The Impact of Biofuels Policy on Agribusiness Stock Prices

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Abstract

Corn markets are important for many industries, including the seed, fertilizer, meat production/processing and agricultural machinery sectors, all of which are highly concentrated. Oligopoly theory suggests that corn input and field equipment suppliers likely benefit from policies that support corn markets, such as U.S. biofuels policy, while meat companies are likely adversely affected. Employing a linear two-factor (S&P 500 and corn prices) equilibrium asset pricing model, this study investigates the impact of biofuels policy on U.S. agribusiness and food processing firm stock prices. Conditional heteroskedasticity in stock returns is accounted for using a GARCH(1,1) model. Corn price increases are found to have positive effects on excess stock returns for seed, fertilizer and machinery companies, while the impact on meat companies is negative. The results may be interpreted as evidence that crop input suppliers gain from U.S. biofuels policy while meat processors lose.

1. Introduction

Corn ethanol production in the United States increased from 3.9 million gallons in 2006 to 9.0 million gallons in 2008 (RFA, 2009). U.S. corn use in ethanol production increased from about 5% of production in the mid 1990s to about 30% in the 2008/09 crop year (FAPRI, 2009). This shift in use has been due in no small measure to the substantial support provided by the U.S. government. Policies to promote demand for ethanol have taken the forms of a blender's tax credit, blending mandate and international trade restrictions (Elobeid and Tokgoz, 2008). Not surprisingly, corn prices have risen. Average U.S. corn prices traded in the $1.80-$3.00 per bushel range over the 30 years leading up to 2006, deviating mainly because of large supply-side shocks. Since 2006, however, corn prices have risen to trade consistently above $3.00 per bushel in spite of an increase in acres planted.

The corn market is critical for many input suppliers. Seed costs account for about 14% of total corn production costs in Iowa (Duffy and Smith, 2008), while fertilizer and machinery costs amount to about 23% and 20% of total costs, respectively. Corn is the dominant crop in the U.S. Midwest, and its price correlates strongly with other field crop prices. Prices correlate because the commodities can substitute in use, and also because an increase in corn acres means a decrease in acres planted to other crops and/or an increase in overall acres under crops. Thus, a demand-driven increase in corn prices should be reflected in an increase in demand for agricultural inputs. Corn is also an important input in many markets, most notably in meat markets. Corn accounted for about 24% of total costs in the feeder-to-finish pig business in Iowa in 2009 (Ellis *et al.*, 2009).

Many field crop input markets are concentrated in structure. This may be because, as is the case with phosphate and potash, control of deposits is concentrated. Or, as is the case with the crop seed industry, some firms have invested heavily over many years in developing high-quality foundation seed. In addition, formal intellectual property rights over yield-enhancing

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and cost-reducing traits give certain firms strong competitive advantage and constitute a barrier to entry.

The agricultural machinery manufacturing industry requires intensive technology and capital investments, as well as complementary knowledge over a wide range of equipment lines. High fixed costs in product development need to be recouped in a limited market so that there can only be room for a handful of competitors. Concentration also exists in corn use markets, including North American poultry and hog production/processing. The reasons for this are less clear, but large integrated processors may have access to better-quality animal genetics. They may also be better positioned to coordinate with retailers in delivering the meat qualities that consumers demand, and to work profitably with the heavily concentrated North American grocery sector.

Our concern is with how biofuels policy, and by extension corn prices, affect agribusiness stock prices. We wish to establish whether investors in share-traded corn input suppliers gain from biofuels policy and whether investors in meat processors lose. These outcomes will arise if the business is possessed of some form of bargaining power over corn growers. Related work concerns the capacity of landowners to extract higher rents for crop land when crop profitability rises. For example, Kirwan (2009) has sought to establish how agricultural subsidies are distributed between the landlord and the tenant. He found that 25% is captured by the landlord through increased rent. Presumably land scarcity in the vicinity of the tenant's farming operation endows the landlord with some bargaining power. In this paper we ask whether share markets indicate that input suppliers have the power to participate in the pecuniary good fortune that biofuels have brought to corn farmers, and whether meat processors are adversely affected.

