



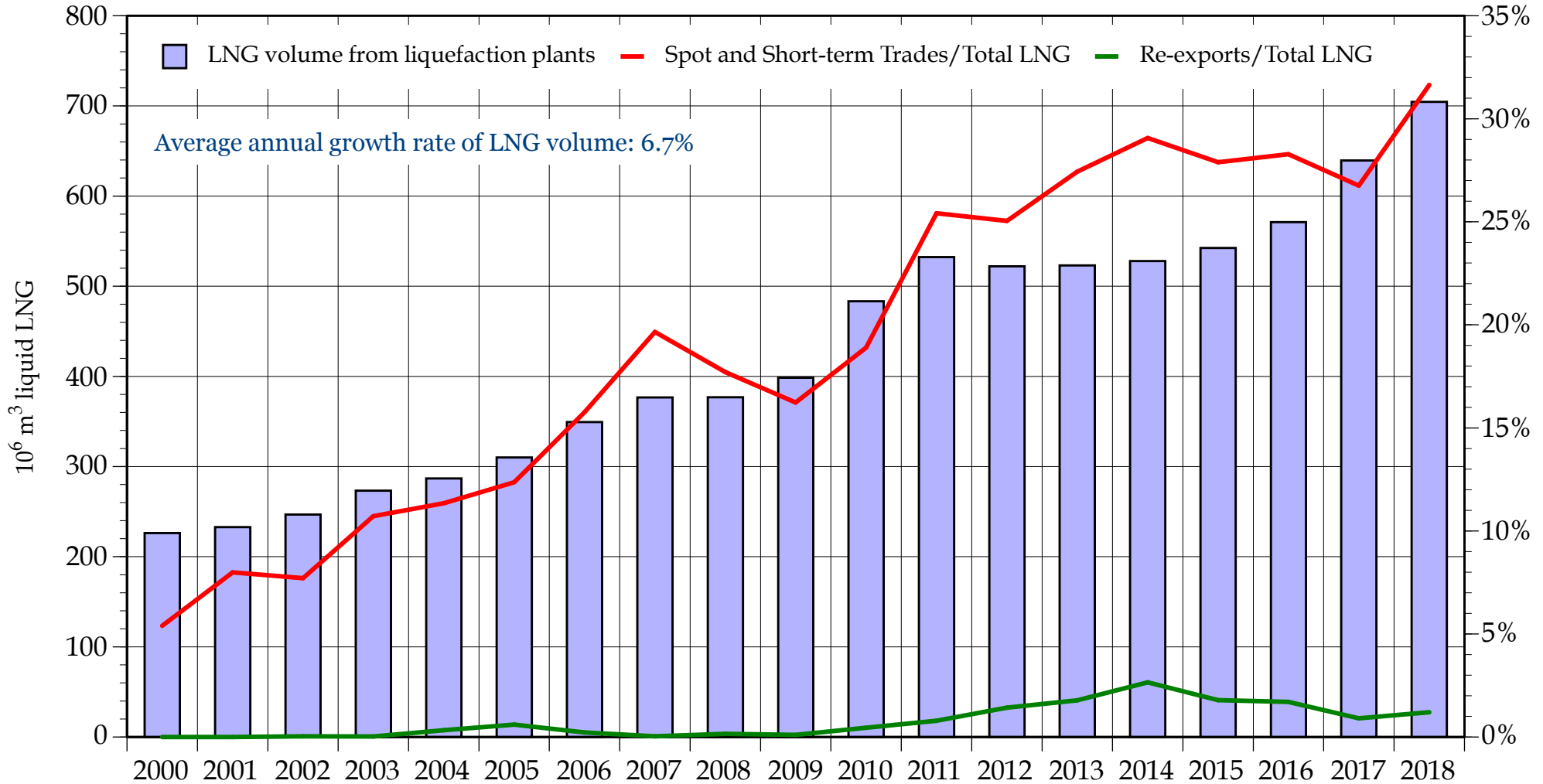
LNG Trade: Recent History and Potential Developments

