Estimating the Linkages Between Fuel Prices and Nitrogen Prices, Nitrogen Demand, and Cotton Production in Texas

Blake K. Bennett and Jeanne M. Reeves

Introduction

Previous research has established that natural gas prices have a direct effect on the price of nitrogen fertilizer. Other research suggests that fuel prices along with the value of the U.S. Dollar and the quantity of domestic fertilizer production are also correlated with fertilizer prices. Recent volatile fuel prices would suggest that any correlation between fuel prices and fertilizer prices can result in volatile fertilizer prices which could impact the demand for fertilizer by the cotton production sector. Further, resulting demand for fertilizer changes could result in a significant change in the production of cotton.

Objective

- Estimate the relationship between fuel prices and fertilizer prices for the Texas cotton production sector.
- Explain the responsiveness of changes in fertilizer price on fertilizer demand by Texas cotton producers.
- Explain the responsiveness of Texas cotton production due to changes in fuel prices.

Methods

This study analyzed data pertinent to the estimation of the price and demand of nitrogen fertilizer used in Texas cotton production between 1980 and 2009. Three equations represented below were then estimated to determine these relationships.

Price of Nitrogen Fertilizer

$$\ln NP_t = f(\ln USDP_t, \ln PNG_t, \ln NP_{t-1}, \ln USPROD_t) \quad \textit{(Equation 1)}$$

Where:

$\ln NP_t$ = natural log of the price of nitrogen fertilizer,

$\ln USDP_t$ = natural log of the price of diesel in the U.S. in 2010 Dollars,

$\ln PNG_t$ = natural log of the price of natural gas in the U.S. in 2010 Dollars,

$\ln USPROD_t$ = natural log of the production of nitrogen fertilizer in the U.S.

Quantity Demanded of Nitrogen Fertilizer

$$\ln TN_t = f(\ln ER_t, \ln NP_t, \ln PI_t, \ln RN_t) \quad \textit{(Equation 2)}$$

Where:

$\ln TN_t$ = natural log of the total pounds of nitrogen fertilizer used in Texas cotton production in time t,

$\ln ER_t$ = natural log of the expected total revenue for Texas cotton producers in time t,

$\ln NP_t$ = natural log of the price of nitrogen fertilizer in time t in 2010 Dollars,

$\ln PI_t$ = natural log of the percent of planted irrigated cotton acres in Texas in time t,

$\ln RN_t$ = the natural log of the annual rainfall in Texas in time t.

Methods

Expected Total Revenue

$$ER_t = EHA_t * YLD_t * MFP_t \quad \textit{(Equation 3)}$$

Where:

EHA_t = expected harvested acres in time t (planted acres less the five year average percentage difference between planted and harvested acres),

YLD_t = expected yield in time t (the last five year average yield per harvested acre),

MFP_t = expected price in time t (the December futures contract price of cotton in March).

Total Production of Cotton In Texas

$$\ln CTP_t = f(\ln TN_t, \ln HA_t, DR_t, \ln MC_t, NT_t \quad \textit{(Equation 4)}$$

Where:

$\ln CTP_t$ = natural log of the quantity of cotton produced in Texas in time t in bales,

$\ln HA_t$ = natural log of the total harvested acres of cotton in Texas in time t,

DR = dummy variable representing the existence of drought in Texas in time t and is derived from the Palmer Z-index,

$\ln MC_t$ = natural log of the cost of machinery for producing cotton in time t in 2010 Dollars,

NT_t = dummy variable used to denote the years that no-till production was used in cotton production in Texas.

Effects of Fuel Price Changes on Fertilizer Demand and Cotton Production

The coefficient associated with an independent variable in a double-log specification is the elasticity associated with that variable. Thus, the elasticity associated of nitrogen fertilizer demand as the price of fuel changes was determined by substituting Equation 1 into Equation 2 for the price of nitrogen ($\ln NP_t$). The resulting coefficient associated with the price of fuel yielded the percentage change in nitrogen fertilizer demand associated with a one percent change in the price of fuel. Similarly, substituting Equation 1 into Equation 2 and then the expanded version of Equation 2 into Equation 4 would provide the elasticity associated with changes in the price of fuel on the production of cotton in Texas.

