Testing Rockets and Feathers Pattern in the Soybean Complex: A Multivariate Quantile Approach

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Introduction

A well-known empirical finding is that output prices respond faster to input price increases than decreases, known as the "rockets and feathers" pattern.

In agricultural markets, this price asymmetry is a policy concern that consumers in downstream markets cannot benefit from decreasing farm prices.

The most cited explanation for price asymmetry is market power in food processing or retailing. Growing evidence suggests that agricultural and marketing systems in developed countries are oligopolistic rather than competitive (Sexton 2000, 2013; McCorriston 2002).

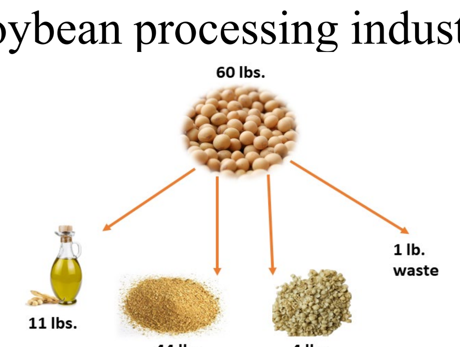
Price-setting ability is one of the key characteristics of an oligopolistic market. Therefore, our goal is to investigate asymmetric price transmission under the circumstance of market power.

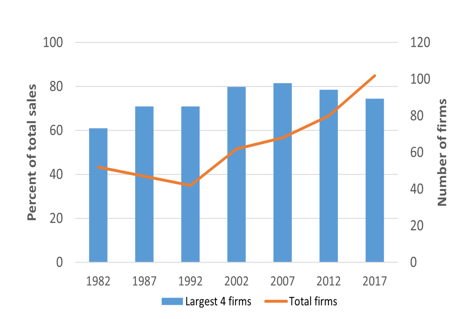
We use a vector autoregressive quantile (VARQ) model to measure and test asymmetric pricing patterns at different parts of the distributions of output prices.

Soybean Complex

We choose the soybean complex (soybeans, meal, and oil) for investigating output price responses to input price changes for three reasons:

- Soybeans are important in the U.S. agriculture.
  - Third largest source of cash receipts from the U.S.-produced farm commodities sales.
  - Most valuable agricultural export accounting for around 15.48% of the total exported value.
- Crushing soybeans into soybean meal and oil is a relatively simple case.
- The soybean processing industry is highly concentrated.





Data

We use monthly cash prices representing #1 yellow soybeans from Central Illinois, 48% protein soybean meal, and crude soybean oil from Decatur, Illinois.

The sample period is from January 1984 to January 2020. The price quotations all are converted into U.S. dollars per bushel.

The natural logarithm of commodity *i*'s cash price in month *t* is denoted as $p_{i,t}$, and the first differenced log prices (returns) is calculated as:

$$\Delta p_{i,t} = p_{i,t} - p_{i,t-1}$$

where $i = M$ (soybean meal), O (soybean oil), and S (soybean).

Methodology

After examining the cointegration among three commodities and weak exogeneity of soybean prices, we build a bivariate model for oil and meal and treat soybean prices as exogenous.

We follow Houck (1977) approach to split soybean price changes to increasing and decreasing parts, $\Delta p^+_{S,t-j} = max(\Delta p_{S,t-j}, 0)$ and $\Delta p^-_{S,t-j} = min(\Delta p_{S,t-j}, 0)$ for $j = 0, 1$.

The multivariate quantiles are defined as directional multi-dimensional hyperplanes indexed by quantile vectors $\boldsymbol{\tau}$ ranging over the open unit ball (Hallin, Paindaveine, and Šiman 2010). The VARQ model is a system of univariate quantile autoregressive models since the directional quantiles are univariate regression quantiles for a fixed orthonormal basis (Montes-Rojas 2017, 2019).

The bivariate VARQ model for soybean end products with multivariate quantile index, $\boldsymbol{\nu} = (\tau_M \in (0,1), \tau_O \in (0,1))'$, is presented as:

$$\mathbf{q}_{\Delta \mathbf{w}_t}(\mathbf{v}|\mathcal{F}_{t-1}) = \{\mathbf{I}_2 - \boldsymbol{\kappa}(\mathbf{v})\}^{-1}\{\mathbf{a}(\mathbf{v})\Delta\mathbf{w}'_{\mathbf{t-1}} + \mathbf{b}^+(\mathbf{v})\Delta\mathbf{p}^+_S + \mathbf{b}^-(\mathbf{v})\Delta\mathbf{p}^-_S + \mathbf{c}(\mathbf{v})\widehat{EC}_{t-1} + \boldsymbol{\mu}(\mathbf{v}) + \boldsymbol{\varepsilon}_\mathbf{t}(\mathbf{v})\}$$

