Elasticities of demand for energy inputs in crop production: impact of rotation

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Abstract

This study estimates the elasticities of derived demand for energy inputs for the state of Iowa using a bottom-up simulation model of farmers' choices of crop rotation, tillage, and nitrogen fertilizer application rate. We find that as diesel prices increase, the changes towards fewer years of corn in rotations and less intensive tillage progress gradually from the lower- to the higher-quality land, and the majority of the decrease in diesel use is attributable to the crop rotation changes rather than to the reduced tillage. The results of analysis suggest that the own-price elasticity of diesel is – 0.135, and the own-price elasticity of the demand for Nitrogen fertilizer is – 0.783. The estimated marginal effects of the changes in energy prices could be used to improve the accuracy of existing, large-scale models of the U.S. energy and agricultural sectors.

I. Introduction

Crop production is profoundly affected by the changes in energy prices as it requires a number of energy inputs: diesel fuel to power planting and harvesting machinery, LP gas to dry harvested crops, and nitrogen fertilizer (which is derived from natural gas) to supply crop nutrients. The changes in energy prices change the costs of operation and alter the net returns to farming for energy and/or fertilizer intensive crops. Most of previous assessments of the derived demand for energy inputs in crop production have been conducted before the significant structural changes in energy consumption in the U.S. agriculture such as the shift from gasoline to diesel use from the 1970s to the early 1990s (Miranowski, 2005).While recent discussions suggest that the increase in fuel prices is likely to widen the use of conservation tillage and lower fertilizer application rates, little is known about the magnitude of these responses. Complicating the assessment is the multitude of the potential farmers' choices - notably, the possibilities for not only changing the levels of energy inputs, but also for substituting between various inputs and/or between various outputs (which crops to grow and in what rotation). In addition to the need to capture both input and output substitution effects, the evaluation of the aggregate, region-total response to the changes in energy prices is further complicated by the inherent within-region heterogeneity of production conditions. Because of the heterogeneity of land, the changes in energy prices may cause a significant compositional change in the use of land in a given region.

This study estimates the elasticities of derived demand for energy inputs for the state of Iowa. In modelling the impact of energy prices, we focus on three components of energy use in crop production: diesel fuel, nitrogen fertilizer, and LP gas. Diesel and fertilizer are the two largest components of the total energy consumption on US farms with fertilizer accounting for 498 Trillion Btu and diesel – for 469 Trillion Btu in the total of 1718 Trillion Btu consumed on

US farms in 2002 (Miranowski, 2005). Corn Belt, of which Iowa is a significant part, used the most fuel among U.S. farm production regions in 2003 (Miranowski, 2005).

The rest of the paper proceeds as follows. We begin by explaining the deficiencies of previous research that we address, continue by presenting our data, model, and results, and conclude with comments and policy implications.

II. Previous research

Our paper builds on and bridges the gap between two threads of literature: landscape-specific, agronomic studies on crop yield determinants, and micro-modeling that accounts for the crop growing conditions that vary across landscape. Notwithstanding the theoretical recognition of the importance of accounting for the compositional and/or spatial heterogeneity of agricultural land for predicting aggregate responses to changes in economic incentives (see, e.g., Lichtenberg et al., 2010), the *recent empirical evidence* on the magnitudes of the compositional responses to changes in energy prices is lacking. Most known, detailed studies of the energy price impact on crop production date back to the years subsequent of the oil crisis of the early 1970s and the downturn in the farm economy of the 1980s (Kliebenstein and Chavas, 1977; Kliebenstein and McCamley, 1983; Uri and Herbert, 1992). While methodologically insightful, the studies report the empirical estimates that are not immediately useful for predicting the changes in contemporary cropping and farming systems because the crop production processes have changed significantly since the 1970s. The US farms shifted from petrol to more efficient diesel fuel, began using larger, multi-function machinery, increased the use of conservation tillage systems, and the energy content of fertilizer has declined notably in the decades after the 1970 energy crisis (Uri and Day, 1992; Collins and Duffield, 2005; Miranowski, 2005).

Since 1978, Iowa soybean producers have been facing a highly destructive pathogen soybean cyst nematode, the population densities of which has been shown to reduce significantly when soybeans are grown in rotations with corn (Chen et al., 2001), and/or when the pathogen-resistant cultivars are used (De Bruin and Pedersen, 2009). In addition to the improved pest and decease resistance, agronomic and seed genetics innovation has resulted in significant increases in overall crop yields since the 1970s. Notably, the rates of growth of yields differed by crop and location. The non-neutral (different rate for different crops) growth in productivity of crops means that the estimates of the changes in relative profitability of alternative crops corresponding to the changes in energy prices obtained in previous studies might no longer be valid.

