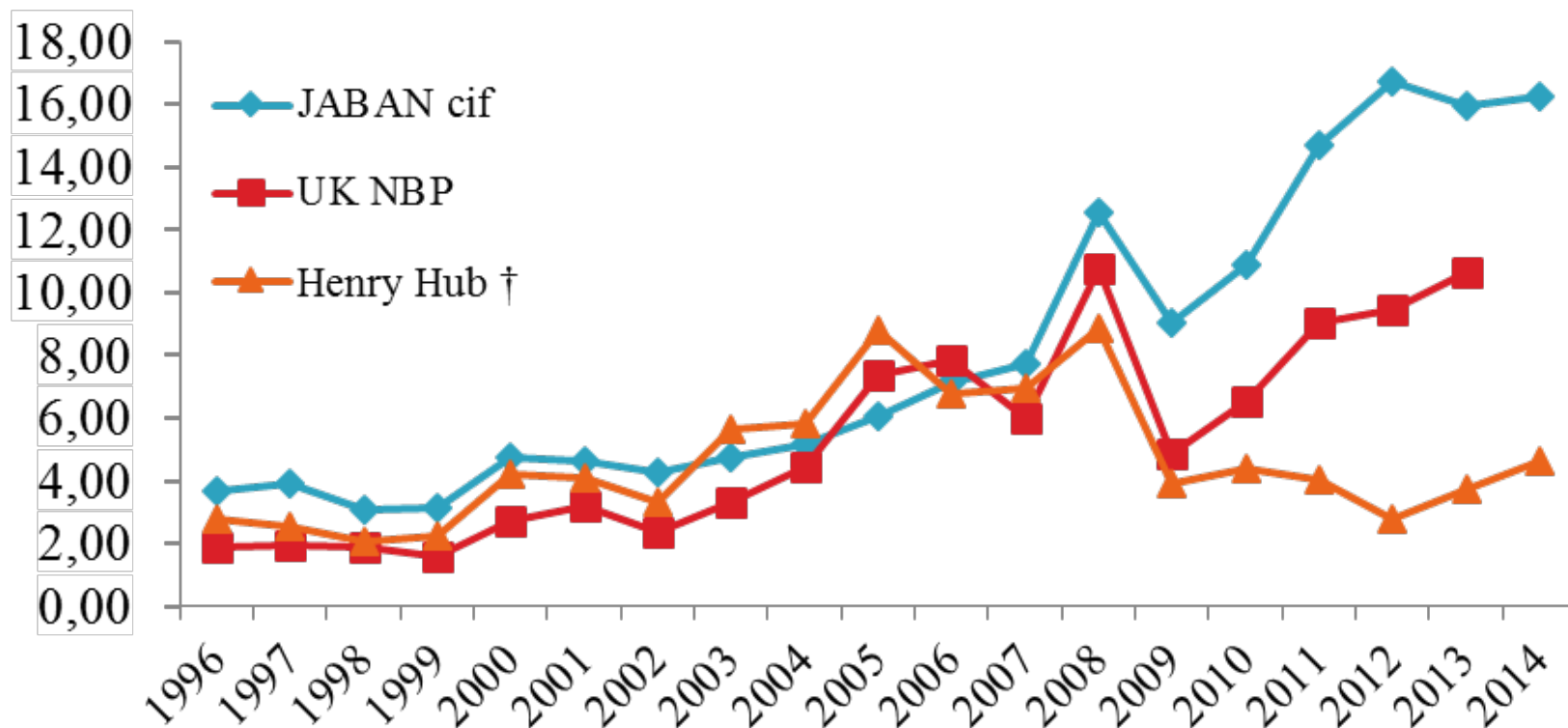
# Arbitrage Opportunity

- Economic theory says that arbitrage is defined as “the simultaneous purchase and sale of the same, or essentially similar, security in two different markets for advantageously different prices” (Sharpe and Alexander, 1990).
- Efficient markets are characterized as arbitrage-free, which is a cornerstone of neoclassical economics, general equilibrium theory (Arrow and Debreu, 1954)
- Price difference across locations may persist if there are significant difference in production costs and if transport cost ( $c$ ) across locations is high.

$$|p(A,t) - p(B,t)| < c$$

- In the case of natural gas, transport costs are much higher than for oil. So we can expect some regional price difference. But how high it should be?
- Next figure shows that after 2008 the divergence between regional prices has increased. We should analyse potential reasons for that.