Study of agribusiness stock price determination has been limited. Turvey *et al.* (2000) employ various measures, including share prices and capital asset pricing model returns, to

analyze the relationship between economic value added (EVA) and stock market performance among seventeen Canadian food processing companies. High EVA is not found to be correlated with higher shareholder value. Using different data sets, Sparling and Turvey (2003) revisit the issue and support the same results. A related line of research has used event study methods to measure effects of economic events on firm values (MacKinlay, 1997; Henson and Mazzocchi, 2002; Jin and Kim, 2008). But that approach is infeasible in the current context. It is difficult to define policy events and to anticipate the event window given the variety of historical biofuels policies, their modifications and the lack of objective clarity in establishing when markets anticipated legislation.

In empirical finance, the multifactor model proposed by Fama and French (1993, 1996) has been found to successfully explain average portfolio returns. Related studies investigating and documenting the relationship between multiple factors and asset returns for the U.S. financial market include, for example, Chen, Roll and Ross (1986), McElroy and Burmeister (1988) and Jagannathan and Wang (1996). In this study, we employ a two-factor model when analyzing excess returns of stock prices for leading companies in the crop seed, fertilizer, machinery and poultry/pork industries. The sample industries have the common characteristic that corn is either a major user or input, and thus corn price changes induced by U.S. biofuels policy are expected to affect the firms' profitability significantly.

The paper proceeds as follows. In Section 2, the standard oligopoly theory model is reviewed to establish what microeconomic theory has to relate about how price movements affect profits in imperfectly competitive markets, and thus how share prices should be affected. The market environments for the companies in the study are then provided. Section 4 presents the empirical model and describes the data. Estimation results are summarized and analyzed in Section 5. We conclude with some suggestions for further research in the area.

2. The Microeconomic Model

Our empirical analysis will consider oligopolist input suppliers to corn producers, and also oligopolist meat producers for which corn is a major input. In order to establish how biofuels policy should affect agribusinesses, we develop a microeconomic model of sectors supplying inputs for corn production. Farm-level production is given as $y = f(s, x_1, x_2, \dots, x_K)$, where s represents the input at issue and x_1 through x_K represent other inputs. Input prices are given as w_s and w_1 through w_K with the obvious assignments. For convenience, other inputs are summarized as $X = \{x_1, x_2, \dots, x_K\}$ while other input prices are summarized as W.

Producers are price takers, where the corn price is given as $P(\theta)$, with θ as an exogenous biofuels policy variable where $P_\theta(\cdot) \geq 0$; i.e., an increase in the policy variable increases demand for corn. The producer's problem is to arrive at

$$(1) \qquad \Lambda\big(P(\theta), w_s, W\big) \equiv \max_{s,X} \quad P(\theta)f(s, X) - w_s s - \sum_{i=1}^{K} w_i x_i,$$

with dual supply and factor demand functions as

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\begin{aligned}
&\text{Supply:} && y^*\big(P(\theta), w_s, W\big); \\
(2) \quad &s: && s^*\big(P(\theta), w_s, W\big); \\
&\text{Other inputs:} && x_i^*\big(P(\theta), w_s, W\big), i \in \{1, \dots, K\}.
\end{aligned}
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Our particular concern is with how demand for input s responds to the policy variable. Namely, does $\partial s^*\big(P(\theta), w_s, W\big)/\partial\theta \equiv s_P^*(\cdot)P_\theta(\cdot) \geq 0$ apply? Given $P_\theta(\cdot) \geq 0$, the condition is that $s_P^*(\cdot) \geq 0$, i.e., the input is normal rather than inferior (Chambers, 1988).

Limited econometric information is available on whether this assumption applies for fertilizer, seed and machinery, in part because of data aggregation across crops and inputs. The data that are available, mainly for fertilizer and machinery, provide mixed but generally supportive results (McKay, Lawrence and Vlastuin, 1983; Huffman and Evenson, 1989). In addition, the law of supply requires that output increases in response to an increase in own

price so that some input must increase. If an input decreases in response to an increase in the output price, then some other input must substitute for it. Given the importance and distinctive roles that macronutrients, seed and machinery play in the crop production process, it is hard to imagine a plausible technology with substitution so strong as to render any of these inputs as inferior.