Our study utilizes the latest advances in agronomic sciences that have been accumulated over the last three decades of agronomic research that embody the yield response to fertilizer and rotation such as the one year memory for corn and two-year memory for soybeans (Sawyer et al, 2006; Hennessy, 2006). These methodological improvements let us explicitly model and estimate the rotation/output substitution and fuel/fertilizer substitution effects of the changes in energy prices.

In addition to limited accounting for input and output possibilities, most previous work has failed to take into account the natural resources based heterogeneity of growing conditions. The studies have been done either for a region-representative farm in the Midwest (Kliebenstein and Chavas, 1977), in Missouri (Kliebenstein and McCampley, 1983) or for a small number of homogenous regions (units of analysis) based on sols characteristics and land slope in a portion of Iowa (Zinser et al., 1985). Large region studies are commonly done with the use of the representative farm concept in political (state, county) rather than natural resources based (soils) units (e.g., Uri and Herbert, 1992 for the whole U.S.; Raulston et al., 2005 for the Western U.S.).

Recent assessments document the high and rising share of operating costs attributable to direct and indirect energy inputs in crop production corresponding to the growth in energy prices (Daberkow et al., 2007). However, econometric detangling the cause (energy price changes) and effect (changes in rotations, tillage systems, use of fertilizer) remains a hard task due to the lack of detailed data needed for such estimation. Specifically, farmer survey cross-sectional data do not exhibit the (energy) price variability that is needed to statistically identify the impact of energy prices on land-use choices. The time series data with varying fuel prices have not been yet collected as the energy prices either stayed constant or changed little until recently. The studies that use regionally aggregated data have to deal with the measurement error problems that originate from the commonly used aggregation of prices and quantities across crops and production inputs (Uri and Herbert, 1992). In the absence of the data suitable for econometric estimation, our study relies on a deterministic model simulated under varying assumptions about the exogenous energy prices.

III. Methods

The analysis uses an extension of a simulation model of Iowa crop production that has been developed in Secchi et al. (2009; 2011) and Kurkalova et al. (2009). The model operates on a 56 square meter grid coming from the USDA National Agricultural Statistical Service (NASS) GIS-based remote-sensing crop-cover maps for the year 2009 (USDA/NASS, 2009). For each grid unit, we use the measures of soil productivity and environmental vulnerability that come from the Iowa Soil Properties and Interpretations Database GIS soil data layer. Soil productivity is measured by the Corn Suitability Rating (CSR), an index from 0 to 100 with the higher CSR values corresponding to the higher land's productivity in corn production.

We use the data on all the land that has been cropped in 2009 and has positive CSR values. Overall, the study data covers approximately 95% of the state's cropped land. Under the assumption of expected profit maximization, the model we develop takes on the crop and production input prices as exogenous and predicts the farmers' choices of cropping rotation, fertilizer use, and tillage system choice, all by the varying soil quality, as represented by the CSR. We estimate the response to the changing energy prices by assessing the changes in the model's endogenous variables as the energy prices are exogenously varied.

We assume that production exhibits constant returns to land of any given quality. For each given acre of land quality, farmers choose the crop rotation, tillage system for each year in rotation, and the rate of Nitrogen (N) fertilizer application for corn years to maximize the average annual profits from the rotation-tillage-Nitrogen rate combination.

Given the rotations currently practiced in Iowa, three possible crop rotations are considered in the analysis: CC, CS, and CCS. These rotations have different impacts on the yields with corn having a "one-year memory" and soy having a "two-year memory." That is, the corn yield is impacted by the previous year's crop (Sawyer et al, 2006), but not by crop selection prior to that one year. However, the soy yield is impacted by the crop selection for the previous two years (Chen et al, 2001; Hennessy, 2006). Since in Iowa soy is rarely planted in consecutive years because of the threat of the soybean cyst nematode infestation, we assume that the crop preceding soy is always corn. However, the crop two years before soy could be either corn or soy. Following Sawyer et al (2006) and Hennessy (2006), expected corn yield is modeled as a previous-crop-specific quadratic function of the Nitrogen fertilizer rate.

Tillage choice impacts crop yields for both corn and soybeans, and impacts corn to a different extent depending on the previous crop. Following CTIC (2010) we consider conventional tillage and two conservation tillage systems, mulch and no-till. Any tillage system that leaves less than 30% of the soil surface covered by plant residue after planting is referred to as conventional tillage and any tillage system that is not conventional is referred to as conservation tillage. We use no-till umbrella term for the tillage systems that leave soil and residue either completely undisturbed from harvest to planting except for nutrient injection or minimally disturbed only on strips up to a third of the row width. We refer to the rest of the tillage systems that leave at least 30% the soil surface covered by plant residue after planting as mulch till. Following the agronomic studies conducted under the conditions similar to our study area (Vetsch and Randall, 2002; Al-Kaisi and Yin, 2004; Wilhelm and Wortmann, 2004; Yin and Al-Kaisi, 2004), we assume that mulch and no-till systems reduce yields relative to conventional tillage systems. Further details on the yield functions used in the model are provided in Randall (2012).