# International prices for LNG \$/Mmbtu



LNG prices started to decouple in 2009. In 2012 they differ by factor 5.

IEA *World Energy Outlook* predicts substantial price differences beyond 2030

Yegorov - Arbitrage LNG

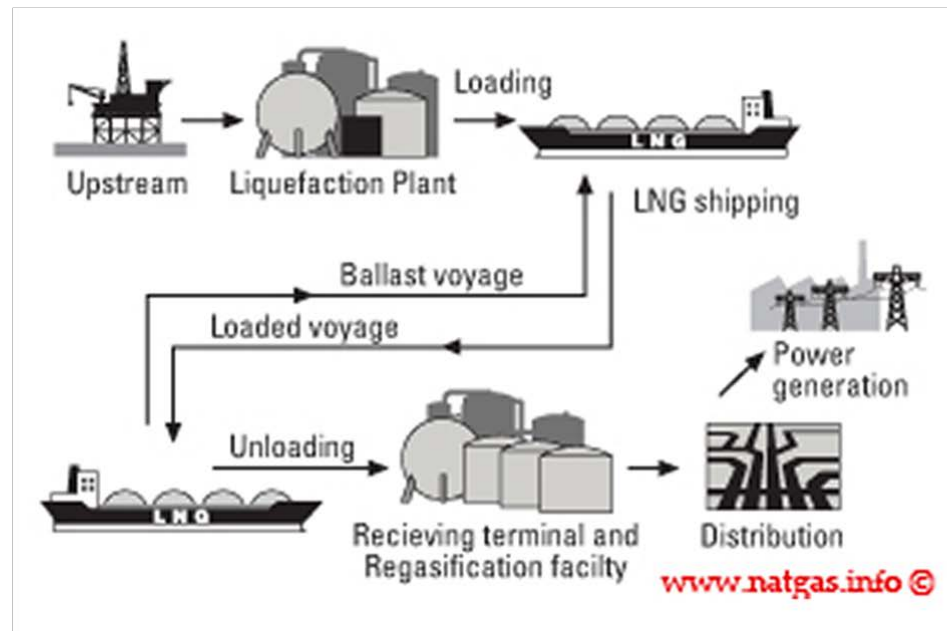
Source: BP Statistical Review of World Energy June 2013, page 27.

# Explanations of Price Difference

- Freight costs
- Capacity constraints in:
  - shipping*
  - liquefaction,*
  - re-gasification capacities*
- Constraints due to contracts and lack of demand
- Investments – delays & expectations
- Politics