If we agree that biofuels policy should increase demand for these inputs, then the next question is how the increase in demand should affect profitability for input suppliers. The markets are oligopolistic, and the effect of demand shifts on oligopoly profits has been addressed in the literature, most notably by Quirmbach (1988). In the exposition to follow, we briefly present Quirmbach's reasoning to show how stock prices should respond to biofuels policy innovations. Upon aggregating over farm-level demands for an input, we arrive at a market-level inverse factor demand function for, say, seed as $S(Q;\theta)$ where $S_\theta(\cdot) \geq 0$.

Let there be a fixed number N of the input producing companies labeled as $n \in \{1, 2, \dots, N\}$, or $n \in \Psi$ to abbreviate, where each produces q_n so that $Q \equiv \sum_{n \in \Psi} q_n$. Each firm is held to be identical with cost function $C(q_n)$ so that nth firm profit is

(3) $\Pi_n(\theta) \equiv S(Q;\theta)q_n - C(q_n)$.

With $\beta_n \equiv (q_n / Q)dQ / dq_n$ as the nth firm conjectural variation, perfect competition is given by $\beta_n \equiv 0 \; \forall n \in \Psi$, cartel behavior to support the monopoly solution is given by $\beta_n \equiv 1 \; \forall n \in \Psi$, and the symmetric Cournot quantity-setting solution is given by $\beta_n \equiv 1 / N \; \forall n \in \Psi$. The restriction $\beta_n \in [0,1]$ is imposed; otherwise, the conjectured response would be outside the bounds of reasonable beliefs about influence on market price.

Writing $R(Q;\theta) \equiv S(Q;\theta)Q$ as industry revenue, and $C_q(q_n)$ as firm marginal cost, consider the symmetric solution with $q_n = Q / N \; \forall n \in \Psi$ and $\beta_n = \beta \; \forall n \in \Psi$ so that the firm subscript may be omitted. Then simple algebra shows that the standard optimization condition

for an oligopolist is

$$(4) \qquad \frac{d\Pi_n(\theta)}{dq_n} \equiv (1-\beta)S(Q;\theta) + \beta R_Q(Q;\theta) - C_q(Q/N) = 0,$$

with equilibrium value for aggregate output as Q^*. If the conjectural variation is independent of the demand shifter, then[1]

$$(5) \qquad \frac{dQ^*}{d\theta} \equiv -\frac{[(1-\beta)S_\theta(Q;\theta) + \beta R_{Q\theta}(Q;\theta)]}{\Omega};$$

where $\Omega = (1-\beta)S_Q(\cdot) + \beta R_{QQ}(\cdot) - C_{qq}(\cdot)/N$ while $\Omega < 0$ is the standard, and quite intuitive, convention.

As pointed out by Quirmbach, $(1-\beta)S_\theta(\cdot) + \beta R_{Q\theta}(\cdot) < 0$ is conceivable since $R_{Q\theta}(\cdot)$ can be negative and of sufficient absolute magnitude. In that case the policy shift makes industry marginal revenue decline so that there is private incentive to reduce output, even among oligopolists who do not share all of the gains from their own efforts to reduce supply. Since $R_{Q\theta}(\cdot) \equiv QS_{Q\theta}(\cdot) + S_\theta(\cdot)$ and $S_\theta(\cdot) \geq 0$, attribute $R_{Q\theta}(\cdot) < 0$ requires that $S_{Q\theta}(\cdot) < 0$. This means that an increase in the value of θ makes the inverse demand function more negatively sloped, i.e., less elastic. Thus, and though unlikely, it is conceivable that equilibrium input production decreases with the advent of policies intended to promote corn-based ethanol. Were $R_{Q\theta}(\cdot) \geq 0$, so that industry marginal revenue shifts up with an increase in θ, then it is certain that $dQ^*/d\theta \geq 0$. But that may not be to the benefit of oligopolists, as the shift may reduce their pricing power.