The cost functions are based on the estimation of typical 2010 Iowa costs of crop production by the Iowa State University Extension (http://www.extension.iastate.edu/agdm/crops/html/a1-20.html, accessed May 2015). We assumed that labor and machine hours are fixed at the predetermined levels for each crop-previous crop-tillage sequence, as determined by machine and labor requirements for pre-planting operations specified in Table 1 and planting and harvest operations specified in Duffy (2009). Likewise, seeding rates and prices, wage rate, and interest rate have been assumed to be fixed at the levels specified by Duffy (2009). Details on the estimation of the cost functions are provided in Randall (2012).

Table 1. Assumed pre- planting operations chosen following Duffy (2009)

Crop	Previous crop	Tillage system	Pre-planting machinery operations
Corn	Corn	Conventional	Chisel plow, tandem disk, fertilize, and field cultivate
Corn	Corn	Mulch	Tandem disk, fertilize, and field cultivate
Corn	Corn	No-till	Fertilize
Corn	Soybeans	Conventional	Fertilize, tandem disk, and field cultivate
Corn	Soybeans	Mulch	Fertilize and field cultivate
Corn	Soybeans	No-till	Fertilize
Soybeans	Corn	Conventional	Chisel plow, tandem disk, and field cultivate
Soybeans	Corn	Mulch	Tandem disk
Soybeans	Corn	No-till	None

In derivation of the cost functions, we assume that the opportunity cost of hired labor is flat $11/hour, yet, it is well understood that the cost is much higher during pre-planting time when the most of the tillage operations are being done. In the absence of relevant data, we do not correct for this limitation. We also assume that all farmers have unlimited access to credit markets under the yearly interest rate of 6.5%. Huang (2009) notes that tightening credit markets for fertilizer purchases may impact fertilizer demand, but we leave the explicit incorporation of credit constraints in the analysis to the future extensions of the study. Following Duffy (2009), all pre-harvest variable costs are assumed to enquire interest for 8 months at the rate of 8%.

Rental rates are not included in the computation of production costs since they are irrelevant to our analysis that focuses on the comparison of alternative cropping and farming systems on the same land that is presently in production.

In order to assess the validity of the model going forward, model predictions were tested against historical data. Anticipated crop prices for 2004 and 2005 were input into the model along with the then current fuel and fertilizer prices. The years 2004 and 2005 were chosen for validation because of most complete data availability. While USDA reports the total acreage by crop consistently every year, the data on the acreage by crop and previous crop is not readily available for most years. The latter data comes from the ARMS data that are based on the surveys administered to a sample of farmers. The results from the 2004 corn survey and the 2005 soybean survey are available from the USDA NASS website and were used for validation of model predictions. In all, the following model outputs were compared with historic data: total acres planted by crop and previous crop, tillage choice percentages, and nitrogen applied per acre by previous crop.

Historical diesel prices and propane prices for March of that year were obtained from the website of the Energy Information Administration (EIA) (http://www.eia.gov, accessed April 2015) for *U.S. No 2 Diesel Retail Sales by All Sellers*, and for *U.S. Propane Residential Price*, respectively. Historical fertilizer prices for April of the years 2004 and 2005 were obtained from the USDA website (http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx, accessed April 2015).

Overall, the model developed in the study predicted the 2004 and 2005 crop acreage data very well. The quality and reliability of the other reference data, the rotation percentages, tillage percentages, and fertilizer application rates is much worse than those for the total acreage data. It was not expect that the model would generate the same results as the estimated actual results because individuals farmers may be relying on their own anecdotal experience to make their management choices, and in particular are not aware of the extent of the diminishing returns for nitrogen fertilizer, especially for mid to low CSR land. Randall (2012) provides the details on the comparisons between the predicted and observed data.

IV. Simulation scenarios

Tyner and Taheripour (2008) note that as the proportion of corn crop utilized in ethanol production increases, the historical separation of agricultural and energy markets is expected to be replaced with integration. However, the exact relationship between the two sets of prices – crop and fuel, is subject to current investigation and depends on numerous factors including ethanol tax credits (de Gorter and Just, 2008), ethanol subsidies and RFS (Tyner and Taheripour, 2008), among others. By simulating the changes in an integrated partial equilibrium framework, the authors predict a strong positive correlation between exogenously changing oil prices and endogenously changing corn price. The results reported in Tyner and Taheripour (2008) imply the elasticity of corn price with respect to fuel price ranging from 0.3 to 1.2, depending on the assumptions about the maintenance of renewable fuel standards and the presence and structure of ethanol subsidy. Given the big uncertainty about the magnitude of the correlation, we decided to treat the crop prices as fixed in this study.