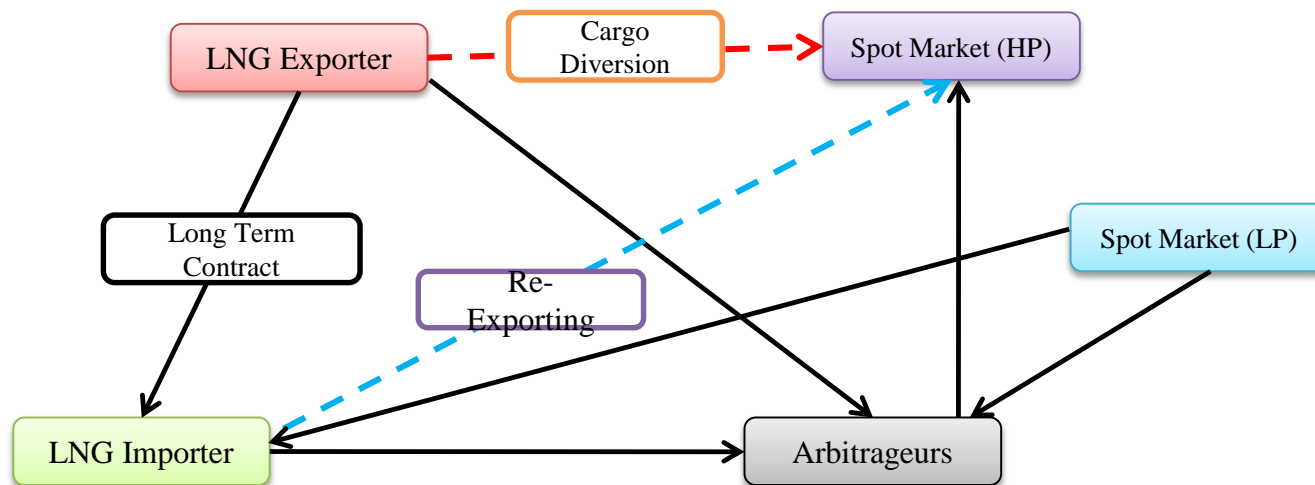
# LNG Supply Chain and its Costs

Item	Cost\$/M MBtu
Exploration & Production	0.5- 1
Liquefaction	0.8-2
Shipping	0.4-2
Regasification & Storage	0.3-1





# A Simple LNG Arbitrage Model



# Barriers for Arbitrage

**There is an **arbitrage opportunity** which lasts now for quite some time.**

## **Possible explanations:**

- 1- Transportation Cost.
- 2- Capacity Constraints.
- 3- Long term Contracts.
- 4- Uncertainty and risk aversion of investors.
- 5- LNG trade is complex in nature, physically and economically.
- 6- Political uncertainty whether the US government will allow these exports or not?

# Short Run Constraints

- ✓ Along the LNG trade network (liquefaction, LNG-vessel, re-gasification).
- ✓ From contracts and related reputation effects that ensure deliveries to US in spite of low prices.

# Freight Costs:

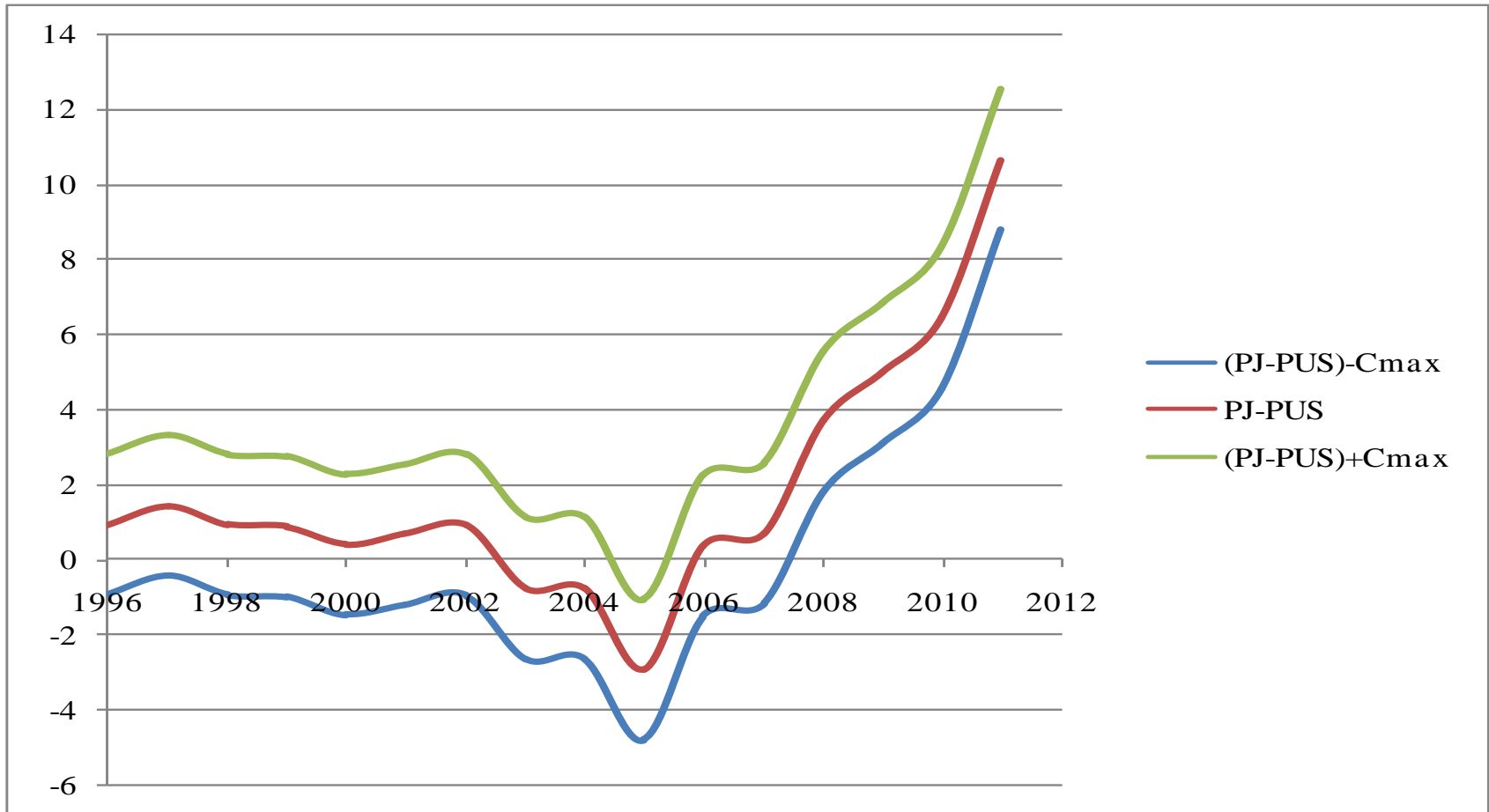
we see that they can explain only up to \$2 difference across prices.

