Commodity Models for Derivatives Pricing and XVAs

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Introduction and Motivation

Commodity markets sit at the intersection of the real economy and global finance. Their prices embed physical constraints (storage, transport, extraction), structural features (seasonality, mean reversion, convenience yield), and sudden shocks (weather, geopolitics, outages). These characteristics make commodities simultaneously indispensable for hedging real-world risks and challenging to model with the tools that work well in rates, FX, or equities. Over the last decade, regulation and clearing have also changed the economics of trading: collateral, funding, initial margin, and capital now contribute materially to the all-in cost of a trade. As a result, institutions increasingly need models that (i) price commodity derivatives with realism and tractability and (ii) feed exposures into XVA frameworks.

In practice, many desks still rely on simplified commodity models that fit parts of the curve or a subset of options but degrade when used for exposure simulation. Conversely, models that capture spikes, regime changes, or convenience yields can be computationally demanding and awkward to calibrate daily. Bridging this gap—between fidelity and practicality—is the central motivation of this master thesis.

Goals of the Project

This thesis investigates commodity price models for potential applications in derivatives pricing and XVAs. The objectives are to:

i. Survey and systematize leading families of commodity models (e.g., mean-reverting with/without jumps), convenience-yield models (e.g., Gibson-Schwartz), multi-factor term-structure models (e.g., Schwartz-Smith), and forward-curve/HJM-style specifications—highlighting how they represent seasonality, mean reversion, and basis.

ii. Calibrate and compare representative models across energy and metals using liquid futures strips and listed options; examine stability, parameter interpretability, and out-of-sample performance.

iii. Build a pricing prototype in Python for common structures (vanilla options, Asian options, spread options; with a discussion of swing and storage features) emphasizing numerical schemes, Greeks, and robustness.

iv. Quantify trade-offs between model realism and computational cost proposing pragmatic choices for different use-cases (e.g., front-office pricing vs. exposure simulation).

v. Propose how to integrate all the above with a realistic XVA engine.

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