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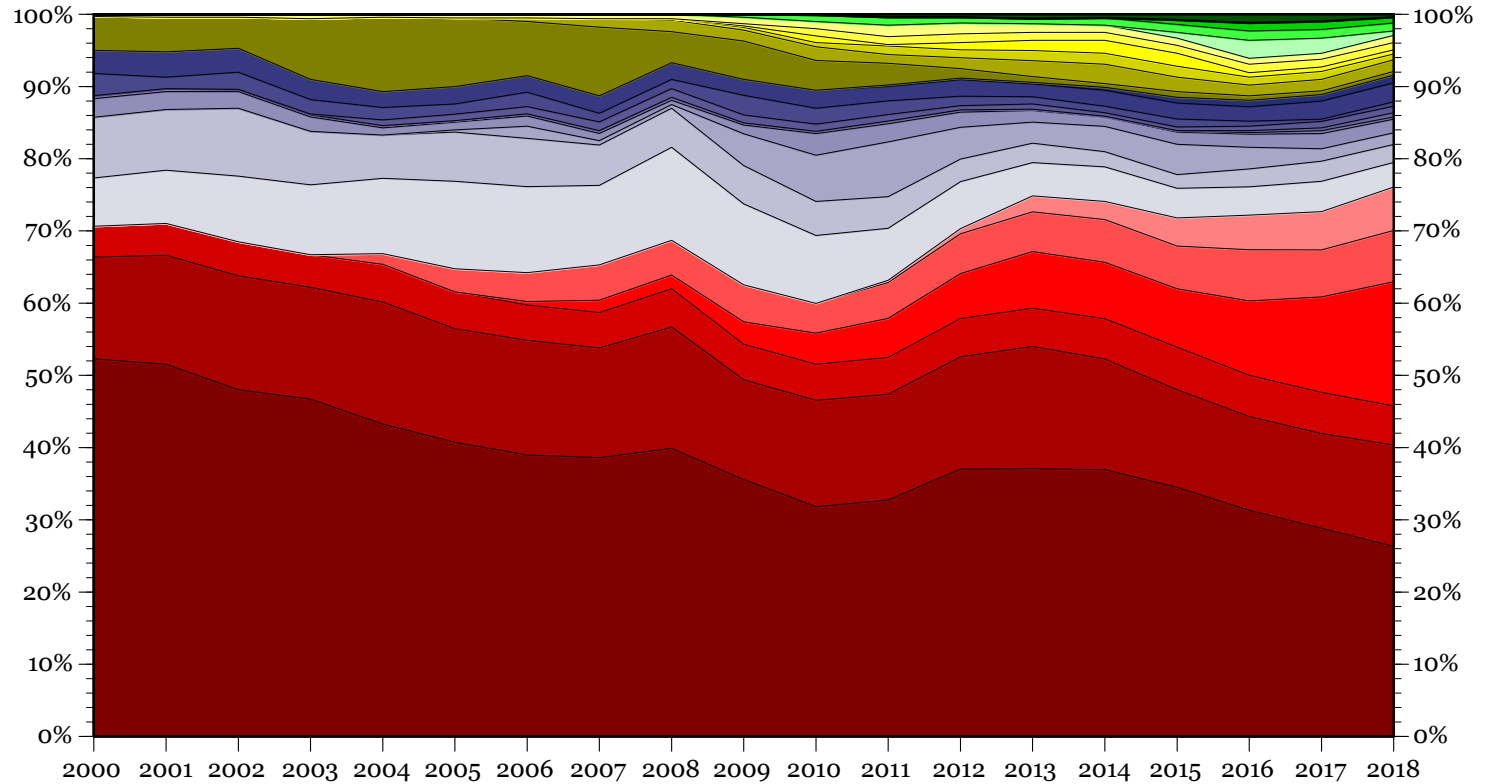
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Increasing spot and short-term LNG trades