- $\mathbf{q}_{\Delta \mathbf{w}_t}(\mathbf{v})$ = conditional quantile of $\Delta \mathbf{w_t}$
- $\Delta \mathbf{w}_{t-1}$ = a 2×1 vector of lagged meal and oil returns, $\Delta \mathbf{w}_{t-1} = (\Delta p_{M,t-1}, \Delta p_{O,t-1})'$
- $\Delta \mathbf{p}^+_S$ = a 2×1 vector of an increase in soybean prices at *t* and *t-1*, $\Delta \mathbf{p}^+_S = (\Delta p^+_{S,t}, \Delta p^+_{S,t-1})'$
- $\Delta \mathbf{p}^-_S$ = a 2×1 vector of a decrease in soybean prices at *t* and *t-1*, $\Delta \mathbf{p}^-_S = (\Delta p^-_{S,t}, \Delta p^-_{S,t-1})'$
- $\widehat{EC}_{t-1}$ = the error correction term indicating the cointegrating relationship at *t-1*

Output price responses to changes in soybean prices:

- Price increases: $\mathbf{B}^+(\mathbf{v}) = \{\mathbf{I}_2 - \boldsymbol{\kappa}(\mathbf{v})\}^{-1}\, \mathbf{b}^+(\mathbf{v}) = \begin{bmatrix} B^+_{M0}(\mathbf{v}) & B^+_{M1}(\mathbf{v}) \\ B^+_{O0}(\mathbf{v}) & B^+_{O1}(\mathbf{v}) \end{bmatrix}$
- Price decreases: $\mathbf{B}^-(\mathbf{v}) = \{\mathbf{I}_2 - \boldsymbol{\kappa}(\mathbf{v})\}^{-1}\, \mathbf{b}^-(\mathbf{v}) = \begin{bmatrix} B^-_{M0}(\mathbf{v}) & B^-_{M1}(\mathbf{v}) \\ B^-_{O0}(\mathbf{v}) & B^-_{O1}(\mathbf{v}) \end{bmatrix}$

Results

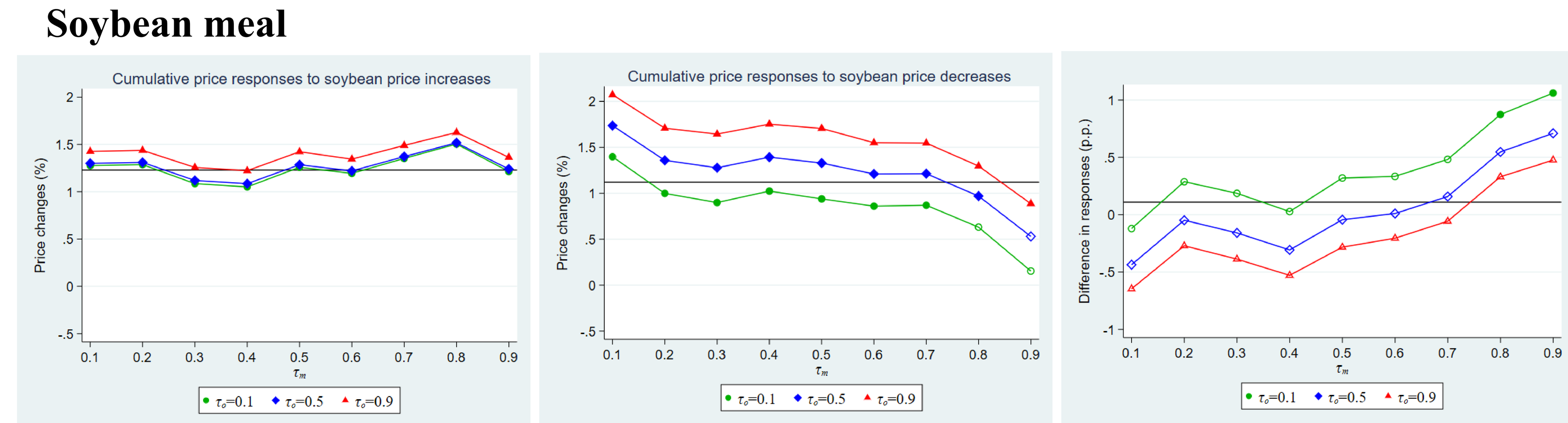
We report the cumulative responses of each product *i* to the positive ($\lambda^+_i(\mathbf{v}) = \sum_{j=0}^{1} B^+_{ij}(\mathbf{v})$) and negative ($\lambda^-_i(\mathbf{v}) = \sum_{j=0}^{1} B^-_{ij}(\mathbf{v})$) change in soybean prices, respectively.

We compare the difference in these two responses, $\lambda_i(\mathbf{v}) = \lambda^+_i(\mathbf{v}) - \lambda^-_i(\mathbf{v})$.

