Causal Relationships among World Fertilizer Markets

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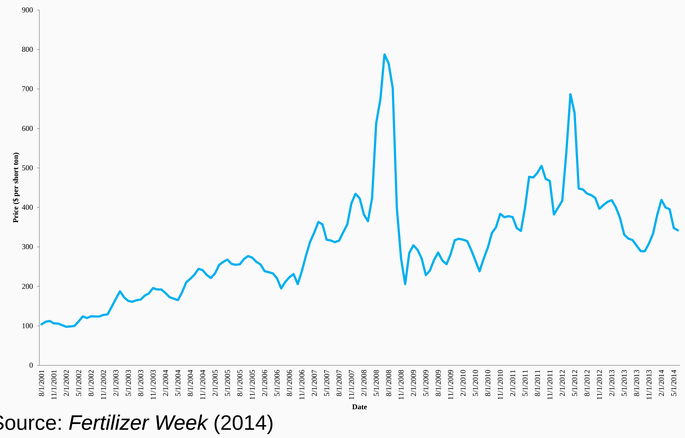
Introduction

Urea prices have fluctuated since 2002, especially after 2008 (Figure 1). This high price volatility and the relatively slow transportation in the urea fertilizer industry make production planning and inventory management difficult.

Figure 1. Granular Urea Prices in New Orleans Spot Markets



Source: *Fertilizer Week* (2014)

Constructing an accurate urea price forecast is needed to manage the price volatility and it is useful for the efficient allocation of resources.

Objectives

To suggest an appropriate forecasting model for weekly granular urea price in the U.S. New Orleans market based on the causality of supply, demand, transportation factors, and leading market price such as Middle East urea price.

Exogenous Variables

Two groups of exogenous variables are:

Group1: Supply, demand, and transportation factors are the price of Henry Hub natural gas, Iowa corn, and Brent oil.

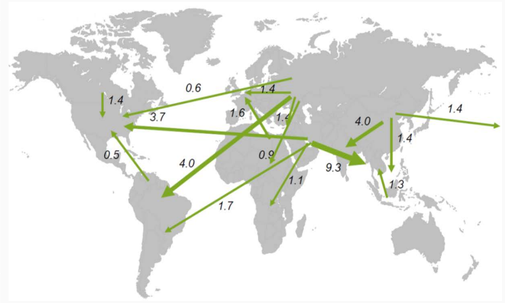
Group2: Group1 and Middle East urea price as a leading urea market price. Middle East countries provide more than 50% of U.S. urea import volume (see table 1 and Figure2).

Table 1. 2012 Big7 Export Urea Countries to the U.S.

Country	Million ton	Million dollars
Canada	1.57	767
Oman	1.16	484
Kuwait	0.55	209
Egypt	0.54	230
Russian Federation	0.54	222
Saudi Arabia	0.50	193
Qatar	0.50	205
World total	7.65	3,210

Source: Fertilizer Imports/Exports (USDA ERS 2014)

Figure 2. Main Urea Trade Flows



Unit: million ton
Source: International Fertilizer Industry Associations 2012

Methods

1) Model Identification: Construct forecast models to check causality of exogenous variables on New Orleans urea price, autoregressive(AR), and autoregressive-generalized autoregressive conditional heteroskedasticity(ARG) models with/without exogenous variables(X). No seasonality was found.

2) Forecasting: To account for possible structural change, rolling window regression is used with window sizes of 156, 208, 260, 312, and 349 weeks.

3) Evaluation: Mean absolute error(MAE) and root mean squared error(RMSE).

4) Forecast Encompassing Test: To test whether competing forecasts may be combined to construct a composite forecast superior to all the original forecasts (Diebold 2007), forecasting encompassing test is conducted.

Results

Weekly log differences of all data are from September 20, 2001 to June 14, 2014. In-sample and out of sample are decided based on May 1, 2008.

Table 2. Optimal Lags for AR Terms, Explanatory Variables, ARCH, and GARCH Terms

Model	Autoregressive	Explanatory Variable				ARCH	GARCH
		Corn	Brent Oil	Natural Gas	Middle East Urea		
AR	1, 11	.	.	.	.	.	.
ARX1*	1, 11	1	3	1	.	.	.
ARX2**	1, 11	1	.	.	1	.	.
ARG	1	.	.	.	.	1	1
ARXG1*	1	1	3	1		1	1
ARXG2**	1	1	.	.	1	1	1

Note: * and ** indicate the model using exogenous variables in group1 and group2, respectively.

Table 3. Mean Absolute Error

w	naïve	AR	ARX1	ARX2	ARG	ARXG1	ARXG2
349	0.857	0.748	0.732	0.733	0.767	0.754	0.736
313	0.857	0.749	0.732	0.735	0.765	0.751	0.735
261	0.857	0.749	0.738	0.742	0.761	0.747	0.732
209	0.857	0.748	0.738	0.732	0.758	0.745	0.727
157	0.857	0.752	0.739	0.730	0.757	0.734	0.728

Table 4. Root Mean Squared Error

w	naïve	AR	ARX1	ARX2	ARG	ARXG1	ARXG2
349	1.099	1.002	0.991	0.993	1.020	1.012	1.002
313	1.099	1.001	0.989	0.992	1.018	1.009	1.000
261	1.099	0.999	0.994	0.995	1.015	1.007	0.997
209	1.099	0.999	0.988	0.988	1.012	1.006	0.995
157	1.099	1.000	0.979	0.983	1.012	0.995	0.991

Table 5. Encompassing Regression (Preferred Model is ARX1 to ARGX2) and MAE and RMSE of Combination Model

MODEL	W	Estimated weight	MAE	RMSE
ARX1	157	0.604**(3.40)	0.725	0.977
ARXG2	209	0.396**(2.23)		

Note: The t-values for the test statistics are presented in parentheses.
** indicates statistical significance at the 1% level.

Conclusions

- All four exogenous variables cause urea prices based on both in-sample and out-of-sample tests.
- ARXG2 with 209 week window has lowest MAE and ARX1 with 157 week window has lowest RMSE. The composite model does not outperform them.
- This research indicates a causal relationship between supply, demand, transportation factors, and leading market price and New Orleans urea price. It also suggest urea price forecasting models to reduce price risk in urea market .

References

Diebold, F.X. Elements of Forecasting. Fourth edition. Mason, OH: Thomson South-Western, 2007.
Fertilizer Week is a kind of commercial publications by CRU group
USDA.2013. Fertilizer Use and Price. Economic Research Service (ERS).
USDA.2013. Fertilizer Imports/Exports. Economic Research Service (ERS).

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