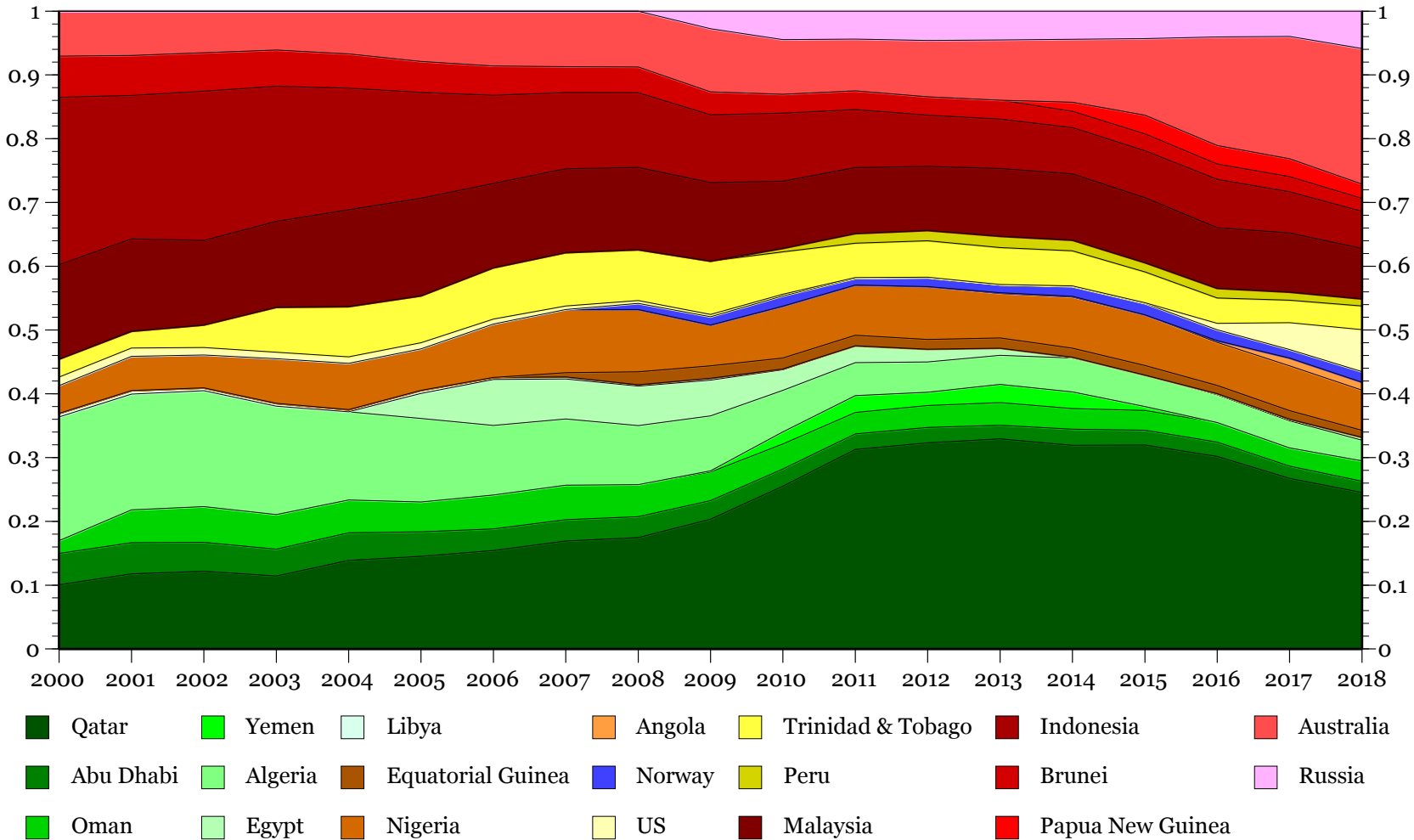
Share of LNG imports by country



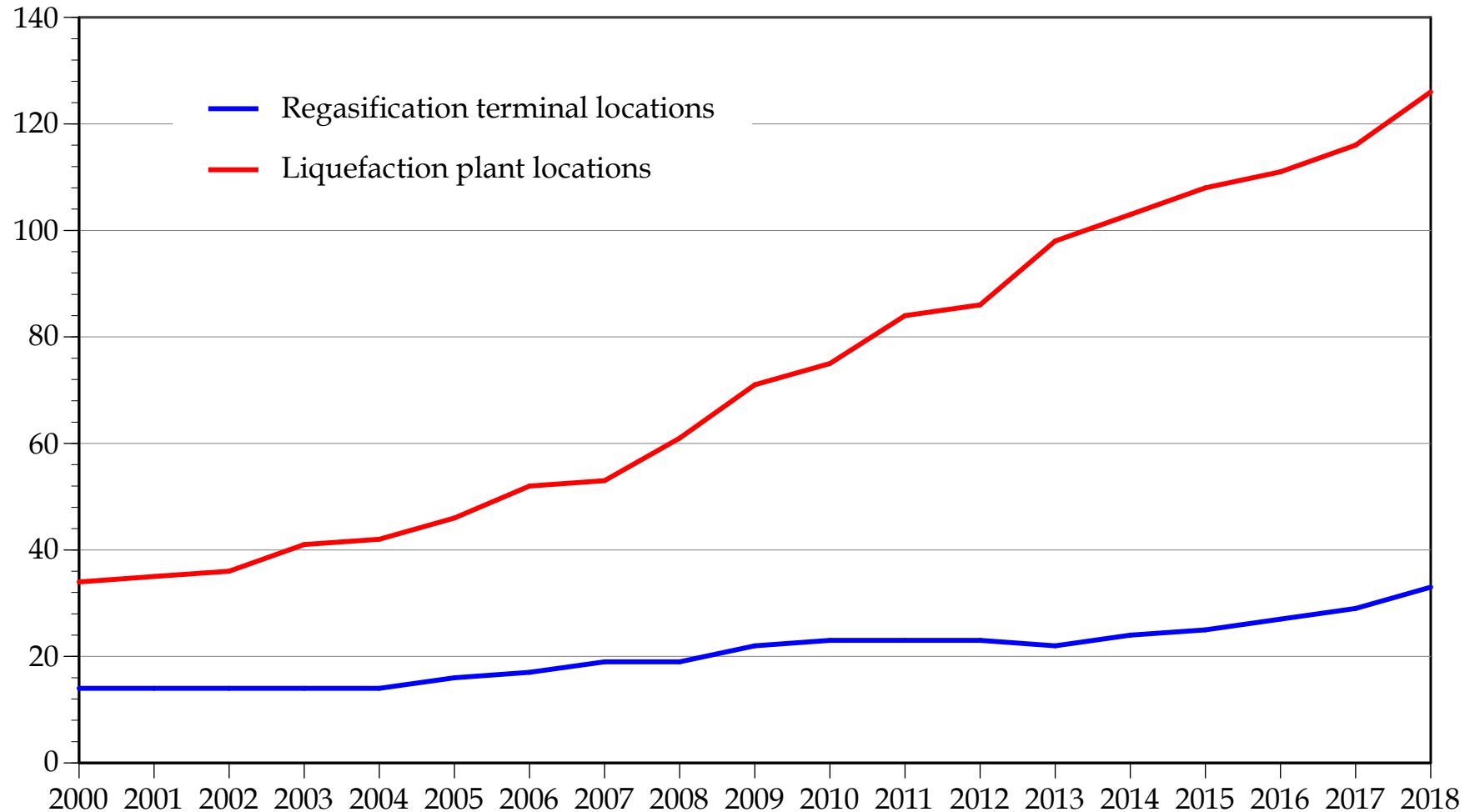
- Japan
 India
 UK
 Portugal
 US
 Chile
 Kuwait
- South Korea
 Other Asia
 Italy
 Belgium
 Mexico
 Other Americas
 Jordan
- Taiwan
 Spain
 Greece
 Turkey
 Argentina
 Egypt
 Other Middle East
- China
 France
 Poland
 Other Europe
 Brazil