- $\lambda_i(\mathbf{v}) = 0 \rightarrow$ price symmetry
- $\lambda_i(\mathbf{v}) > 0 \rightarrow$ larger responses to soybean price **increases**
- $\lambda_i(\mathbf{v}) < 0 \rightarrow$ larger responses to soybean price **decreases**

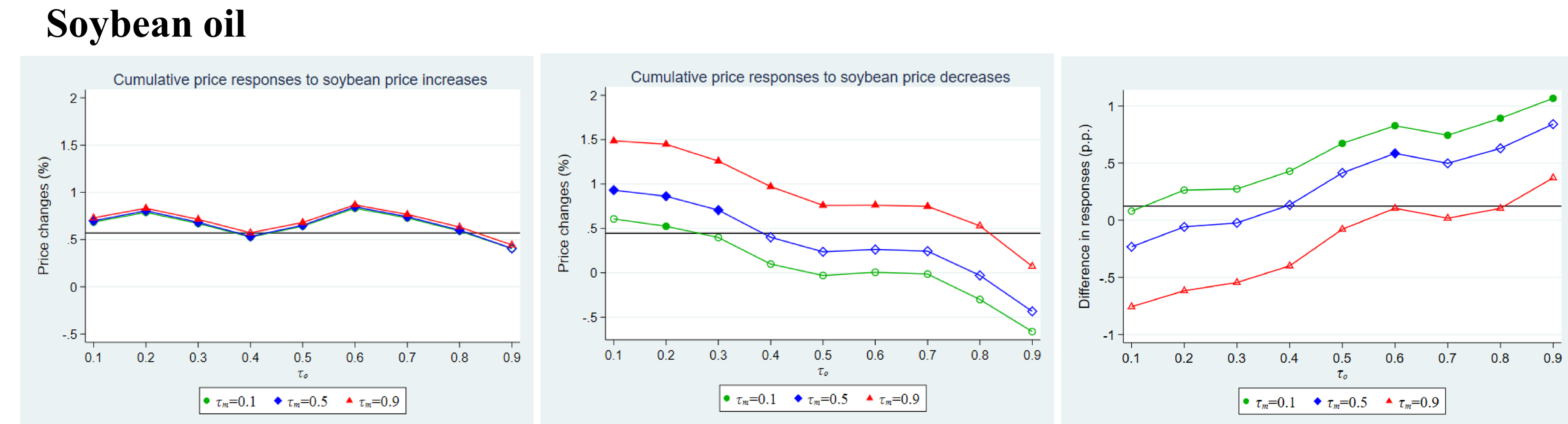
We first fix one of the end product's quantiles (at 0.1, 0.5, and 0.9) and then investigate the other end product's price responses varying its own quantile.

Soybean meal



Notes: 1) A filled marker symbol is for the significant estimates that are at the 5% level or lower, while the open symbol is for the insignificant estimates.
2) The vertical line is the estimates from the traditional model, vector error correction model.

Soybean oil



Notes: 1) A filled marker symbol is for the significant estimates that are at the 5% level or lower, while the open symbol is for the insignificant estimates.
2) The vertical line is the estimates from the traditional model, vector error correction model.

- For both soybean products, price responses to soybean price increases are more likely to be statistically significant than the responses to soybean price decreases.
- Although price responses of soybean meal are often larger than soybean oil, the magnitude of price asymmetries are not much different in these two products.
- For a given quantile of another product, there is a decreasing trend in price responses to soybean price decreases, but no clear trend in price responses to soybean increases as its quantile increases.
- The quantiles of a product only affect the price responses of another product to soybean price decreases.

Conclusions

We show that the rockets and feathers pattern (positive price asymmetries) occurs when the prices of soybean end products are in the opposite extreme deciles of their distributions.

As price levels are a signal of market conditions, our findings indicate that the rockets and feathers pattern in any of the end products occurs when its own market is bullish but the other product's market is bearish.

Overall, our multivariate quantile approach unveils the complexity of asymmetric price transmission and sheds light on the condition for the occurrence of the rockets and feathers pattern.

References

[1] Hallin, M., D. Paindaveine, and M. Šiman. 2010. "Multivariate Quantiles and Multiple-output Regression Quantiles: from L1 Optimization to Halfspace Depth" The Annals of Statistics 38(2):635-675.

[2] Houck, J.P. 1977. "An Approach to Specifying and Estimating Nonreversible Functions." American Journal of Agricultural Economics 59(3):570-572.

[3] McCorriston, S. 2002. "Why should Imperfect Competition Matter to Agricultural Economists?" European Review of Agricultural Economics 29(3):349-371.

[4] Montes-Rojas, G. 2017. "Reduced Form Vector Directional Quantiles." Journal of Multivariate Analysis 158:20-30.

[5] Montes-Rojas, G. 2019. "Multivariate Quantile Impulse Response Functions." Journal of Time Series Analysis 40(5):739-752.

[6] Sexton, R. J. 2000. "Industrialization and Consolidation in the US Food Sector: Implications for Competition and Welfare." American Journal of Agricultural Economics 82(5):1087-1104.

[7] Sexton, R. J. 2013. "Market Power, Misconceptions, and Modern Agricultural Markets." American Journal of Agricultural Economics 95(2):209-219.