The simulations assume that the prices of all energy inputs considered (diesel fuel, LP gas, and fertilizer) are positively correlated. These assumptions are based on published assessments of historical data (Huang, 2009) as well as on our own estimation. Huang (2007) estimates the correlation between prices of ammonia (the main input source for all Nitrogen fertilizers) and natural gas (the primary raw material used to produce ammonia) ranging between 0.7 and 0.8 in the period from 2000 to 2006. The simple correlation coefficients computed from the 1994-2006 annual data on diesel fuel prices (Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/pet_pri_gnd_dcus_nus_a.htm, accessed June 2011), October LP gas prices (Energy Information Administration, http://www.eia.doe.gov/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/wpsr.html , accessed June 2011), and fertilizer prices (National Agricultural Statistical Service, http://www.ers.usda.gov/Data/FertilizerUse/, accessed June 2011) are 0.97, 0.92, 0.90, and 0.73 for diesel fuel price versus LP gas price, Nitrogen fertilizer, all fertilizer, and Phosphate fertilizer, respectively. In simulations, we use the following computation formulas obtained via linear regression analysis of the 13 annual observations:

$$p_N(\$/lb\ Nitrogen) = 0.069 \quad + 0.089 \cdot p_{dsl}(\$/gal),$$

$$p_P(\$/lb\ Phosphate) = 0.315 \quad + 0.064 \cdot p_{dsl}(\$/gal),$$

$$p_K(\$/lb\ Potash) = 0.120 \quad + 0.0561 \cdot p_{dsl}(\$/gal),$$

$$p_{LPG}(\$/gal) = 0.058 \quad + 0.680 \cdot p_{dsl}(\$/gal).$$

Klienebstein and Chavas (1977) noted that prices of fuel and LP gas are expected to be closer related to energy prices that the prices of fertilizer since the latter production inputs undergo more processing than the former. The price relation formulas we use are in agreement with this expectation as the slope coefficient for the LP gas price is greater than the slope coefficients for the fertilizers.

A base case scenario was selected with the price of diesel at $2.00/gallon, and the price of corn at $4.21/bushel. Thirteen prices of diesel are included from $2.00 up to $6.28/gallon each 10% higher than the previous price. Five prices for corn are included from $4.21 up to $5.02/bushel each 4.5% higher than the previous price, and each associated with five overlapping diesel prices. The first five scenarios, including the base case, include $4.21/bushel for corn and the first five prices for diesel ($2.00, $2.20, $2.42, $2.66, and $2.93/gallon).

The next five scenarios all include the second price for corn at $4.40/bushel. The diesel prices started with the middle diesel price ($2.42/gallon) for the previous corn price demand level and the next four higher diesel prices ($2.66, $2.93, 3.22, and $3.54/gallon). This pattern is repeated for all the remaining scenarios. The 10% increase in the price of diesel was selected as a reasonable incremental value. The 4.5% increase in the price of corn was selected also as a reasonable incremental value and because by selecting this percentage in each case the middle diesel price for a given corn price demand level included the same total acres in production. This was used in order to incorporate the assumption that corn prices would eventually rise with increases in the price of diesel. The results presented below summarize the findings from the 25 scenarios described.

V. Results

V.1. Land use implications

The continuous corn (CC) rotation option was never estimated to be the most profitable rotation in any of the scenarios included in this analysis. This finding was not surprising because the of relative energy intensity of corn production when compared to soybeans, the reduction in the expected yield of corn after corn when compared to that after soybeans, and the relative price ratio of corn to soybeans. Both the corn-corn-soy (CCS) and the corn-soy (CS) rotations were significant in the number of acres that were predicted by the model.

The CCS rotation in the base case scenario includes 11.7 million acres or 54% of all available acres. As the price of diesel increases this percentage decreases because the increased diesel and nitrogen pre-harvest costs impact this rotation disproportionately higher compared to the CS rotation. This is because corn, especially corn after corn, is a very tillage intensive crop. Therefore as the price of diesel increases more acres shift from the CCS rotation to the CS rotation. In addition, corn following corn is much more nitrogen intensive. Figure 1 illustrates the decrease in the CCS rotation, and the increase in the CS rotation as the price of diesel increases at the base case. Although this chart illustrates the base case scenario, the same trend transpired for each level of corn price modeled in this analysis.

