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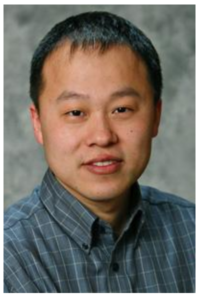

Causality and Granger Causality

by

Jing Li
Assistant Professor

Causality is an important topic for empirical researchers. For instance, a researcher notices the quality of beef improves after beef price rises. He wonders if the price change causes the quality change. If that is the case, then the government can use price as a tool to encourage improvement of beef quality. Otherwise the price tool would be useless. The researcher hopes certain statistical analysis is informative to address this issue. Unfortunately, the statistical and econometric methods commonly used can only provide an *incomplete* answer to his problem. This short note is intended to show the degree to which causality can be established by statistics and econometrics.

Strictly speaking, X causes Y if the next two conditions are *both* satisfied: (1) a change in X is followed by a change in Y, and (2) all other factors are held constant. It is relatively easy to show condition (1) is true. The Granger causality test, for instance, can be used to prove (1). On the other hand, condition (2) is nearly impossible to prove. The difficulty is controlling all relevant factors. Ideally, condition (2) could be confirmed or refuted by an experiment in which all relevant factors are under control. In economics, however, we are most often working with non-experimental data. To make matters worse, a typical economic phenomenon is so complicated that it involves some factors for which data are not even available. As a well-known example, it is very difficult to obtain reliable data about people's ability. (Continued on page 2)

Dependency on the Ethanol Industry

by

Yonas G. Hamda
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The year 2008 will long be remembered as a year when corn based ethanol has seen tremendous change. The Energy Independence and Security Act, which passed in late 2007, gave a huge boost to the industry as it mandated an increase in biofuel production and use. In 2008, the industry witnessed record high prices on corn and crude oil. Ultimately, a big ethanol and distiller's grain company--Vera Sun Energy-- filed for Chapter 11 bankruptcy leaving farmers with contracts wondering what will happen next. South Dakota is a major corn growing and ethanol producing state and this article assesses the relative magnitude of corn based ethanol on the local economy in terms of distribution of ethanol plants and corn disappearance ratios.

U.S. corn based ethanol has increased considerably in recent years. In 1990, ethanol production was barely a billion gallons a year. It took more than ten years before the industry doubled its production. The industry has recorded more growth in the last five years since it started. By 2002, production was just over 2 billion gallons a year and in 2007, close to 6.5 billion gallons of ethanol was produced or 3 fold growth in 5 years (see figure 1).

Distribution of Ethanol Plants

As of September 2008, there were 165 ethanol plants in the U.S. with total capacity of 9.9 billion gallons a year. With the expansion of five plants and the construction of 34 new plants, national ethanol

(Continued on page 2)

(Causality … continued from page 1)
One may argue that we may ignore condition (2) due to its complexity. But we cannot, if we want to demonstrate the real causality. Go back to the beef example. Just because a quality change follows a price change, that does not mean the latter causes the former. Let us imagine that the true cause for the improved quality is a new technology for raising cattle. This new technology is introduced by the government for free. Therefore, farmers' adopting the new technology has nothing to do with the market price of beef. It just happens at the same time we see an increasing beef price, but clearly this price change is not the cause for improved quality. Here, the new technology is a relevant factor that we must account for.

Conceptually it is hard to show X causes Y because of uncontrolled factors. Nevertheless, it is much easier to show X does not cause Y. Condition (1) is a necessary condition for causality. Hence if we can show condition (1) is false, then it must imply that X does not cause Y. The Granger causality test uses this idea, and the null hypothesis of the Granger test is that X does not help when forecasting Y (so that a change in X leads to no change in Y).

The Granger causality test is easy to use. To show X does not Granger cause Y, the first step is to consider an autoregression for Y. Next, we add lagged values of X as extra independent variables. Finally we test if the coefficients of the lagged X are equal to zero. We reject the null hypothesis if those coefficients are significantly different from zero.