Of direct relevance to our empirical analysis is the effect on aggregate profits in equilibrium, $\Pi^*(\theta)$. The derivative is[2]

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[1] This is equation (3) in Quirmbach (1988).

[2] See equation (7) in Quirmbach.

$$(6) \qquad \frac{d\Pi^*(\theta)}{d\theta} \equiv \overbrace{S_\theta(\cdot)\frac{Q^*}{N}}^{\text{Term I: } \geq 0} + \overbrace{\frac{\{R_Q(\cdot) - C_q(\cdot)\}}{N}\frac{dQ^*}{d\theta}}^{\text{Term II: ?}},$$

where (4) ensures that $R_Q(\cdot) - C_q(\cdot) = (1-\beta)[R_Q(\cdot) - S(\cdot)] = (1-\beta)Q^*S_Q(\cdot) \leq 0$. Thus, if

$dQ^*/d\theta \leq 0$, then both terms I and II are positive and input industry profits will certainly

increase upon the advent and strengthening of biofuels policy intended to promote demand for

corn. But when $dQ^*/d\theta > 0$, as is more likely the case, then term II is negative, and we cannot

preclude the possibility that the policy decreases industry profits.

To summarize our analysis to this point, two possibilities need to be acknowledged. They

are generally unlikely to occur but may be relevant in some settings. One is that an input is

inferior in corn production so that input demand declines with the strengthening of policy that

promotes corn biofuels. The other is that the biofuels policy shifts demand up but does not

rotate demand to be too inelastic, such that output expands greatly and oligopolist profits

decline.

For the sake of completeness, we present how standard theory would suggest that biofuels

policy will affect share prices. If the firm's discount factor is r and firm profits are otherwise

constant over time, then the (continuous time) discounted present value model identifies the

company value as

$$(7) \qquad V(\theta) = \frac{\Pi^*(\theta)}{r},$$

so that the sign of $d\Pi^*(\theta)/d\theta$ in (6) determines the effect on the share price. Based on the

above reasoning, the main hypotheses that we wish to test are that an increase in the level of

corn prices should (*i*) increase the rate of returns for companies supplying inputs to crop

agriculture, and (*ii*) decrease the rate of returns for companies using corn as an input.

3. The Companies

In order to test these hypotheses, we choose a sample of sixteen companies from concentrated industries likely to be materially affected by corn prices. In the crop seed industry we choose Pioneer/DuPont, Monsanto and Syngenta. Seed costs account for about $94 per corn acre in Iowa (Duffy and Smith, 2008), while about 85 million corn acres are sown each year in the United States. Pioneer, long the dominant supplier of corn seed, was purchased by DuPont in 1999. Its market share in corn seed was above 40% of production through much of the 1990s (Fernandez-Cornejo, 2004) but was believed to have declined to about 30% by 2008 (Gerson Lehrman Group, 2008). The agricultural seed and nutrition sector accounted for about 25% of DuPont sales over the 2007 and 2008 accounting years and a slightly smaller percentage of gross profits.[3]

Monsanto's interest in seed markets arose from the realization that glyphosate tolerant seed would promote sales of its patented Roundup herbicide, i.e., complementarity in demand exists between tolerant seed and the herbicide. The company first licensed seed trait technologies in the middle 1990s, but it also decided to enter the seed business directly. Through grower demand for seed traits and seed company purchases, the company's share of the corn seed market grew to about 25% in 2008 (Gerson Lehrman Group, 2008). To the extent that higher corn prices would increase the sale of all seed, it would also increase profits from the herbicide. Corn seed and traits accounted for about 36% of total gross profits over the 2006, 2007 and 2008 accounting years. Albeit with a smaller corn seed market presence, Syngenta also seeks to exploit complementarity between seed and agrichemicals. Over the accounting years 2007 and 2008, seed sector activities were attributed an average of 21% of company sales and 19% of company gross profits.