Source: GIIGNL

Share of LNG exports by country

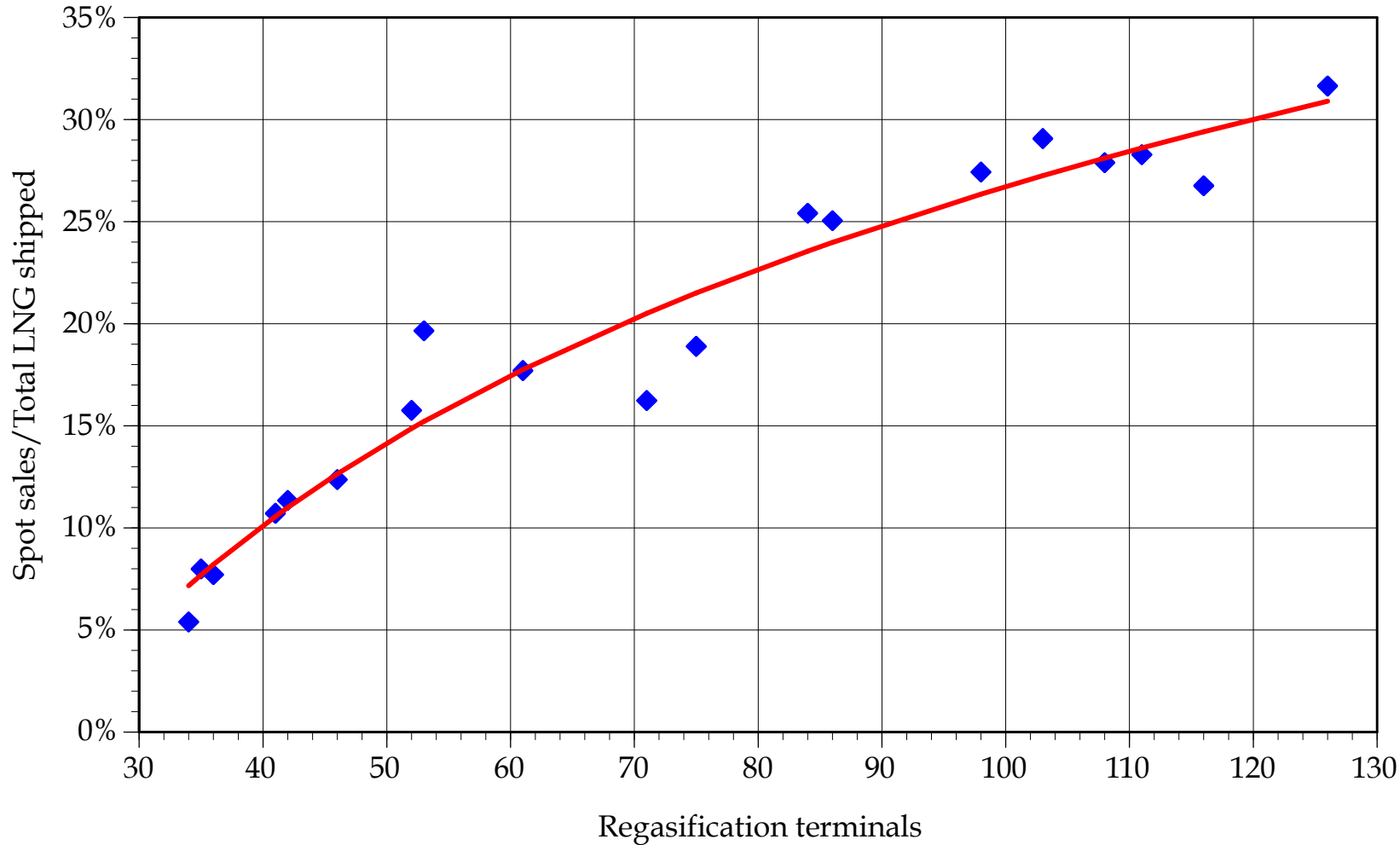


Increasing numbers of LNG trading locations



Source: GIIGNL

Spot trading is related to the number of importing terminals

