Revisiting the competitive storage model as a tool for the empirical analysis of commodity price volatility

PhD Defense

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Introduction

Motivations and Objectives

The high stakes in understanding the commodity price behavior stem from:

- The typical volatility;
- The episodic and recent price spikes;
- The income, political and social stability of countries;
- The importance for economic agents decisions;

Introduction

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- The importance for economic agents decisions;

$\Rightarrow$ Quantitative analyses of commodity price volatility need a consistent model explaining the commodity price formation.

Introduction

The storage model in words

- Very basic supply and demand equilibrium model;
- Supply planned with a lag;
- Demand for immediate consumption;
- Speculative demand for storage,
  $\Rightarrow$ Thereby inducing serial dependence in prices;
- A non-negativity constraint on storage;
- Both supply and demand subject to exogenous additive random shocks;

Able to explain the main features of commodity prices (nonlinearity, positive skewness, volatility clustering,...).

Introduction

Contributions

This thesis adds to the literature at three levels:

- On the theoretical front:
  - To study the trade-off between inventory and capital accumulation dynamics;
- On the empirical front:
  - To account for the trend without restricting the model's specifications;
  - A Bayesian estimation of the model on prices & quantities for more structural parameters of interest to be identified and estimated (e.g., supply reaction, demand shocks);

The model's empirical performances I

The debate

- The model fails to match the high level of autocorrelation in the observed prices (Deaton & Laroque, JPE 1996);
- A more accurate numerical resolution leads to higher levels of autocorrelation
  - But at the cost of the absence of stockouts over the sample period (Cafiero et al., JoE 2011);
- A maximum likelihood estimator helps reducing biases and improving the model fit (Cafiero et al., AJAE 2015).

The model's empirical performances II

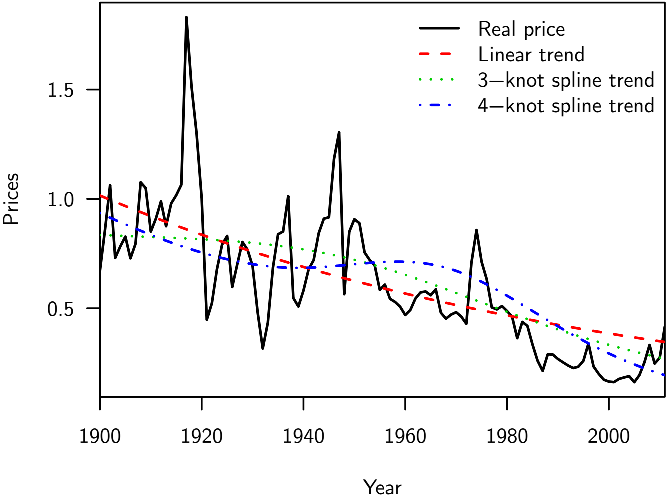
Potential remedies

However, so far,

- Structural estimations relied on prices only;
- Restrictions are needed on parameters left unidentified (e.g., inelastic supply and a single calibrated structural shock);
- Most estimations have been done on real prices without any correction for possible trends.

Dealing with long-run trends I

Trends and cycles decomposition



Source: World Bank

Dealing with long-run trends II

The joint estimation strategy

We take inspiration from the hybrid approach of Canova (2014):

- Observed prices are assumed to be decomposable between
  - A multiplicative trend;
  - A cycle explained by the competitive storage model;
- The trend is assumed to be deterministic, which allows the likelihood to take an explicit expression;
- Joint estimation of the trend and of the storage model by 2 nested algorithms (model resolution and optimization of the ML estimator).

Dealing with long-run trends III

Detrending effects on the parameters

To match the high autocorrelation in prices, stocks should be often present so the estimation results lead to:

- Storage costs higher once accounting for a trend;
- More elastic demand, because the trend capture some of the autocorrelation;
- The storage costs from the best model remain low compared to surveys of storage costs (e.g., World Bank & FAO, 2012);
- Our detrended estimates of elasticities are similar to Roberts & Schlenker (2013) estimates on an aggregate of maize, wheat, rice, and soybeans.