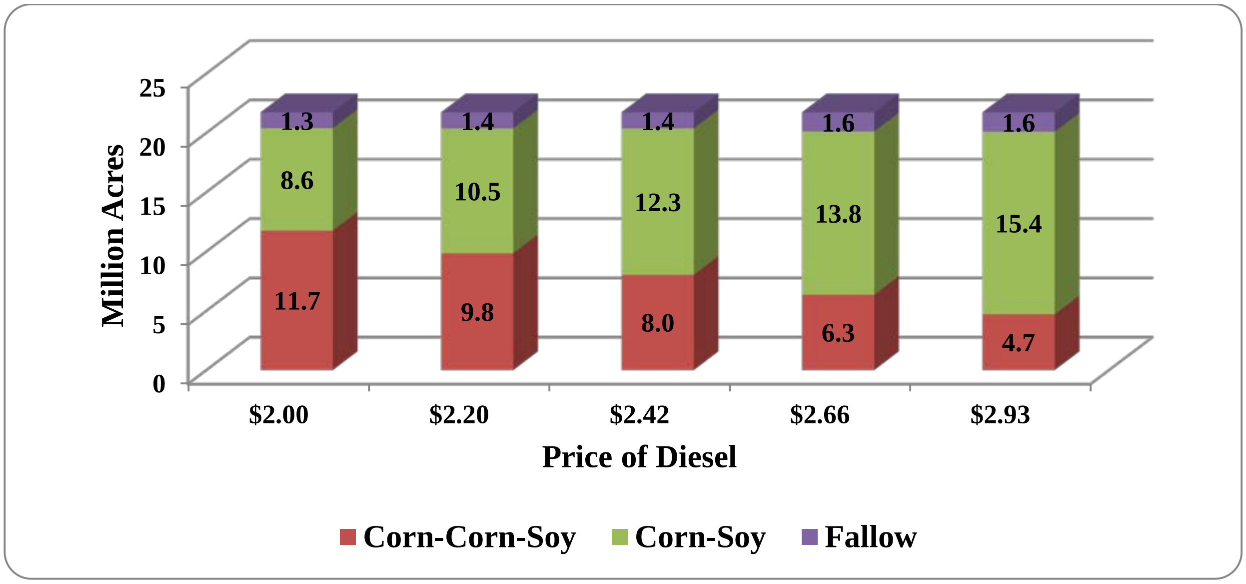

Figure 1. Acres Planted by Rotation

This crop rotation trend is clearly evident in Figure 2, which identifies the percentages of acres in the CCS for all 25 scenarios in this analysis. Each of the five corn price demand levels is grouped with overlapping diesel prices. Each corn price demand level is represented by a different color. The blue trend represents the base case scenario. The initial CCS rotation percentage is 54% and decreases with each increase in the price of diesel.