Suppose the coefficients of lagged X are close to zero, so that the null cannot be rejected. In this case, the lagged X is not informative about future values of Y. Put differently, the time path of Y only depends on its own history, not on X. In the time series sense, we can say that Y is *exogenous* because of its independence from other variables. Some researchers then want to treat Y as the regressor to study the relationship between Y and X. Typically a researcher has no prior knowledge about the direction of Granger causality. Therefore he may treat all variables equally, and use vector autoregression (VAR) to check whether X Granger causes Y, or vice versa.

There are potential pitfalls for the Granger causality test. First, some researchers have shown that the Granger test result sometimes is very sensitive to the number of lagged terms in the regression. In practice, we may show the test result is robust to the lag number by conducting the Granger test repeatedly for different lag numbers.

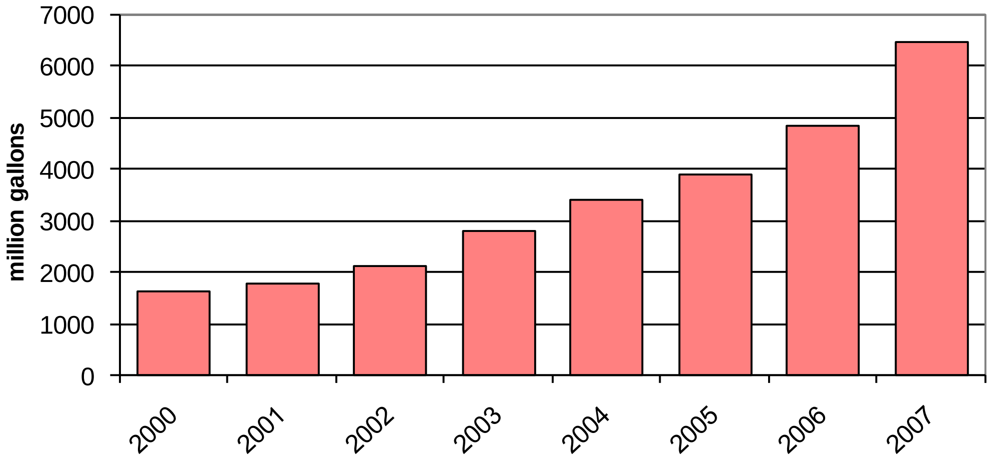
The second issue is the stationarity of data. In general, the Granger test follows nonstandard distributions when data are not stationary. However, when data are nonstationary but *cointegrated*, the distributions become standard again. This is a technical but important issue. The lesson is that we need to check stationarity and cointegration when we apply the Granger test to seemingly nonstationary data (such as Gross Domestic Product).

Finally, it should be emphasized again that Granger causality is not the usual causality we have in mind. To be precise, we should label the Granger test as testing for predictive power. If X Granger causes Y, the only implication is that X is useful for predicting Y, or X occurs prior to Y. It remains unclear whether X really causes Y, since we do not know whether there is another factor. On the other hand, if we can show X does not Granger cause Y, then it is safe to say that X must not be the cause for Y.

(Dependency On … continued from page 1)

production capacity will increase to 13.8 billion gallons per year (table 1). The top five states (Iowa, Nebraska, Illinois, South Dakota and Minnesota) account for two-thirds of the current ethanol production capacity. In South Dakota 15 ethanol plants have the capacity to produce 874 million gallons a year or 9 percent of the nation's ethanol producing capacity. Three companies, Vera Sun, Poet, and Archer Daniel Midland, own 43 plants with total capacity of 3.6 billion gallons/per year, thus accounting for 36% of the nation's ethanol production capacity (Qasmi, Hamda and Fausti, 2008).

Figure 1. U.S. Ethanol production, 2000-2007



Source: Renewable Fuel Association.

Table 1. Ethanol Production Capacity, as of September 4, 2008.

