TIME-VARYING INTEGRATION BETWEEN GLOBAL NATURAL GAS HUBS

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Overview

For decades, natural gas was not priced independently but was contractually indexed to oil through take-or-pay agreements, particularly in Asia and continental Europe (Stern, 2014; Asche et al., 2002; Agerton, 2017). Even as hub-based pricing has gained ground, roughly sixty per cent of Asian LNG volumes remain oil-indexed today (International Energy Agency, 2025). Moreover, a residual substitution-based linkage persists wherever industrial consumers can switch between gas and petroleum products at the burner tip (Brown and Yücel, 2008; Hartley et al., 2007). The econometric consequence is that two gas hubs may appear to co-move not because the gas-on-gas market is mature, but because both track the same underlying oil price. Loureiro et al. (2023) make this point explicitly, arguing that earlier findings of intercontinental convergence may have been artifacts of shared oil-indexation rather than evidence of genuine gas-to-gas integration.

Erdős (2012) reached a similar conclusion for the transatlantic relationship: once the US oil–gas link broke after 2009, the apparent convergence between American and European gas prices disappeared. This limitation is particularly consequential given recent evidence that the oil–gas price relationship is itself time-varying, regime-dependent, and regionally heterogeneous (Halser et al., 2023; Hasanli, 2024). Similarly, the assumption of constant transportation costs between hubs, which is implicit in most existing integration studies, is difficult to sustain in a market where tight shipping capacity markets, lumpy infrastructure investments, and innovations such as floating regasification units cause the effective cost wedge between regions to vary substantially over time (Oglend et al., 2020; Chiappini et al., 2019; Hartley et al., 2007). We thus argue that neither oil sensitivity nor transportation costs can be treated as static parameters; both must be modeled as evolving processes if genuine gas- on-gas integration is to be meaningfully assessed.

This paper seeks to address the following research question: Is there a globally integrated commodity market for natural gas? We decompose this overarching question into three sub-questions: i) To what extent do regional hub prices maintain independence from oil prices, and how has this decoupling evolved over the sample period? ii) Once oil sensitivity is controlled for, is there empirical evidence of long-run integration among the major global natural gas hubs? iii) Is there a stable cost wedge between hubs, or does the transportation and processing spread vary systematically over time?

Methods

This paper addresses this by extending the Kalman filter - a methodology with a long tradition in this field (King and Cuc, 1996; Neumann et al., 2006; Neumann, 2009; Loureiro et al., 2023) - by augmenting the standard law of one price measurement equation. We add crude oil as an additional explanatory variable and allow the traditional transportation cost wedge to be time-varying. Thus, our model yields a state-space specification in which three parameters evolve simultaneously over time: the hub-to-hub integration coefficient β_t, the oil dependency coefficient δ_t, and the intercept α_t, which we interpret as a time-varying transaction cost wedge. This allows us to decompose observed gas price co-movement into a component driven by shared oil exposure and a component driven by genuine inter-hub integration, while the time-varying intercept captures fluctuations in the effective cost of arbitrage across basins. We further augment the model with structural break dummies identified via the Bai and Perron (1998, 2003) procedure, ensuring that abrupt regime shifts are captured as deterministic jumps rather than being absorbed into the stochastic drift of the state parameters.

Preliminary Results & Conclusions

We expect our findings to yield several insights. If, after controlling for oil, the inter-hub transmission coefficients are weaker than those estimated in the traditional models, this would suggest that the degree of genuine gas-on-gas integration is weaker than previously thought and likely attributable to oil-linkage. Conversely, if the oil-adjusted coefficients are stronger or more stable, it would indicate that oil price noise has obscured an underlying integration

process that is more advanced than the raw price data suggest. In either case, the time-varying oil dependency coefficient will provide empirical evidence on the extent to which natural gas has “decoupled” from oil across different regions and time periods. For cross-basin LNG arbitrage, the time-varying intercept offers a direct measure of how the effective cost of redirecting cargoes has evolved, which is information embedded in existing price data but has not previously been extracted in a systematic way.

Preliminary findings of applying a Kalman filter augmented with dummy variables that coincide with the structural breaks identified via the Bai-Perron procedure, challenge the notion of a monotonic progression towards a unified global market. Our analysis suggests two primary conclusions regarding the current state of market linkages: Firstly, the North American market remains segmented from Europe and Asia. Secondly, Europe and Asia seem to have a ”crisis-driven” relationship, in which price transmission spikes during periods of undersupply or high demand.

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