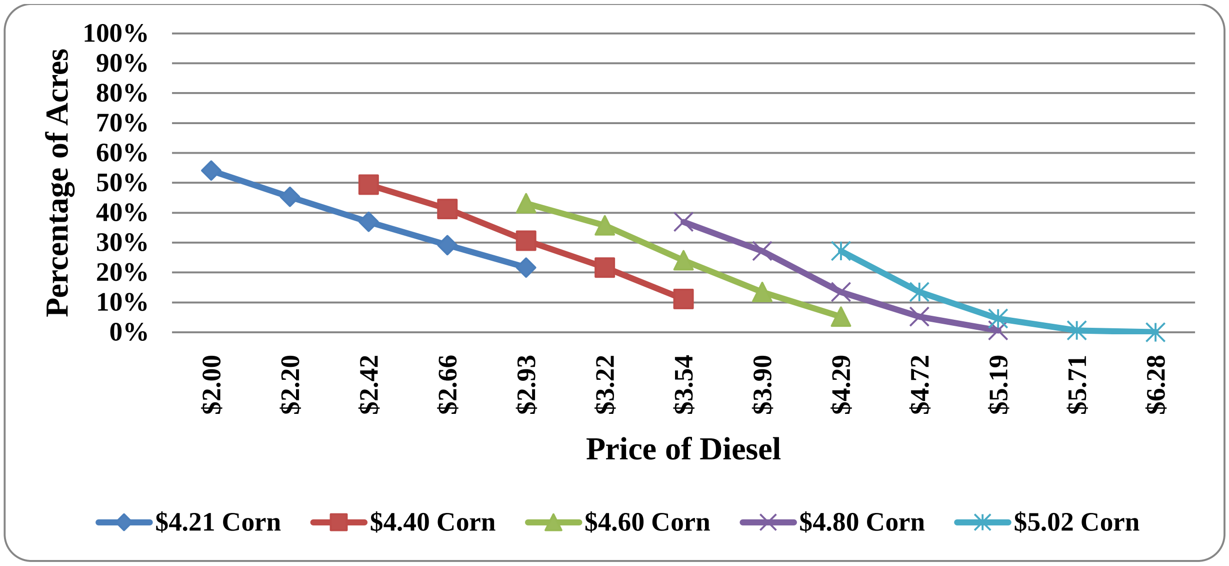

Figure 2. Percentage of CCS Rotation

Figure 3 provides further details on how the crop rotation decision is dependent on the CSR. At all the prices considered, the CCS rotation was the most profitable rotation in the acres with the highest CSR, and the CS rotation was the most profitable rotation in the acres with the lower CSR ratings. The chart indicates the number of acres at each CSR rating by the height of the bars, and the rotation by the color of the bar. Note that the small red section and the large purple section are transitional acres.

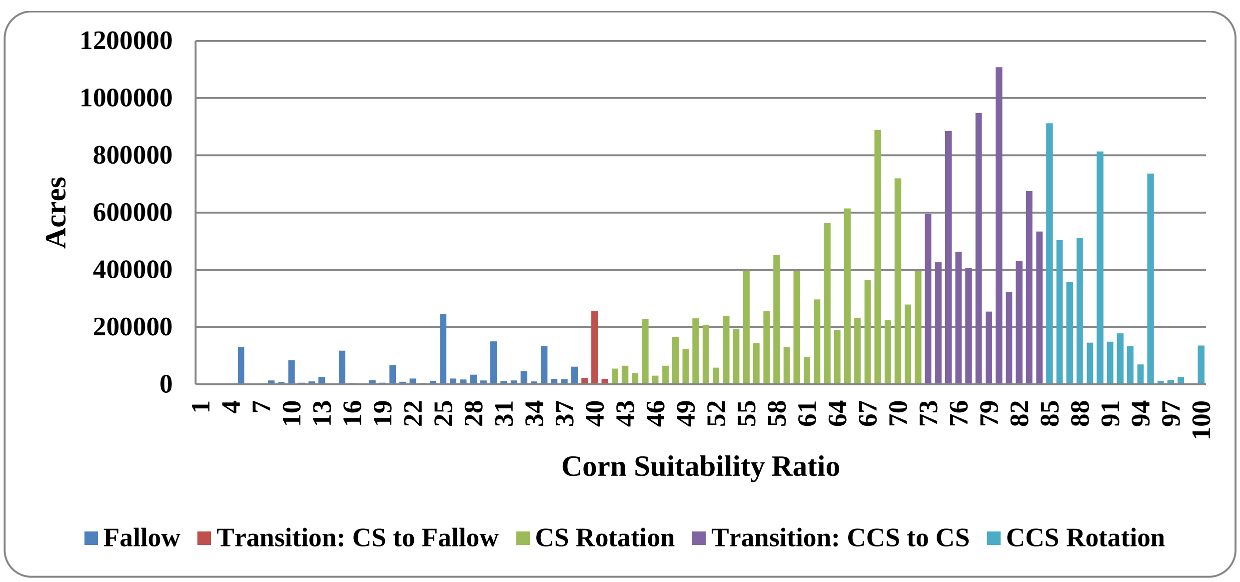

Figure 3. Crop Rotation Changes by CSR (Corn Price = $4.21, Diesel Price $2.00 to $2.93)

At $2.00/gallon for diesel the red transitional acres and the green CS acres are in the CS rotation. The acres in red switch to fallow as the price of diesel increases to $2.93. Similarly at $2.00/gallon for diesel the purple transitional acres and the CCS acres are in CCS rotation. The acres in purple switch to the CS rotation as the price of diesel increases to $2.93. There are very few acres that are moved into a fallow rotation even with a nearly 50% increase in the price of diesel and these are the least productive acres. However, almost one third of the high quality acres are predicted to switch from a CCS to a CS rotation. This significantly decreases the number of acres in corn production, but increases the corn yield.

Conventional tillage dominates the three tillage options modeled in all 25 scenarios. Conventional tillage averaged over 99% of the acres tilled, and it was the only tillage in 14 out of the 25 scenarios. By contrast, conservation tillage which included mulch tillage, ridge tillage, etc. did not have any acres in any of the 25 scenarios. No till accounted for the few remaining acres in 11 of the scenarios.

However, these results are highly sensitive to the relative fixed tillage costs between conventional and conservation tillage. A reduction of as little as 2% in the fixed tillage costs for conservation corn tillage and a 5% reduction in the fixed tillage costs for conservation soy tillage dramatically change the tillage selections. In this example 52% of the corn acres and 30% of the soy acres in the base case scenario switch from conventional to conservation tillage. If those fixed tillage cost reductions are increased just 1% more to 3% for corn and 6% for soy even more significant changes to the tillage selection occurs. Corn is switched to 99.5% conservation tillage acres, and soy is switched to 63% conservation tillage acres in the base case scenario.