Bayesian inference on quantities I

Towards richer models specifications

Price is the outcome of a supply and demand matching;

$\Rightarrow$ Reasoning from a price change is unhelpful to improve the quantitative merit of the storage theory.

Even noisy, information on quantities is needed and allow to:

- Disentangle production from consumption shifts;
- Test for the presence/absence of producer's response;
- Estimate a higher number of parameters.

Bayesian inference on quantities II

Estimation results

- New estimation methods for the storage model inspired from the standards in macroeconomics;
- Very inelastic supply and demand estimates but not implausible for such an aggregate of staple food products and consistent with R & S, 2013;
- Large measurement errors call for richer specifications.

Investment and storage dynamics I

The intuition

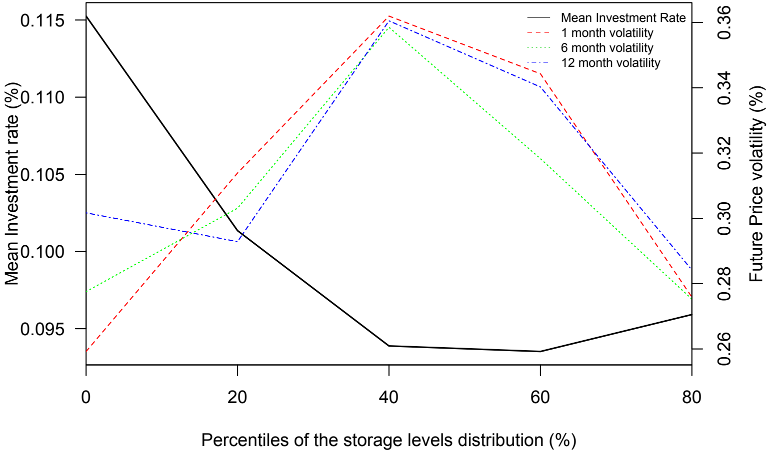
Storage and investment are the key intertemporal economic decisions and:

- Investment is irreversible and decreasing in uncertainty;
- Uncertainty increases with expected price volatility;
- Storage displaces uncertainty into the future, and thus
  - delays investment in fixed capital;

$\Rightarrow$ There is a case for understanding the interaction of storage with investment irreversibility with their effects on the commodity prices.

Investment and storage dynamics II

Empirical facts in the oil industry



Sources: NYMEX, Baker Hughes and IEA

Investment and storage dynamics III

The missing link

There are two streams of literature which can be reconnected,

- Literature on the capital accumulation focusing on:
  - Investment decisions under price uncertainty;
  - Irreversibility and adjustment costs;
- Literature on the competitive storage model and the term structure of commodity prices which focuses on
  - the mediation effects of storage on the price behavior;

$\Rightarrow$ Augmenting the storage model on the supply-side to account for the capital accumulation dynamics.

Investment and storage dynamics IV

The crowding-out effect of storage

- Storage and investment are the two main economic mechanisms in most dynamic commodity models;
- The tight link between two consecutive prices through storage arbitrage, translates into higher future uncertainty, rendering the nonnegativity constraint even more binding;
- Ultimately, storage displaces uncertainty into the future which reinforces the irreversibility of investment;
- The strength of the crowding-out effect is linked to the level of uncertainty brought about storage.

Conclusion and perspectives

Theoretical developments

- Supply-side developments
  - Effects of capital adjustment costs of various nature (e.g., fix, convex and non-convex);
  - Introduction of a second but not predetermined factor of production (for e.g., labor among the very first expendable in times of turmoil);
- Introduction of macroeconomic spillovers
  - Effects of exchange rates and monetary policy in the spirit of the overshooting theory;
  - Addition of financial frictions using the interest rate channel (e.g., heterogeneous agents, behavioral economics).

Conclusion and perspectives

Empirical developments

Full structural estimation of the richer specifications leads to:

- Express the model in a state-space form;
- Increase the set of observed variables augmented with measurement errors;
- Relax the assumption of prices observed without noises;
- Use the particle filter to evaluate the likelihood $L(Y^{\text{obs}}|\theta)$ given the non-linearities of our state-space system;
- Favor Bayesian techniques in view of the growing number of estimated parameters.

Thank you for your attention