## Approximate Distance and Transportation Costs between 3 Largest LNG markets

Countries	Exporting Terminal	Importing Terminal	Distance (miles)	LNG Transportation Cost (US\$/mbtu)
US- Japan	New Orleans	Himeji	9424	1.13- 1.88
		Sodegaura	9141	1.09- 1.82
US-UK	New Orleans	Isle of Grain	4777	0.573- 0.954
		Dragon	4468	0.53- 0.89
Japan- UK	Isle of Grain	Himeji	10917	1.308-2.185
	Dragon	Himeji	10742	1.284-2.148
	Dragon	Chita	10826	1.296-2.164

# Freight Costs

after 2008 transport cost cannot explain price difference



# Constraints?

LNG Importer Countries Status			LNG Exporter Countries Status		
Country	Regasificati on Capacities	LNG Import	Country	Liquefaction Capacities	LNG Export
USA	157.9	12.23	USA	1.9	1.64
Canada	10.6	2	Trinidad & Tobago	20.5	20.38
Mexico	19.1	5.77	Peru	6.1	1.82
Argentina	3.2	1.78	Belgium	0	0.57
Brazil	7.9	2.78	Norway	5.8	4.71
Chile	6	3.07	Russia	13	13.4
Dominican Republic	2.4	0.82	Algeria	27.5	19.31
Puerto Rico	4	0.77	Egypt	16.6	9.71
Belgium	9.5	6.43	Eq. Guinea	5	5.16
France	25.1	13.94	Libya	0.8	0.34
Greece	5.3	1.17	Nigeria	29.5	23.9
Italy	11.9	9.08	Oman	14.6	11.49
Portugal	5.5	3.01	Qatar	94.1	75.75
Spain	63.3	27.54	UAE	7.6	7.9
Turkey	12.9	7.92	Yemen	9.1	5.48
United Kingdom	53.9	18.67	Australia	26.9	25.36
Kuwait	7.5	2.78	Brunei	9.8	8.83
UAE	3.2	0.16	Indonesia	36.8	31.36
China	13.4	12.8	Malaysia	30.9	30.54
India	16.8	12.15	Total	356.5	297.63
Japan	264.2	93.48			
South Korea	110	44.44			
Taiwan	33.8	14.9			
Total	847.4	297.63			

Source: BP Statistical Review of World Energy, 2011; Natural Gas Information, 2011

- We see that regasification capacity is not a global bottleneck (capacity 847 bcm, import 297 bcm in 2011), while liquefaction might be (USA).
- The stock of LNG vessels capacity exceeds the current LNG flow .
- Contracts do not bring constraints. Introduction of flexible contracts allows exploiting short term price differences. Since about 37% of US LNG import contracts are f.o.b., any US firm owning such a contract, can re-route it.