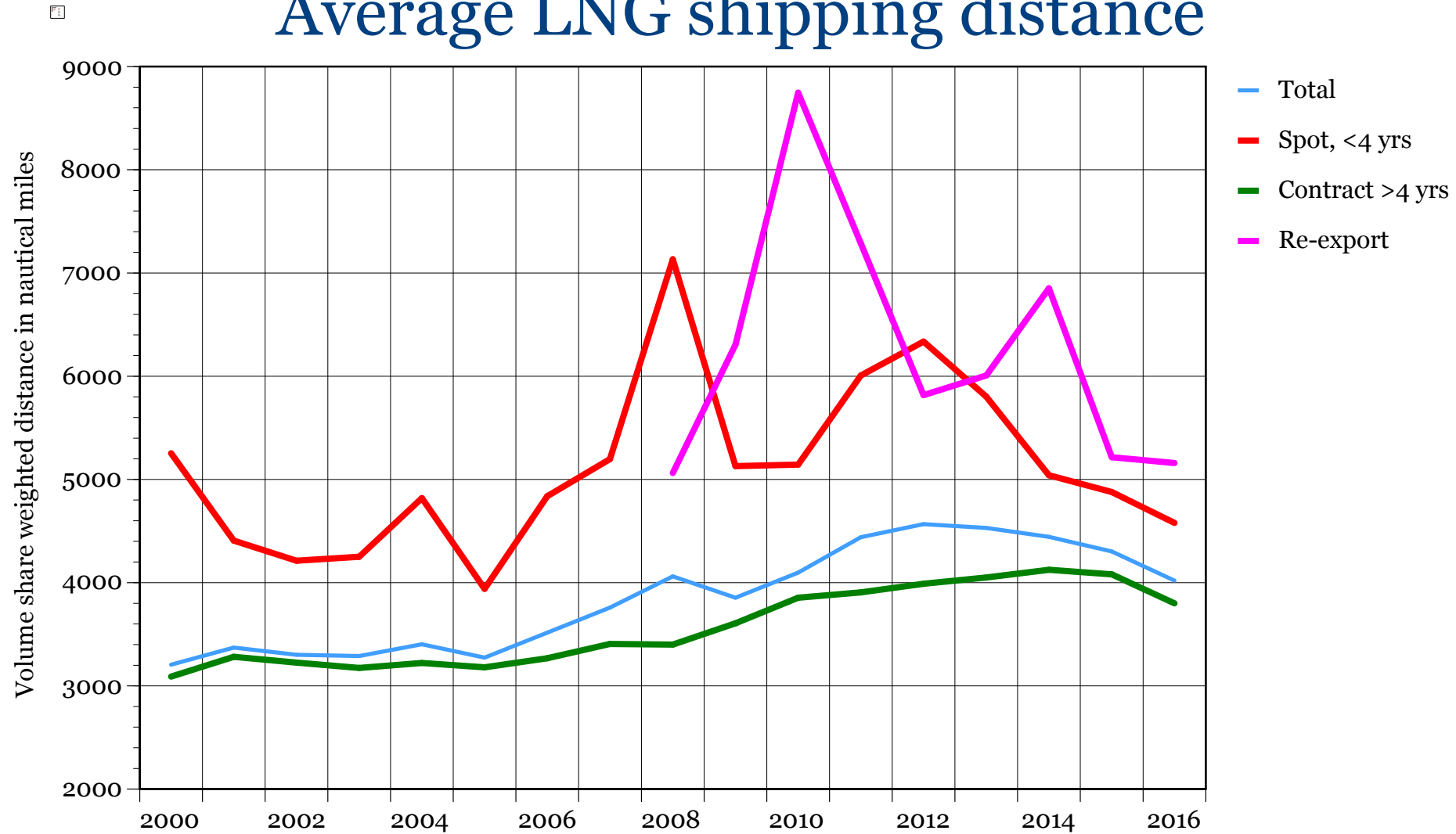


Source: GIIGNL

$$\text{SpotFrac} = 0.181 \ln(\text{Regas}) - 0.567; \quad R^2 = 0.9475$$

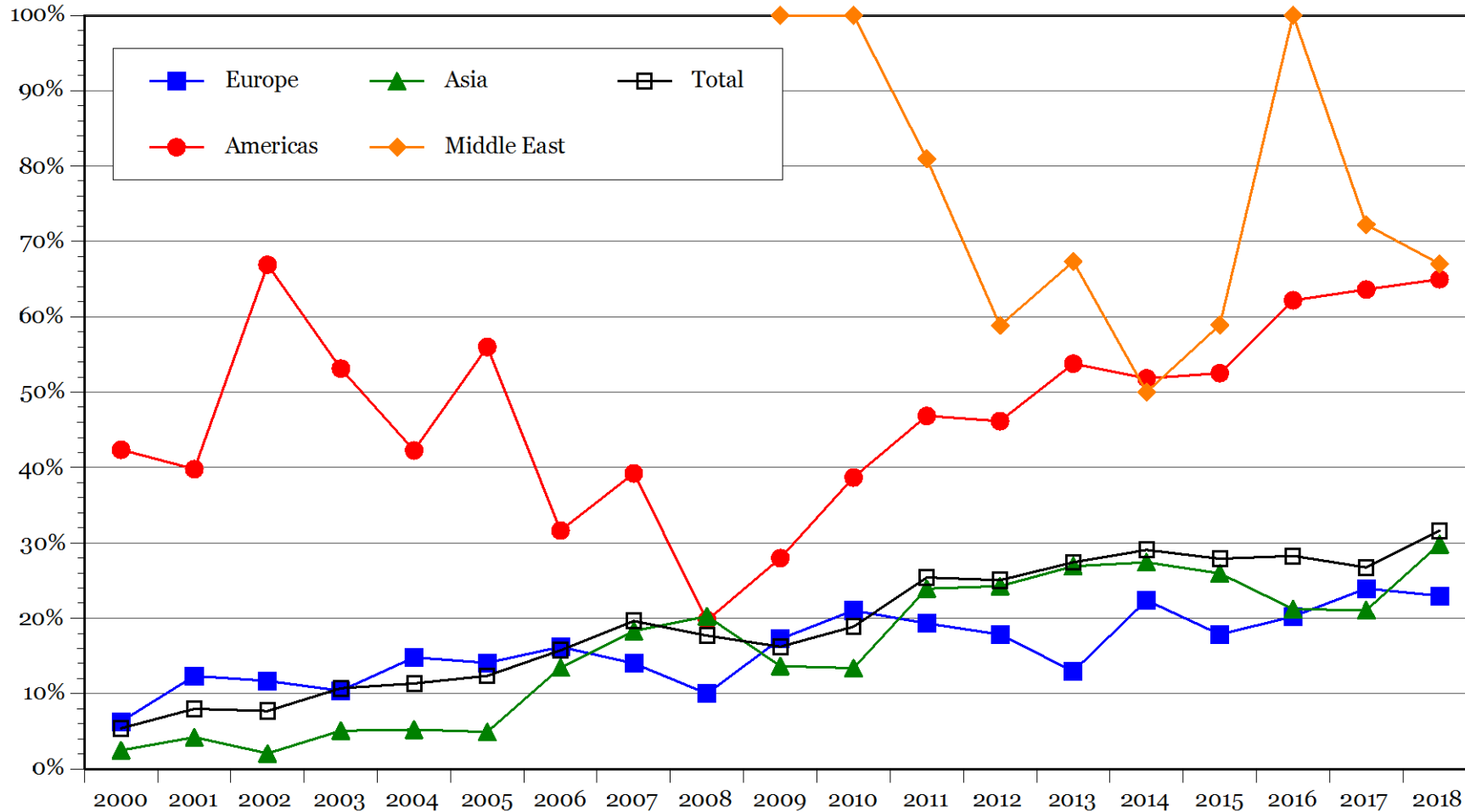
(0.010) (0.044)

