EFFICIENCY MARKET HYPOTHESIS AND OPTIMAL HEDGE RATIO
THE ETHANOL MARKET

HACHE EMMANUEL & PARIS ANTHONY
ETHANOL MARKET – EFFICIENCY AND HEDGING

Key facts

- Increase of ethanol production/consumption in the U.S. since the last decade
- Ethanol futures market opening on the CBOT in 2005
- Decrease of transaction volume since 2013, especially for commercial agents
Motivation and Objectives of the paper

• To test the Efficiency Market Hypothesis

• To describe price relationships between spot and futures markets

• To provide an efficient hedging strategy for commercial agents

• To check the efficiency of a cross-hedging strategy with gasoline futures market

• To check the ability of the Nielsen (2010)’s non parametric cointegration procedure to improve the efficiency of the hedge ratio estimation compared to Johansen (1988)’s cointegration estimation
Short Literature Review

• Kaldor (1939), Working (1948), Brennan (1958), Telser (1958): The cost-of-carry model

\[ f_t^T = s_t + (r_t - \bar{s})(T - t) \]

• Garbade and Silber (1983): Validity of the unit relationship only in the long-term
  Information flow from futures to spot market

• Figuerola-Ferretti and Gonzalo (2010): To allow for non unit relationship by adding the convenience yield \( \gamma_t \)

\[ \gamma_t = \gamma_1 s_t - \gamma_2 f_t \]

\[ f_t^T = \frac{1 - \gamma_1}{1 - \gamma_2} s_t + \frac{(r_t - \bar{s})(T - t)}{1 - \gamma_2} \]
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• Ederington (1979): Hedge ratio ($\delta$) with OLS estimation

$$\Delta S_t = c + \delta \Delta F_t + u_t$$

• Baillie and Myers (1991), Kroner and Sultan (1993): Time-varying hedge ratio

$$\delta_t | \Omega_{t-1} = \frac{\sigma_{t-1}(\Delta S_{t-1}, \Delta F_{t-1})}{\sigma^2_{t-1}(\Delta F_{t-1})}$$


• Brooks et al. (2002): Inclusion of the leverage effect (asymmetric response from past shocks)

• Lee and Yoder (2007): Inclusion of different regimes in the variance process (high/low volatility)

• Alizadeh et al. (2008): Inclusion of different regimes in the variance and mean processes
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• No studies on the Efficiency Market Hypothesis focused on the ethanol market

• Franken and Parcell (2003): Efficiency of cross-hedging with gasoline futures market

• Dahlgran (2009): Direct hedging outperforms cross-hedging with gasoline futures market
Econometric model

\[ \Delta X_t = \mu_{st} + \Gamma_{st} \Delta X_{t-1} + \Pi_{st} X_{t-1} + \varepsilon_{t, st} \]

\[ \Pi_{st} = \alpha_{st} \beta' \]

\[ \varepsilon_{t, st} \sim N(0, H_{t, st}) \]

\[ H_{t, st} = C'_{st} C_{st} + A'_{st} \varepsilon_{t-1} \varepsilon_{t-1} A_{st} + B'_{st} H_{t-1} B_{st} + D'_{st} \eta_{t-1} \eta_{t-1} D_{st} \]

\[ s, t = \{1, 2\} \]

\[ P = \begin{pmatrix} P_{11} & P_{21} \\ P_{12} & P_{22} \end{pmatrix} = \begin{pmatrix} 1 - P_{12} & P_{21} \\ P_{12} & 1 - P_{21} \end{pmatrix} \]

\[ f_{st}(X_t, \theta) = \frac{1}{2\pi} |H_{t, st}|^{-\frac{1}{2}} \exp\left(-\frac{1}{2} \varepsilon_{t, st} H_{t, st}^{-1} \varepsilon_{t, st}\right) \]

\[ f(X_t, \theta) = \sum_{st=1}^{2} \pi_{t, st} f_{st}(X_t, \theta) \]

\[ L(\theta) = \sum_{t=1}^{T} \log(f(X_t, \theta)) \]
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Results

• Existence of a long-term relationship (at 1% significance level) with a unit coefficient (at 10%)
• Information flow from futures to spot prices (at 10%)

Efficiency Market Hypothesis is valid but

• No long-term relationship during some periods (2009-2011 and 2013-2016)
• No unitary coefficient during some periods (2009-2014 and 2015-2016) that alternates between coefficient inferior and superior to one
• No adjustment of the spot price if deviation from long-term equilibrium
• Slower adjustment to the equilibrium of futures price during high volatility periods
• No short-term relationship during low volatility periods
• Impact of futures price on spot price in the short-term during high volatility periods
• High volatility in 2008-2009 (low liquidity) and in 2013-2014 (exit of commercial agents)
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- Direct hedging always more efficient than cross-hedging with gasoline futures market
- But cross-hedging strategy sometimes more efficient than situation without hedging strategy
- Model with long-term relationship, regime shifts and without leverage effect more efficient
- But not for all periods studied
- Multivariate GARCH model more efficient according to the out-of-sample simulation
- Best hedging strategies mainly with Johansen (1988)’s cointegration procedure
Conclusion

• Efficiency Market Hypothesis valid without unit coefficient

• Price discovery process from futures to spot prices in the long-term

• Ability of futures market to explain spot price dynamics during high volatility periods

• Direct hedging always more efficient than cross-hedging but with different econometric models depending on the considered period

• Good explanatory power for Nielsen (2010)’s cointegration procedure but not efficient for hedging