# World LNG Trade Movement

TO	US	T&T	Peru	Belgium	Norway	Russia	Algeria	Egypt	Equatorial Guinea	Libya	Nigeria	Oman	Qatar	UAE	Yemen	Australia	Brunei	Indonesia	Malaysia	LNG Imp
US	--	5.38	0.45	--	0.76	--	--	2.07	--	--	1.18	--	1.29	--	1.10	--	--	--	--	12.33
Canada	--	1.59	0.08	--	0.08	--	--	--	--	--	--	--	0.25	--	--	--	--	--	--	2
Mexico	--	--	0.26	--	--	--	--	0.16	--	--	2.23	--	1.02	--	0.18	--	--	1.87	--	5.72
Argentina	--	1.63	--	--	--	--	--	--	--	--	--	--	0.15	--	--	--	--	--	--	1.78
Brazil	0.09	0.85	0.16	0.08	--	--	--	--	0.08	--	0.89	--	0.59	0.04	--	--	--	--	--	2.78
Chile	--	0.52	--	--	--	--	0.17	0.55	1.50	--	--	--	0.25	--	0.08	--	--	--	--	3.07
Dominica	--	0.82	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.82
Puerto Rico	--	0.77	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.77
Belgium	0.05	0.08	0.08	--	0.09	--	--	0.17	--	--	0.16	--	5.80	--	--	--	--	--	--	6.43
France	--	0.35	--	--	0.51	--	6.27	0.73	--	--	3.57	--	2.43	--	0.08	--	--	--	--	13.94
Greece	--	0.08	--	--	--	--	0.98	0.08	0.03	--	--	--	--	--	--	--	--	--	--	1.17
Italy	--	0.32	--	--	5.75	--	27.56	0.72	0.09	--	--	--	6.18	--	--	--	--	--	--	9.08
Portugal	--	0.18	--	--	0.05	--	--	--	--	--	2.70	--	0.08	--	--	--	--	--	--	3.01
Spain	0.12	3.32	0.63	0.08	3.3	--	12.05	2.62	--	0.34	7.82	0.17	5.54	--	0.18	--	--	--	--	27.54
Turkey	--	0.26	--	0.08	0.26	--	3.87	0.27	--	--	1.26	--	1.92	--	--	--	--	--	--	7.92
UK	0.18	1.63	--	--	0.94	--	1.25	0.12	--	--	0.40	--	13.89	--	0.26	--	--	--	--	18.67
Kuwait	--	0.33	--	0.09	--	0.09	--	0.33	0.29	--	0.08	0.91	--	0.25	0.09	0.09	--	--	0.24	2.78
UAE	--	--	--	--	--	--	--	--	--	--	--	--	0.16	--	--	--	--	--	--	0.16
China	--	0.07	0.08	0.08	--	0.51	--	0.08	0.08	--	0.17	--	1.61	0.08	0.70	5.21	--	2.45	1.68	12.80
India	--	0.66	--	--	--	--	--	0.09	0.17	--	0.33	--	10.53	--	0.37	--	--	--	--	12.15
Japan	0.85	0.15	--	0.08	--	8.23	0.08	0.57	0.72	--	0.84	3.80	10.15	6.86	0.16	17.66	7.78	17	18.55	93.48
S. Korea	0.35	0.88	0.08	0.08	0.16	3.90	--	0.98	1.85	--	1.18	6.11	10.16	0.25	2.27	1.33	1.05	7.42	6.39	44.44
Taiwan	--	0.51	--	--	0.07	0.67	--	0.17	0.35	--	1.09	0.50	3.75	0.42	--	1.06	--	2.62	3.68	14.90
LNG. EXP	1.64	20.38	1.82	0.57	4.71	13.40	19.31	9.71	5.16	0.34	23.90	11.49	75.75	7.90	5.48	25.36	8.83	31.36	30.54	297.63

# Contract Restrictions

Many LNG contracts are long term (especially in Asia), but the share of short term contracts has been rising and reached 18-20% in 2007-2008, Rogers (2010).

f.o.b (flexible) contracts versus d.e.s (not flexible) contracts.