Average LNG shipping distance

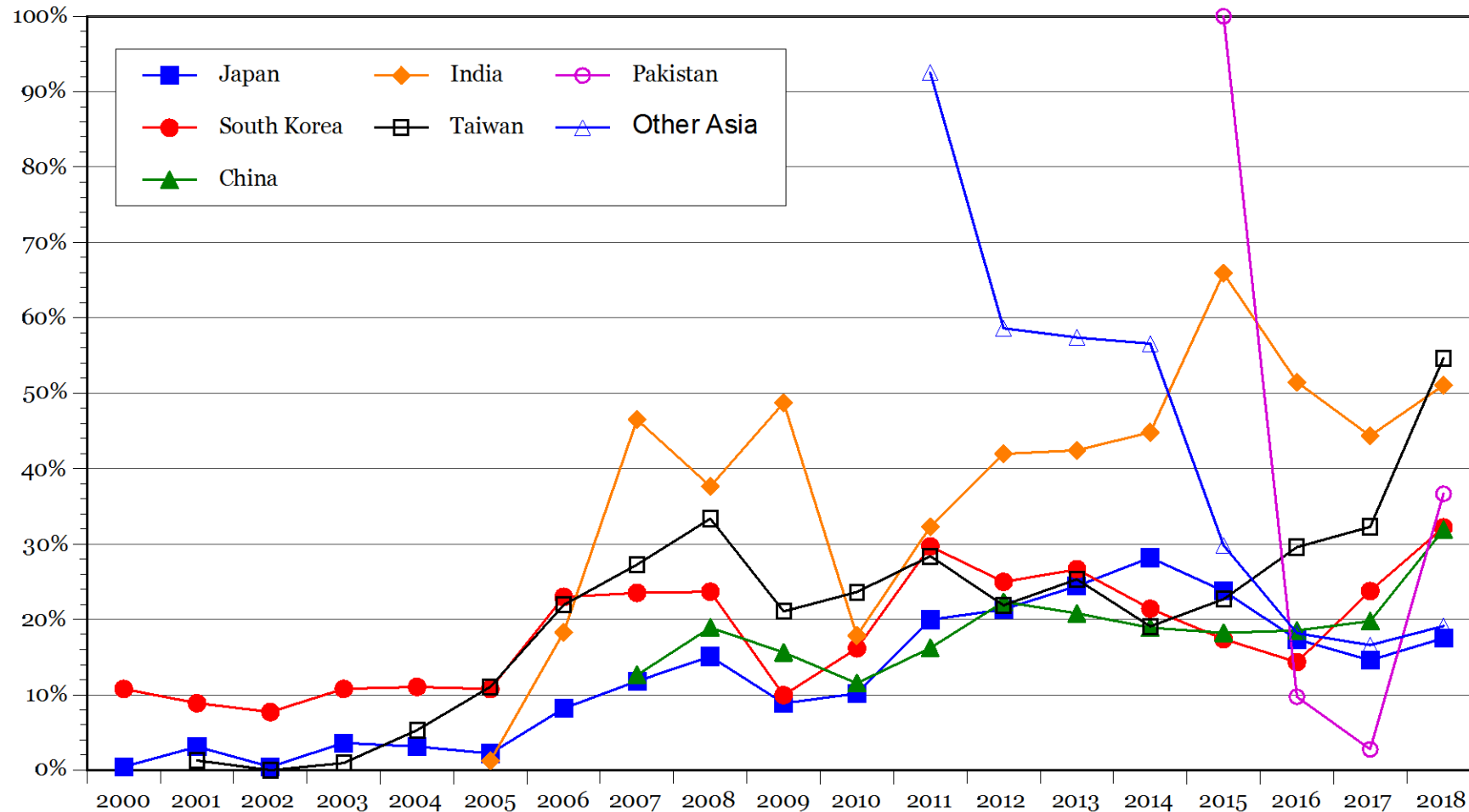


Sources: Author calculations based on GIIGNL and VesselDistance.com

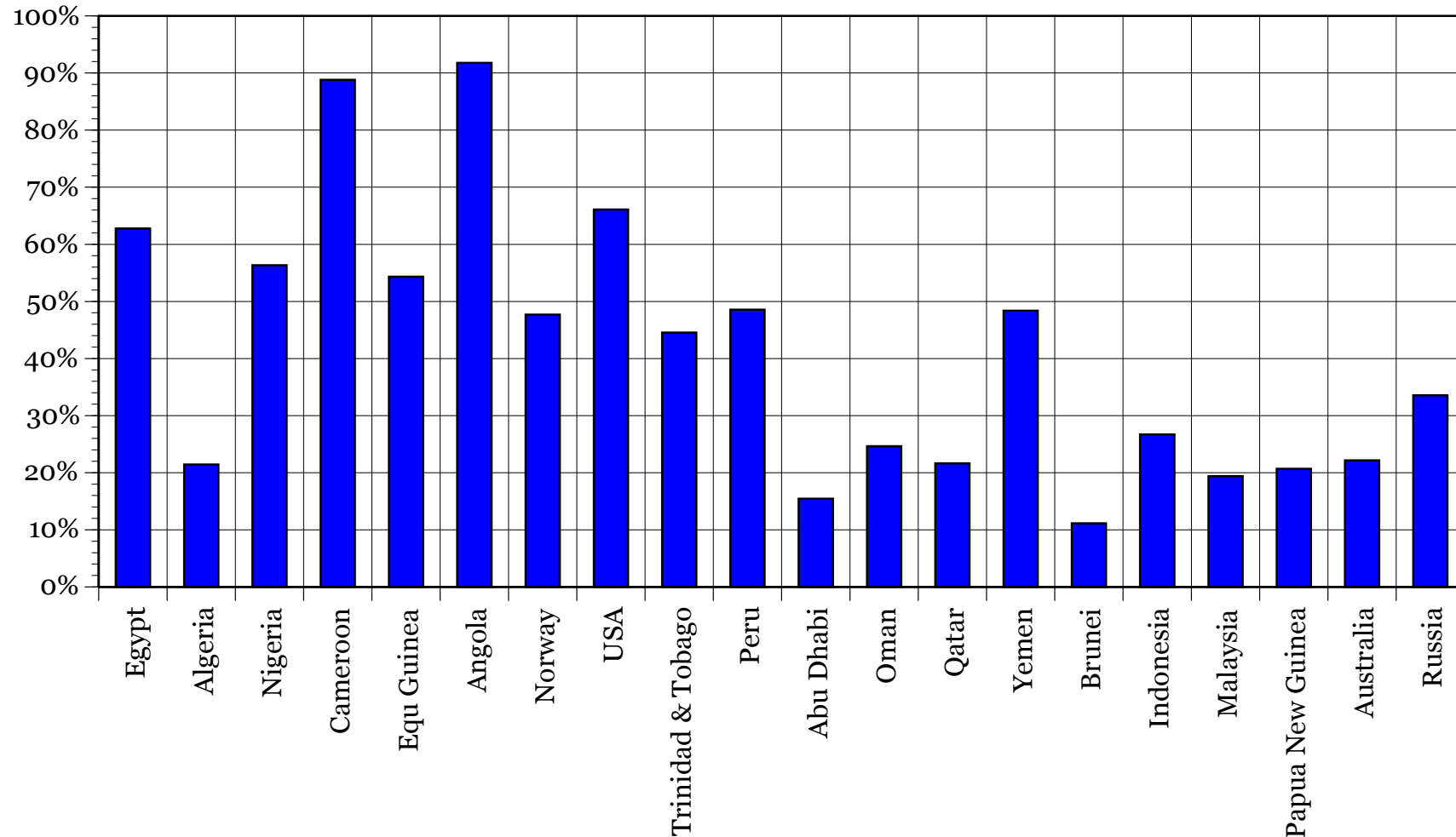
Regional spot and short-term (< 4 yrs) proportion



