Behavior and Determinants of Petroleum Product Prices

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Catalog of Topics

- Product prices and oil prices
- 'Rockets and Feathers', product price responses to oil price changes
- The time series behavior of product prices: volatility, mean reversion, jumps
- Speculative activity and product prices
- Where price discovery occurs (futures versus spot)
- The predictive accuracy of product futures prices
- The influence of unexpected information on price formation.

A Question

- Empirical examinations of oil price/product price relations have tended to focus on
  - Oil prices → Product prices
  - Empirical studies predominately find causal path from oil prices to prices of petroleum products, or, assume that oil prices are exogenous relative to product prices
- But some have argued
  - Product prices → Oil prices
  - Some but limited evidence that petroleum product prices influence oil prices

Crude Oil Prices and Product Prices

- Single equation models
  - Long run relation between oil price and refined product prices
  - Often treat oil price as exogenous de facto
- Multivariate VECM - examples
  - Asche et al. (2003) do not reject the null hypothesis that that oil prices are weakly exogenous (oil prices, several products), international data (Europe)
  - Lanza, Manera, and Giovannini (2005)
    - International sample (Europe EU, America AM), markers (Brent, WTI) vs. regional prices.
    - Marginal significance of product prices for regional oil prices in EU after accounting for benchmark oil price (Brent) but no significance for AM.

Additional Evidence

- Gasoline Price Determinants
  - Variation in national gasoline prices associated with changes in crude oil prices
    - Time series as well as geographic variation
      - Other factors: inventory, refinery utilization (refinery outages), prices of substitutes (natural gas), weather
        - Chouinard and Perloff (2007), Kaufmann, Dees, and Mann (2009)
  - Price differentials across states due to taxes, population density, and age distribution
  - Some evidence that oil price driver of gasoline prices in U.S. is world oil price (proxy is Brent price)

Example Evidence: Inventory, Outages

- Inverse relation between product price changes and changes in inventories
  - Gorton et al. (2012)
- Refinery outages lead to increase in product prices
  - Kendix and Walls (2010)
- Tropical storm forecasts (hurricane activity) for the Gulf tend to push prices up for forecasts of more extreme activity
  - Fink, Fink, and Russell (2010), Fink and Fink (2014)

Oil Price Benchmark

- WTI Price or Brent Price?
  - Brent crude oil prices explain more of the variation in U.S. spot gasoline prices
    - U.S. Energy Information Administration (2014)
  - Hedging performance of WTI and Brent during the crisis not clearly attributable to the latter reflecting fundamentals and the former not.
    - Pirrong (2010)
  - Neither is best, traders use a weighted average
    - Fattouh (2011)
  - and Baumeister et al. (2015) (refiners' acquisition cost since that number would also reflect transportation costs)
    - Refiners often blend crudes to obtain a desired mix

Asymmetric Price Adjustment

- Size and Speed of Adjustment of Petroleum Product Prices (downstream prices) to changes in Oil Prices
  - "Rockets and Feathers" (Bacon, 1991) asymmetric responses
  - Conjecture: Faster adjustment of downstream prices to oil price increases and slower adjustment to oil price decreases

Asymmetric Responses of Product Prices

- 16 of 23 studies report asymmetric responses
  - Grasso and Manera (2007), Global markets
- 60% of 403 model estimation results find that product prices exhibit asymmetric price adjustments to oil price changes
  - Perdiguero-Garcia (2013), Global markets
  - Frey and Manera (2007)
- Statistical approaches and data vary

Menu of Different Study Features

- The country being investigated
- The level of aggregation, cities, states, countries
- The sample period and the frequency of the price observations (daily, weekly, monthly)
- The stage of the transmission, that is whether the analysis is between oil prices and spot gasoline prices or retail prices, or spot prices and retail prices
- The statistical model estimated as part of the analysis.
  - Geweke (2004), Frey and Manera (2007), and Grasso and Manera (2007)
    - Error correction model is common (ex. *y* downstream price, *x* oil price)

$$\Delta y_t = \varphi^+(\Delta x_t)^+ + \gamma^+(y_{t-1} - \beta_0 - \beta_1 x_{t-1})^+ + \varphi^-(\Delta x_t)^- + \gamma^-(y_{t-1} - \beta_0 - \beta_1 x_{t-1})^-$$

  - Short run effects (number of lags $(\Delta x_t)^-, (\Delta x_t)^+$) depend on opt. specification
  - Traditional Wald tests, Impulse Response test
- Models sometimes based upon an examination of 'margins' (a difference between the product price and the oil price) in contrast to 'prices'

Asymmetric Responses for Product Prices

- Degree of asymmetry in gasoline prices declines with an increase in oil price volatility
  - Radchenko (2005b)
- When refinery utilization rates and the level of stocks are included in the model, the asymmetry between oil and gasoline prices vanishes
  - Kaufmann and Laskowski (2005)

Asymmetric Responses for Product Prices

- 97% of changes in crude oil prices are short-term and that may be the driving factor in the lag in the response of retail gasoline prices
  - Radchenko (2005a)

