

## **Global LNG Pricing Terms and Revisions: An Empirical Analysis**

**Executive Summary**  
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It is commonly accepted that LNG prices have historically been indexed to crude oil benchmarks using slope--intercept pricing formulas, especially in Asia. This should imply that statistical evidence for cointegration between oil prices and LNG prices will be quite strong and easily found. Cointegration tests bear out this hypothesis for South Korean, Spanish and Taiwanese prices, but the same tests for cointegration of LNG and oil prices from Japan do not find particularly robust statistical support. The fact that LNG prices from the region's largest importer do not appear to have strong long-run links to oil is a puzzle given the commonly held view that Japanese LNG prices are oil-indexed. This paper shows how one can resolve this puzzle by allowing for structural breaks in the LNG--oil relationship. Additionally, it uses data on long-term contracts to understand which estimates are representative of actual contract terms and whether breaks are occurring due to changes in contract pricing terms or a country's portfolio of LNG contracts.

A long line of literature examining convergence of natural gas spot prices has indirectly approached this puzzle by measuring whether regional gas prices are cointegrated, which is a sign markets are linked and arbitrated. Recent papers on global gas prices have acknowledged a lack of cointegration in gas markets and begun using the Kalman filter to measure the degree and speed of price convergence.

Returning to a framework in which LNG and oil are cointegrated but with structural breaks has a number of advantages. First, it ensures parameter estimates are unbiased and that tests for

cointegration do not erroneously suggest that LNG--oil relationships are spurious. Second, the econometric model explicitly accounts for the pricing terms in long-term contracts. Estimates for sixteen oil--LNG pricing relationships between different importer--exporter pairs in Japan, South Korea, Spain and Taiwan shed light on the confidential pricing formulas in these contracts and when they have been revised. Time series of LNG prices are not widely available, but public customs data can be used to generate average LNG prices at a more granular level than considered in previous studies.

Before embarking on the main econometric analysis of LNG prices, I examine data on long-term contracts and the proportion of spot trades that underlie each price series. This descriptive analysis demonstrates which series should correspond to a single contract, and which experience increasing heterogeneity in contracts that may lead to structural breaks. Econometric analysis shows that empirical LNG--oil relationships, which are likely to correspond to contract terms for several series, are far from uniform even within importing countries, and structural breaks appear to be present in many. Nevertheless, most LNG prices appear strongly linked to oil, despite the initial lack of evidence for Japan. Japanese price series exhibit the most structural breaks. This appears to be for two main reasons. First, the number of contracts under which LNG is imported to Japan from a single country has generally increased and made LNG cargos more heterogeneous in terms of pricing. Second, Japanese contracts also appear to have undergone more revision than those signed by South Korean, Spanish or Taiwanese companies. In particular, pricing terms appear to have increased as tight LNG markets during the mid-2000s caused a mismatch between the price of LNG determined by the upper tail of an S-curve and its value as a substitute for oil products. South Korean and Taiwanese LNG prices have generally been oil-indexed, and the relationships seem relatively stable. Spanish contracts also appear to be oil-indexed, though less tightly and with a shallower slope term.