V.2. Diesel use implications

The total amount of diesel used in the base case scenario was nearly 100 million gallons. This amount always decreased with each increase in the price of diesel (Figure 4). These decreases were based on three changes: switches in crop rotations, acres lost to fallow, and switches in the tillage choice. The most important impact on the gallons of diesel used was the switch in rotation from CCS to CS as the price of diesel increased. This accounted for an average of 53% of the reduction in diesel use, and occurred in all twenty transitions, with an average reduction in diesel use of 667,002 gallons.

The second most important impact on changes in the number of gallons of diesel used was based on acres in the CS rotation being lost to fallow due to the minimum profit requirement. This accounted for an average of 31% of the reduction in diesel use, and occurred in fifteen of the twenty transitions, with an average reduction in diesel use of 383,193 gallons. The third impact on changes in the number of gallons of diesel used was based on acres in the CS rotation being switching from conventional tillage to No Till. This accounted for an average of 16% of the reduction in diesel use, and occurred in ten of the twenty transitions, with an average reduction in diesel use of 199,046 gallons.

The log-log regression on diesel use (million gallons) to the prices of diesel and corn has an R squared value of 0.925. The estimated elasticity of diesel use to the price of diesel from this regression is -0.137. In addition, from the regression equation the estimated elasticity for diesel use to the price of corn is 0.406.

$$\ln \text{Diesel Use} = \underset{(0)}{4.13} - \underset{(0)}{0.137} * \ln P_D + \underset{(0)}{0.406} * \ln P_C$$

(P-value)

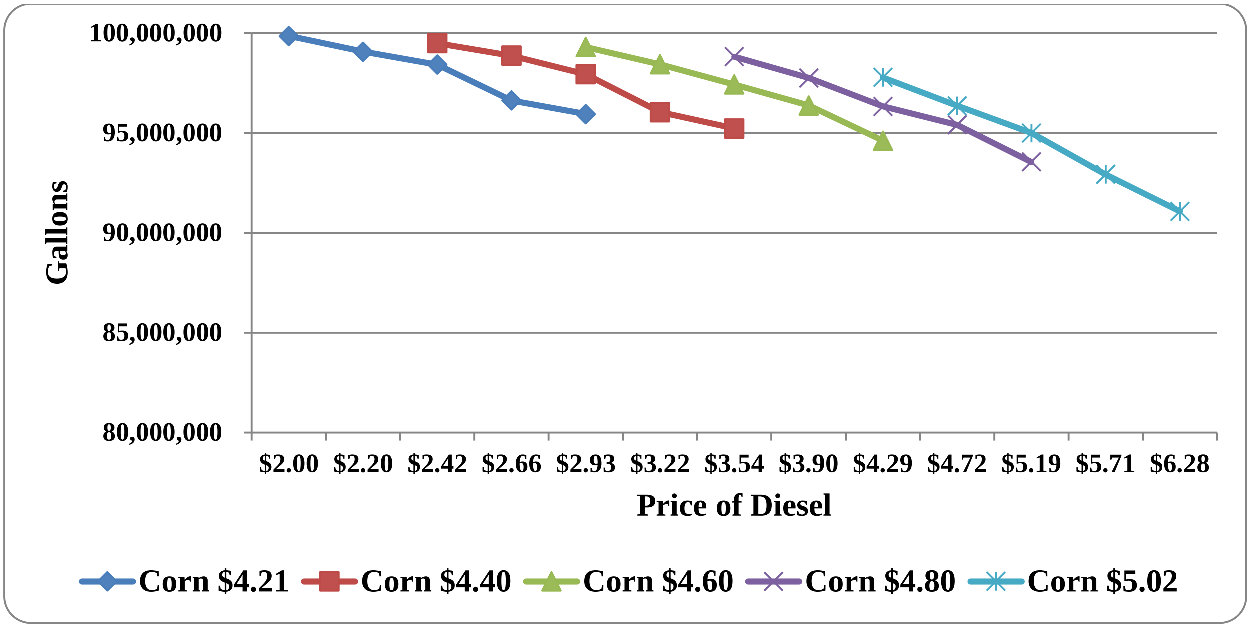

Figure 4. Diesel Use

V.3. Nitrogen fertilizer use implications

Total nitrogen use in the model decreases as the price of diesel increases for three reasons, the two most important of which are related to changes in the rotation. As the rotation shifts from CCS to CS there are fewer total acres of corn requiring nitrogen. Also, the acres of corn that remain have a greater percentage of corn following soy which requires less average nitrogen per acre than corn following corn does. The third reason is the gradual decrease in the profit-maximizing level of nitrogen use for any given rotation due to the gradual increase in the price of nitrogen. Figure 5 indicates this overall decrease in nitrogen use as the price of diesel increases. The nitrogen demand curve flattens out at the highest diesel prices as fewer acres of CCR are converted to the CS rotation.