The major crop macronutrients are nitrogen, potash and phosphate. Corn is the most

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[3] Unless otherwise stated, company financial data are from audited reports retrieved from company websites on 8/4/09 and 8/5/09.

fertilizer-intensive among major field crops grown in the United States. Nitrogen, phosphate and potash account for expenditures of about $73, $54 and $35, respectively, per grown acre in Iowa (Duffy and Smith, 2008). Macronutrient markets are international, but location does matter, as the commodities are bulky and some chemical forms can be volatile. The five companies we consider are Agrium, CF Industries, PotashCorp, Mosaic and Terra Nitrogen, specialists in agricultural crop macronutrient fertilizer and allied markets.

Both potash and phosphate deposits are mined so that ownership of deposits determines capacity to benefit from demand growth.[4] While available data are not definitive, PotashCorp and Mosaic each control 13% or more of global potash deposits. Morocco is the largest phosphate exporter, competing in the North American market with PotashCorp and Mosaic. PotashCorp controls about half of North American phosphate deposits while Mosaic controls a further third. Agrium and CF Industries are smaller players in this market.

Commercial nitrogen production for crop fertilization is produced primarily through the Haber-Bosch process, which uses natural gas to remove nitrogen from the atmosphere. As such, nitrogen fertilizer can be produced at low cost in parts of the world where natural gas is cheap. Yara International, an Oslo commodity merchandiser, has a 25% share of the global trade in ammonia fertilizers. Utilizing plentiful natural gas in Trinidad (off the Venezuelan coast) for much of its production, PotashCorp is the second-largest global nitrogen producer, with about 16% of world trade. Agrium and CF Industries both have a somewhat smaller presence in these markets. Terra Nitrogen is much smaller and focuses on North American nitrogen markets.

The four meat sector companies we consider are Pilgrim's Pride, Tyson, Sanderson Farms and Smithfield Foods. According to Hendrickson and Heffernan (2007), the four-firm concentration ratio in broiler processing was 58.5% circa 2006-07. The largest chicken

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[4] Information is from company websites, retrieved 8/3/09.

producer, Pilgrim's Pride, with about 25% of the market in the United States, declared

bankruptcy in late 2008, in some measure because of rising corn prices. Tyson was second

largest, with about 20% circa 2006, and Sanderson Farms was fourth largest, with about 5%.[5]

The third-largest firm, Perdue Farms, is privately held.

With about 31% of the market, Smithfield Foods is the largest pork processor in an

industry in which the four-firm concentration ratio is about 66% (Hendrickson and Heffernan,

2007). As with broiler processors, Smithfield is heavily vertically integrated back through the

production chain and owned about 1 million sows during much of the 2000-09 period. With its

Butterball brand, Smithfield is also the largest turkey processor in the United States. Tyson is

the second-largest pork processor in the United States and also has a strong presence in the

highly concentrated beef packing market.

We also consider the three dominant players in the U.S. farm machinery sector. These are

Deere & Co., CNH, and AGCO in descending order of company sales. All three provide a full

line of agricultural field machinery, including tractors, combines, planters and cultivation

equipment. Deere & Co. and CNH are also diversified into construction equipment markets

whereas AGCO is focused on the agricultural sector. Machinery expenditures can amount to

$100 or more per corn acre planted (Duffy and Smith, 2008). An increase in corn prices is

likely to increase acres planted, and also to increase intensity of cultivation on those planted

acres. Furthermore, new farm machines are very expensive: the typical tractor for row cropping

costs about $150,000 while a combine costs about $200,000. Farmers tend to purchase when

cash flow is strong, i.e., when corn prices are high.

Though the nature and levels of exposure differ across these sixteen companies, all are

heavily exposed to corn price movements. If a crop input supplier owns resources that afford it

bargaining power, then it should be able to participate in gains from a non-transient increase in

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[5] From http://www.wikinvest.com/stock/Tyson_Foods_(TSN), retrieved 8/4/09.

corn prices. In the next section we develop a two-factor equilibrium share price model to discern the extent of a firm's capacity to profit from favorable corn price movements.