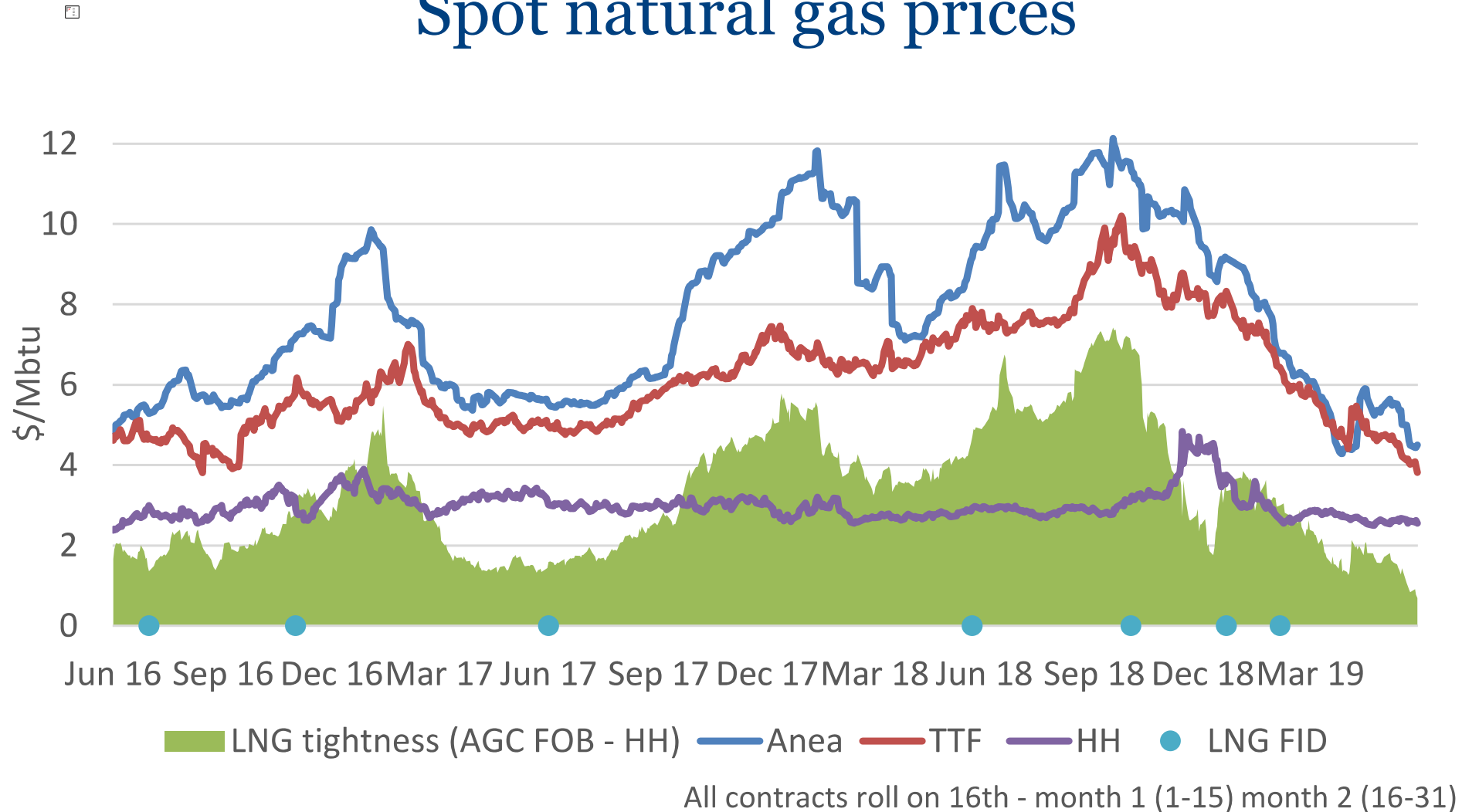
Asian importers spot and short-term (< 4 yrs) proportion