About 37% of US LNG import contracts are f.o.b., so re-exporting or rerouting is possible.

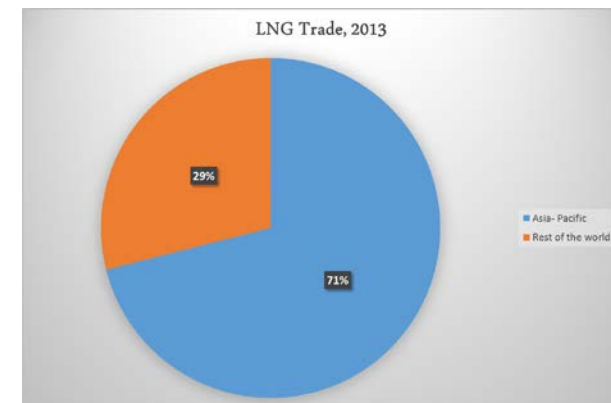
Negotiation between exporters and importers.



# Re-Export of Cargoes Contracts (2013)

Export Country/ Exporter	Import Country	Number of Cargoes	Re-exported Volumes (Mt)
<b>Belgium</b>	Argentina	13	1.10
	Spain	3	
	South Korea	2	
	Brazil	1	
	Portugal	1	
<b>France</b>	Spain	2	0.35
	Belgium	1	
	Brazil	1	
	Japan	1	
	Portugal	1	
	Thailand	1	
	Turkey	1	
<b>Netherlands</b>	Brazil	1	0.17
	China	1	
	Italy	1	
	Turkey	1	
<b>Portugal</b>	Argentina	4	0.24
	Brazil	2	
<b>Spain</b>	Brazil	13	2.13
	Argentina	6	
	Mexico	5	
	Japan	4	
	Israel	3	
	Italy	3	
	South Korea	2	
	Portugal	2	
	Taiwan	2	
	<b>Europe</b>		
<b>Brazil</b>	Argentina	1	0.06
<b>USA</b>	Mexico	1	0.1
	Portugal	1	
<b>Americas</b>		3	0.16
<b>South Korea</b>	Japan	1	0.06
<b>Asia</b>		1	0.06
<b>World</b>		82	4.21

Japan has the highest price but 27 bcm are imported using spot of short term contract. Speculators have access.



# Intertemporal Constraints

## **Investments in particular into US liquefaction capacities**

- (i) The high fixed cost of liquefaction plants in the USA.
- (ii) For how long this arbitrage opportunity exists?
- (iii) The national regulations (like an export tax) affect the future profitability at the individual level.

# Regasification and Shipping Capacities

<b>LNG Importer Countries Status</b>		
<b>Country</b>	<b>Regasification Capacities</b>	<b>LNG Import</b>
USA	170.8	2.7
Japan	247.5	119
World	1022	325.3

Source: The LNG Industry, GIIGNL, 2013. BP, 2014.

The world re-gasification capacity exceeds the volume of global LNG imports by factor 3

A similar conclusion holds for LNG vessels

# Conventional vs Nonconventional Gas Reserves. Impact

1. Reduces competition for LNG suppliers from the Middle East.
2. Reduces the future share of world gas supply from Russia, Iran and Venezuela.
3. Reduces U.S. and Chinese dependence on Middle East natural gas supplies.



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SHALE GAS AND U.S. NATIONAL SECURITY

# Intertemporal Speculation

Even if

- the transport costs,
- constraints
- and the investment hurdles

explained the large current differences in regional gas prices, the **puzzle remains**.

Why do not gas producers enter as arbitrageurs and delay their extraction in order to gain from higher future prices? Why do they instead produce at levels that drive the current gas below the coal price in the US? And this against the fact, that shale extraction is much more flexible and even interruptible.

## Political & Economical uncertainty whether the US government will allow these exports or not?

“... Shale gas production **has come like a valentine for U.S. manufacturers**. Natural gas from shale has injected new life into the U.S. chemical industry and has begun to bolster **energy-intensive manufacturing sectors** such as aluminum, steel, paper, glass and food”.