Potentially Unsettled Questions

- Direction of causation?
- Benchmark oil price?
- Are asymmetric responses present?
  - Most work has been done on gasoline prices

Some Conjectures

- Is it possible that causality may operate in both directions but be conditional on market conditions
  - Demand shocks to petroleum products could act as a force in determining crude demand and crude oil prices (Verleger 1982, 2011)
    - Conversely supply shocks to petroleum products due say to refinery outages could have the opposite impact
  - Supply shocks to crude production/inventory could act as a force through marginal cost in determining petroleum product prices.
    - Conversely demand shocks to crude could have the opposite effect
- The environment could therefore dictate the statistical connection observed and whether causality runs from oil prices to product prices or product prices to oil prices.
    - Also potential for feedback effects
- Conditioning on the type of shock could provide insight into what is observed empirically.

Speculation and Petroleum Product Prices

- The limited empirical evidence indicates speculation has not increased volatility nor excess returns of petroleum product prices

Evidence on Speculation and Prices

- NYMEX heating oil and gasoline futures markets
  - Workings T statistic
  - The T indices are within range of what has been considered reasonable/normal for the agricultural futures markets
    - Till (2009)
  - Univariate GARCH models suggest that higher speculation is associated with lower volatility
    - Manera et al. (2014)

Speculation

- Financial speculation is not a significant factor in explaining the time series behavior of returns on energy commodities (futures)
  - Manera et al. (2013)
- No evidence that hedging pressure from changes in the positions of commercial and non-commercial traders is related to excess returns
  - Gorton et al. (2012)

Speculation

- Irwin and Sanders (2012) using CFTC Index Investment Data and separately daily positions of the US Oil Fund and US Gas Fund, they find no evidence that lagged daily position changes of these funds Granger cause daily futures returns.

- Sanders and Irwin (2014) using proprietary data on the daily futures positions of a large, representative commodity index fund (the "Fund") during February 13, 2007 through May 30, 2012 find no evidence of causality from Fund position changes to returns in all markets

Petroleum Product Excess Futures Returns

- Do products offer a risk premium?
  - Yes, Heating oil and unleaded gasoline futures
- Are product returns excessively volatile?
  - Yes, relative to the DJIA
- Are product returns positively or negatively skewed?
  - Returns exhibit little skewness
- Do product returns exhibit “fat tails?”
  - Yes, heating oil and unleaded gasoline futures
- Are product returns autocorrelated?
  - Yes, heating oil and unleaded gasoline futures
- Kat and Oomen (2007), Gorton et al. (2012)
- Room for updating results

Time Series Behavior of Product Prices (generally nearby futures price)

- Exhibit mean reversion
- Exhibit jump diffusion behavior
- Volatility conditioned on past volatility (GARCH-type models)
- Long-memory in volatility (volatility persists)
- Volatility spillovers between products
- Low or no correlation between either gasoline or heating oil future returns and stocks and bond returns

Empirical Models

- Mean Reversion Jump Diffusion-EGARCH(1,1) model fits best and has the best predictive power for heating oil, and gasoline
  - Nomikos and Andriosopoulos (2012)
  - Asymmetry in the response of volatility to news also found by Lee and Zyren (2007)

Empirical Models – Volatility Spillovers

- Evidence of volatility spillovers between crude oil, heating oil, gasoline, and natural gas prices using multivariate GARCH models
  - Manera, Nicolini, and Vignati (2013)
- Bi-directional causal relation between crude spot and heating oil spot using ECM GARCH models
  - Hammoudeh, Li, and Jeon (2003)

Empirical Models – Volatility Spillovers

- Volatility spillovers from futures to spot markets, but not the reverse
  - Ng and Pirrong (1995)

Futures Prices and Spot Prices

- On average price discovery occurs in the futures market for petroleum products
- Oil futures price changes appear to cause gasoline futures price changes in the short run
- Some evidence that gasoline futures prices influence oil futures prices but limited to a single study
- Futures prices for heating oil and gasoline are unbiased predictors of spot prices at the 3 month maturity but not 6 and 12 months
- Gasoline futures do best at predicting future spot prices while heating oil and crude oil do worse

Other Evidence

- Accounting for asymmetries improves predictions of the sign of the change in product prices, but does not lead to more accurate point forecasts than a standard Error Correction Model
  - Bastianin, Galeotti, and Manera (2014)

Price Discovery – Questions

- Influence of futures contract liquidity
- Interrelation between prices of different commodities and oil
- Limited evidence of the influence of speculators on price discovery in petroleum product markets
  - Sanders and Irwin (2012) – find no evidence

Unexpected Information and Prices

- Negative relation between surprises about changes in inventories and changes in futures prices (gasoline and heating oil)
  - Halova et al. (2014)
- No evidence that the price of WTI crude oil and the U.S. retail price of gasoline respond to U.S. macroeconomic news announcements
  - Kilian and Vega (2011)
- Immediate and negative response of gasoline and heating oil prices to unexpected changes in the fed funds target rate
  - Basistha and Kurov (2015)

Thank You