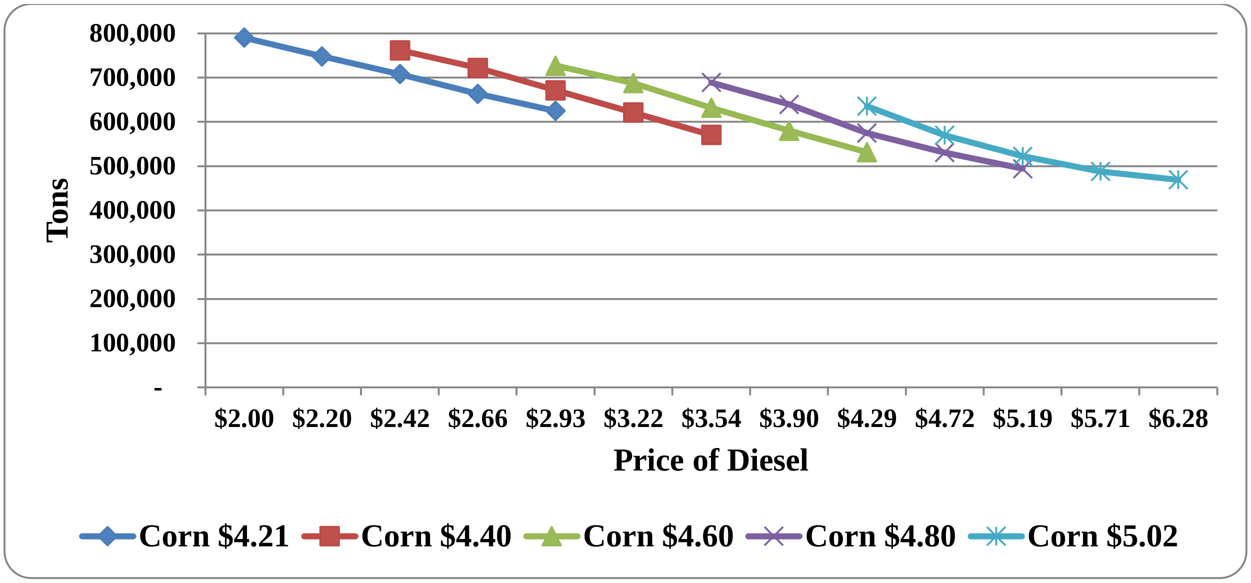

Figure 5. Nitrogen Use

The log-log regression on nitrogen use (tons) to the prices of diesel and corn has an R squared value of 0.983. The estimated elasticity of diesel use to the price of diesel from this regression is -0.783. In addition, from the regression equation the estimated elasticity for diesel use to the price of corn is 1.82:

$$\ln \text{Nitrogen Use} = 11.5 - 0.783 * \ln P_D + 1.82 * \ln P_C$$

(P-value) (0) (0) (0)

VI. Concluding comments

The study's contribution to the literature is both empirical and methodological. On the empirical side, we estimate the responsiveness of the derived demand for energy inputs for a major crop production region of the U.S. In contrast with previous work, we go beyond measuring the responsiveness as the expected change in the region-aggregate quantities such as the area under alternative crops and rotations, the amount of diesel fuel used, and the amount of fertilizer applied. Rather, we take the assessment of the impact of energy prices to a fundamentally richer level by evaluating the expected change in the *spatial distribution* of the rotations, fuel use, and fertilizer rates.

The methodological contribution of the study is in developing of an integrated economic and geographic modelling system that combines the newly available, field-level, GIS-based soil and cropping history data with the latest advances in soil and crop sciences' understanding of the response of crop yields to rotation, tillage, and nitrogen applications. The presented modelling system could be used for subsequent analyses of Iowa's crop production response to changing economic conditions and/or agricultural, energy, and conservation policies, as well as a prototype for other large-region crop production modelling systems. We estimate the marginal effects that are needed to improve the accuracy of existing, large-scale models of the U.S. energy and agricultural sectors (Elobeid et al., 2013). Due to unavailability of reliable estimates, most of these models do not presently explicitly account for the impact that the changing economic conditions may have on farmers' tillage choices, or on the total per-acre energy use in crop production in general (Whistance and Thompson, 2010).

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