[http://www.huffingtonpost.com/sridhar-kota/frackings-unexpected-envi\\_b\\_5907334.html](http://www.huffingtonpost.com/sridhar-kota/frackings-unexpected-envi_b_5907334.html)

"Gas exports in U.S. are still in a grey zone. Not forbidden, but not encouraged"

Chen Wei Dong, Senior Economist with CNOOC Energy Economics Institute.

“As pressure builds on the Obama administration to speed up approvals to sell U.S. natural gas overseas, the Energy Department on Monday authorized exports from a proposed Oregon terminal”.

<http://fuelfix.com/blog/2014/03/24/obama-administration-grants-approval-to-sixth-natural-gas-export-project>

# Agreements on Liquefaction Rights

Origin	Export country/exporter	Purchaser	Import country	Amount (mmtpa)	Duration (years)	Extra years	Start	Delivery format
Agreements on regasification (R)/liquefaction rights (L)	Petronet LNG Limited, Dahej (R)	GAIL(India) Limited	INDIA	2.5	20		2016-17	Regasification agreement
	Petronet LNG Limited, Dahej (R)	GSPC	INDIA	1.3	20		2013	Regasification agreement
	Petronet LNG Limited, Dahej (R)	GSPL	INDIA	1.0	20		2013	Regasification agreement
	Petronet LNG Limited, Dahej (R)	BPCL	INDIA	1.0	20		2013	Regasification agreement
	USA/Dominion Cove Point (L)	GAIL Global LNG LLC (USA)	INDIA	2.3	20		2017-18	F.O.B.
	USA/Dominion Cove Point (L)	Sumitomo Corporation		2.3	20		2017	F.O.B.
	USA/Freeport LNG Train 2 (L)	BP	BP Portfolio	4.4	20	10	2018	F.O.B.
	USA/Freeport LNG Train 3 (L)	SK E&S LNG	SOUTH KOREA	2.2	20	20	2019	F.O.B.
	USA/Freeport LNG Train 3 (L)	Toshiba Corporation	JAPAN	2.2	20	20	2019	F.O.B.
	USA/Cameron LNG LLC (L)	Japan LNG Investment LLC (Mitsubishi Corp/NYK)	JAPAN	4.0	20	10	2018	F.O.B.
	USA/Cameron LNG LLC (L)	Mitsui & Company, Ltd.	JAPAN	4.0	20	10	2018	F.O.B.
	USA/Cameron LNG LLC (L)	GDF SUEZ	TBD	4.0	20	10	2018	F.O.B.

# Conclusions

There is an **arbitrage opportunity** which lasts now for quite some time.

**Possible explanation:**

**1- Transportation Cost;**

**2- Capacity Constraints;** no constraints of capacities along the supply chain are observable, except for the lack of US liquefaction capacities.

**3- Long term Contracts; Contracts are becoming increasingly flexible**

**4- Uncertainty and risk aversion of investors -**

is not a significant explanation as financial intermediaries and the large energy companies should be ready to shoulder this risk.

**5- LNG trade is complex in nature, physically and economically.**

**6- Political uncertainty whether the US government will allow these exports or not?**



# Final Remarks

- Standards reasoning - transport costs & various constraints (capacities, contractual, etc.) - cannot explain the huge price differences due to the possibility of intertemporal speculation
- Expectations and in particular (political?) uncertainty can explain why some differences and thus apparent arbitrage can persist.
- Indeed, the US gas market is regulated; export permission out of NAFTA countries has to be obtained. There is also an interest to keep domestic price of natural gas in the USA at low level, since this creates more jobs. Thus, huge arbitrage volumes that would bring US gas price to EU level might be prevented by regulators and politicians. Thus, investment in costly liquefaction plants is risky.