Proportions spot and short-term (< 4 yrs), 2015–18



Spot natural gas prices



□

Other recent developments

- ❖ LNG swaps and other spot trades increasingly exploit arbitrage opportunities
- ❖ Many regasification terminals are adding storage capacity to support arbitrage
- ❖ Expiration of long-term contracts for some early liquefaction developments has created spare capacity and without a need to finance large investments
 - ❖ More of their output is being sold short-term and spot
- ❖ Many recent contracts have greater volume flexibility, destination flexibility, and less than 100% off-take commitments by buyers
- ❖ After the EU restructuring directive of 1998 (promoting competition in EU gas markets), the Commission found destination clauses anti-competitive in 2001
 - ❖ This stimulated re-export of cargoes and increased destination flexibility
- ❖ Japan's anti-trust authority has also ruled destination clauses anti-competitive
- ❖ Growth of “branded LNG” sourced from many sellers and sold to many buyers

Operational/In construction US LNG export terminals

Terminal status and location	Capacity bcf/d	As % 2018 LNG exports
Operational		
Sabine Pass, LA (trains 1-5)	3.5	8.4
Cove Point, MD	0.82	2.0
Corpus Christi, TX (train 1)	0.71	1.7
Hackberry, LA (train 1)	0.7	1.7
Sub-total operational	5.73	13.7
Under construction		
Hackberry, LA (trains 2-3)	1.0	2.4
Corpus Christi, TX (trains 2-3)	1.4	3.3
Freeport, TX	2.14	5.1
Sabine Pass, LA (train 6)	0.7	1.7
Elba Island, GA	0.35	0.8
Cameron Parish, LA	1.41	3.4
Sabine Pass, TX	2.1	5.0
Sub-total under construction	9.1	21.7

Source: FERC and Sempra press release

Approved/Pending/Proposed US LNG export terminals

Terminal status and location	Capacity bcf/d	As % 2018 LNG exports
Approved, not under construction		
Lake Charles, LA (Southern Union)	2.2	5.3
Lake Charles, LA (Magnolia)	1.08	2.6
Hackberry, LA (expansion)	1.41	3.4
Port Arthur, TX	1.86	4.4
Calcasieu Parish, LA	4.0	9.6
Freeport, TX (expansion)	0.72	1.7
Gulf of Mexico, FLNG	1.8	4.3
Sub-total approved	13.07	31.2
Pending applications		
Pascagoula, MS	1.5	3.6
Brownsville, TX (Texas LNG)	0.55	1.3
Brownsville, TX (Rio Grande LNG)	3.6	8.6
Brownsville, TX (Annova LNG)	0.9	2.1
Jacksonville, FL	0.13	0.3
Plaquemines Parish, LA	3.4	8.1
Nikiski, AK	2.63	6.3
Coos Bay, OR	1.08	2.6
Corpus Christi, TX (expansion)	1.86	4.4
Sub-total pending	15.65	37.4
4 terminals (LA, TX) in pre-filing	3.93	9.4

Some key issues affecting US exports

- ❖ Cost of the feed gas is likely higher on average, and especially more variable, than the net cost (after any liquid sales) of stranded gas in most traditional LNG projects
- ❖ Shipping costs from US Gulf coast to key NE Asian market are likely larger than key competitors
 - ❖ Marginal shipping costs co-vary positively with energy prices, reducing the variability of netback prices
- ❖ Capital costs of initial US projects are less than for traditional LNG projects, reducing the desire for debt finance and thus for long-term contracts
- ❖ Arbitrage opportunities abound as the US is well-placed to serve European and Latin American as well as Asian LNG customers
 - ❖ US LNG plants are essentially real options on the differentials between export netback prices and the HH feed gas cost
 - ❖ Keeping prospective output exposed to market prices better enables temporary arbitrage opportunities to be exploited
- ❖ Existence of significant re-gasification and storage capacity in the US also ensures a floor for LNG prices

Understanding optionality in US LNG export projects

- ❖ Used historical data to characterize natural gas spot and NE Asia contract prices, and shipping costs
- ❖ Simulated the random variables for a 20-year project
- ❖ Found that the probability of low cash flows relative to debt service costs were minimized at around 70% of exports under long-term contract for 47.5% leverage and around 50% for 25% leverage
 - ❖ But bankruptcy probability increased in the proportion of output under contract for all leverage above 25%
- ❖ For all leverage values from 25–50%, cash flow mean, variance and skewness all declined monotonically as the proportion of exports under long-term contract increased
 - ❖ Kurtosis reached a minimum at around 60% of output under long-term contract
- ❖ For all leverage values examined, mean equity return fell as the long-term contract proportion rose
- ❖ Some measures of the value of optionality with 70% of output under long-term contract
 - ❖ NW Europe netback exceeded NE Asia netback prices around 20% of the time
 - ❖ Variable cost exceeded the best spot netback price around 3.7% of the time
 - ❖ Contract trade would be best fulfilled with a swap around 4.3% of the time

US LNG exports will likely accelerate several trends

- ❖ Higher elasticity of supply and demand for natural gas in general and LNG in particular as a result of a number of factors:
 - ❖ Higher elasticity of supply of shale gas compared to conventional gas
 - ❖ Increasing numbers of buyers of natural gas including in the form of LNG
 - ❖ Competition between LNG and pipeline gas in more markets
 - ❖ Increased geographic dispersion of LNG importers creating more substitute trading partners
 - ❖ Increased share of LNG coming from competing private firms rather than NOCs
- ❖ Further increases in the volume of spot and short-term trades of LNG
- ❖ Increased liquidity of spot LNG markets, encouraging more participation in such markets
- ❖ Reduced geographic variability of spot LNG prices and hence also natural gas prices
- ❖ Increased trade in derivatives based on spot LNG prices