Results

Nitrogen Fertilizer Price Estimation

$$\ln NP_t = -2.1060 + 0.3639*(\ln USDP_t*\ln PNG_t) + 0.3412*\ln NP_{t-1} + 0.5101*\ln USPROD_t \quad \textit{(Equation 5)}$$

(5.57) (2.89) (2.87)

R^2 = 76.63, F-Statistic = 28.42, VIF = 4.57, Durbin-Watson = 1.68

Nitrogen Fertilizer Demand Estimation

$$\ln TN_t = 1.1235 + 0.8793*\ln ER_t - 0.8273*\ln NP_t + 0.5945*(\ln PI_t*\ln RN_t) \quad \textit{(Equation 6)}$$

(7.47) (-5.21) (2.86)

R^2 = 76.54, F-Statistic = 28.28, VIF = 3.17, Durbin Watson = 1.55

Results

Total Texas Cotton Production Estimation

$$\ln CTP_t = -2.3149 + 0.4248*\ln TN_t + 0.5503*\ln HA_t - 0.1090*DR_t + 0.2041*\ln MC_t + 0.3199*NT_t \quad \textit{(Equation 7)}$$

(4.84) (3.45) (-1.62) (1.53) (4.32)

R^2 = 80.99, F-Statistic = 20.45, VIF = 6.44, Durbin-Watson = 2.22

Effects of Fuel Price Changes on Nitrogen Fertilizer Demand

$$\ln TN_t = 2.8658 + 0.8793*\ln ER_t - 0.3011*\ln(USDP_t*PNG_t) - 0.2823*\ln NP_{t-1} - 0.4220*\ln USPROD_t + 0.5945*\ln(PI_t * RN_t) \quad \textit{(Equation 8)}$$

Given that the coefficients associated with each independent variable in Equation 8 represent the elasticities, it can be concluded that a one percent change in the price of the multiplicative of the U.S. diesel price and the price of natural gas ($\ln(USDP_t*PNG_t)$) results in a 0.3011 percent change in the opposite direction of the quantity demanded of nitrogen fertilizer used in cotton production in Texas.

Effects of Fuel Price Changes on Texas Cotton Production

$$\ln CTP_t = -1.0883 + 0.3763*\ln ER_t - 0.1289*\ln(USDP_t*PNG_t) - 0.1208*\ln NP_{t-1} - 0.1806*\ln USPROD_t + 0.2544*\ln(PI_t*RN_t)] + 0.5503*\ln HA_t - 0.1090*DR_t + 0.2041*\ln MC_t + 0.3199*NT_t \quad \textit{(Equation 9)}$$

Equation 9 would suggest that a one percent change in the price of the multiplicative of the U.S. diesel price and the price of natural gas ($\ln(USDP_t*PNG_t)$) results in a 0.1289 percent change in the opposite direction of the production of cotton in Texas.

Conclusions

The results of this study establishes that the price of fuel not only impacts the price of nitrogen fertilizer used by cotton producers, but also the quantity demanded of nitrogen fertilizer and production of cotton in Texas. These linkages made it possible to determine the elasticity of a change in fuel prices as it relates to the price of nitrogen fertilizer, the quantity demanded of nitrogen fertilizer in Texas, and production of cotton in Texas. Specifically, this study found that a one percent change in the price of the multiplicative of the diesel price and price of natural gas increases by one percent, the price of nitrogen fertilizer increases by 0.3639 percent, the quantity demanded of nitrogen fertilizer decreases by 0.3011 percent, and the total production of cotton lint decreases by 0.1289 percent. The magnitude of the elasticities estimated in this study being less than one suggests that the price of nitrogen fertilizer, quantity demanded of nitrogen fertilizer in Texas, and production of cotton in Texas are relatively inelastic in regards to changes in the price of fuel. However, results also indicate that changes in fuel prices are significant in affecting all of these variables. This would suggest that the increasingly volatile fuel prices can result in significant changes to the production of cotton in Texas.