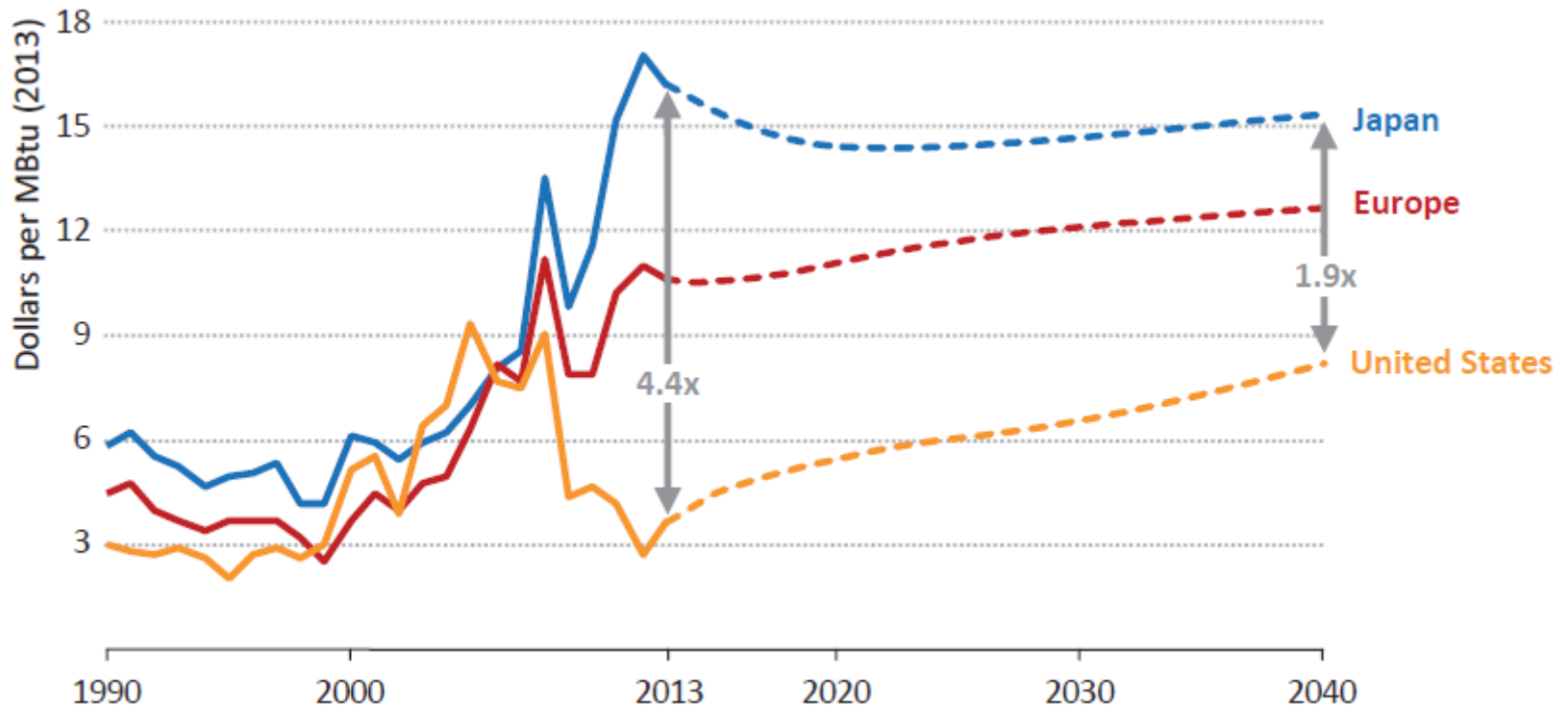
# Will the arbitrage opportunity remain?

## **Regional prices will gradually converge after 2020:**

- ✓ China shale gas reserves will gradually come in line.
- ✓ Australia FLNG huge project is targeting East-Asian market.
- ✓ Russia is constructing a pipeline to China.
- ✓ Some gas rich countries (like Iran and Venezuela) are not yet substantial suppliers. U.S. liquefaction plants preparations are underway to begin exports in 2018.
- ✓ It is uncertain how long US gas prices will remain low.

***The arbitrage opportunity will probably remain at least until 2030***

# For How Long will the Arbitrage Opportunity Remain?



Source: World Energy Outlook, 2014

# Thank you for your attention!

Questions and suggestions are welcome.

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