Location/ Ownership	Number of Plants	Current Capacity (mil gal/yr)	Number of Plants Expanding	Number of New Plants Planned	Under Construction/ Expansions Capacity (mil gal/yr)	Total Capacity with New Construction/ Expansion (mil gal/yr)
State:						
Iowa	31	2,269 (19%)	2	9	1,265	3,534 (26%)
Nebraska	19	1,347 (14%)	1	1	319	1,666 (12%)
Illinois	9	1,035 (10%)	0	1	188	1,223 (9%)
South Dakota	15	874 (9%)	1	0	18	892 (6%)
Minnesota	19	827 (8%)	1	2	275	1102 (8%)
Others	72	3,609 (36%)	0	21	1,725	5,334 (39%)
USA	165	9,961 (100%)	5	34	3,790	13,751 (100%)
Ownership:						
Vera Sun	13	1,290 (13%)	0	3	360	1,650 (12%)
Poet	23	1,225 (12%)	0	3	195	1,420 (10%)
ADM	7	1,103 (11%)	2	0	550	1,653 (12%)
Others	122	6,343 (64%)	3	28	1,725	9,028 (66%)
USA	165	9,961 (100%)	5	34	3,790	13,751 (100%)

Source: Renewable Fuel Association

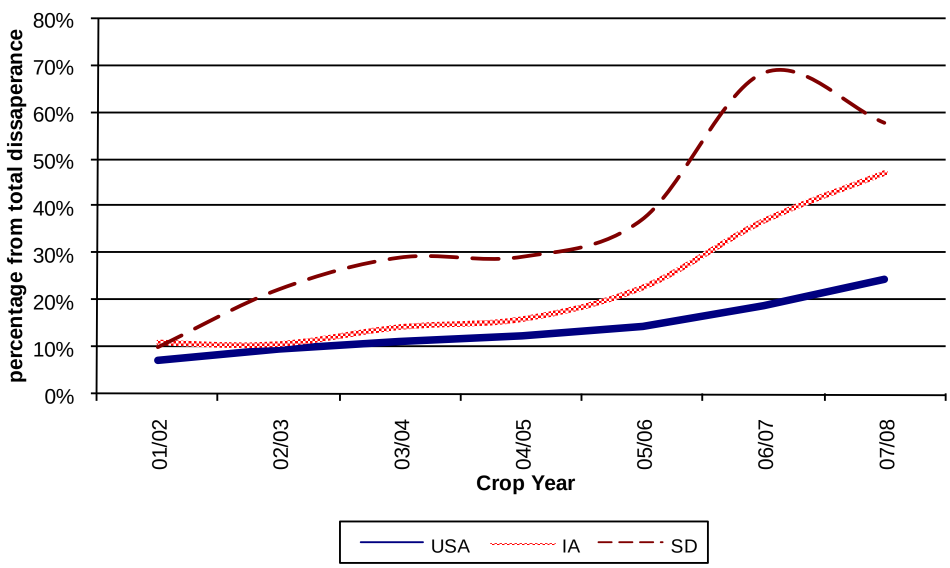
Corn Disappearance Rates

Large increases in ethanol production have in turn led to large increases in corn use by ethanol plants. One method of examining the amount of ethanol corn intake is to look at the change in the share of corn used in ethanol production in terms of domestic corn disappearance. In 1990/91, less than 5% or 333 million bushels of corn disappearance in the U.S. was accounted for by ethanol production. By the 2007/08 crop year, as much as 24%, or 3.1 billion bushels, of corn was accounted for by ethanol production (figure 2). During the same crop year period, the proportion of corn going into ethanol production was about 30% in Minnesota and Illinois, 40% in Nebraska, 50% in Iowa and 60% in South Dakota. The increasing rate of corn use for ethanol has affected availability of the commodity for feed and exports. Moreover, it implies a heighted level of dependency and vulnerability of South Dakota's agriculture economy to the industry (Qasmi, Hamda and Fausti, 2008).

Reference

Qasmi, A. B., Yonas G. Hamda and Scott Fausti (2008) Ethanol Co-products: Trends in Production, Domestic Use, and Potentials for International Market Development. Paper prepared for presentation at South Dakota International Business Conference and Missouri Valley Economic Association annual meetings in 2008.

Figure 2- Percentage of Corn used by Ethanol, 01/02-07/08



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