4. The Empirical Model and Data

To empirically evaluate the impact of U.S. biofuel policy on the stock prices of agricultural companies in seed, fertilizer, farm equipment and meat processing sectors, we assume that firm-specific stock returns are largely determined by the general market risk premium and a common risk factor represented by corn price. Our linear two-factor capital asset pricing model (CAPM) is specified as

$$(8) \qquad R_{t,i} - R_{t,f} = \beta_{0,i} + \beta_{1,i}(R_{t,m} - R_{t,f}) + \beta_{2,i}R_{t,C} + \varepsilon_{t,i}, \qquad \varepsilon_{t,i} \sim N(0, \sigma_{t,i}^2);$$

where time t returns on individual stock i and the markets are denoted by $R_{t,i}$ and $R_{t,m}$, respectively. Excess stock (market) returns, $R_{t,i} - R_{t,f}$ ($R_{t,m} - R_{t,f}$), are obtained after subtracting risk-free rate $R_{t,f}$. Returns on corn is given by movement in corn futures contract prices and is represented by $R_{t,C}$.

Specifically, returns $R_{t,k}$ ($k = i, m, C$) are considered as continuously compounded and calculated as the natural log of changes over consecutive daily prices, i.e., $R_{t,k} = \ln(P_{t,k} / P_{t-1,k})$. To calculate returns, daily closing stock prices $P_{t,i}$ are adjusted to account for historical corporate actions such as stock splits, dividends, distributions and rights offerings. The closing value of the Standard & Poor's 500 composite price index is employed to represent the general market price $P_{t,m}$. Settlement prices for December-maturity corn futures contracts traded on the Chicago Board of Trade are used to represent corn price $P_{t,C}$. Expiring contracts are rolled over into the next December contract on the last trading day of November, a few weeks prior to

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contract expiration.[6] The risk-free rate $R_{t,f}$ is the three-month Treasury bill secondary market rate.[7]

Selected firms in seed, fertilizer, machinery and poultry/pork processing industries and their stock tickers, sample periods and revenues in 2008 are listed in Table 1. All firms are leading companies and play important roles in specific sectors, with all but one of these stocks continuing to trade daily on the NYSE and NASDAQ markets (as of August 2009). The exception is Pioneer Hi-bred International, Inc. (formerly NYSE: PHB), which was delisted after the acquisition by DuPont (Public, NYSE: DD) in October 1999. We pick up coverage of DuPont commencing October 1999. Historical stock price and S&P 500 index data are collected from the website of Yahoo! Finance.

In the empirical finance literature, it has long been recognized and widely documented that daily financial return series display strong conditional heteroskedasticity. In order to produce appropriate and efficient estimation, corrections for heteroskedasticity must be made. ARCH and GARCH models have been very successful in doing so and are widely used. Bollerslev, Engle and Nelson (1994) provide a comprehensive overview of this matter. To test for ARCH effects in our data, the Lagrange multiplier (LM) test proposed by Engle (1982) is applied. The test results presented in Table 2 indicate the presence of significant ARCH effects in all stock return series except for those of Mosaic and CF Industries. The failure to reject the no-ARCH null hypotheses for these two companies may be because of their relatively short sample periods.

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[6] The return on the rollover date is calculated using the prior date within the appropriate price series.

[7] Data were retrieved from the Federal Reserve System website:
https://www.federalreserve.gov/datadownload/Download.aspx?rel=H15&series=bd891f9aa455467f8e6d0abbd14eda18&from=01/02/1990&to=06/02/2009&lastObs=&filetype=spreadsheetml&label=include&layout=seriescolumn.

Of theARCH/GARCH type models, GARCH(1,1), as introduced in Bollerslev (1986), is the mostly widely used specification. It has proved to be a superior model and is parsimoniously parameterized (Hansen and Lunde, 2005). Therefore, the conditional heteroskedasticity of individual excess stock return is modeled as

(9) $\quad \sigma_{t,i}^2 = \omega + \alpha_1 \varepsilon_{t-1,i}^2 + \gamma_1 \sigma_{t-1,i}^2,$

where α_1 and γ_1 are the so-called ARCH and GARCH effects. Equations (8) and (9) are jointly estimated using the maximum likelihood method, and standard errors are computed using the robust method of Bollerslev and Wooldridge (1992). The estimates are presented in Table 2.

5. Discussion

Results in Table 2 provide strong support for our hypotheses. It can be seen from the β_2 coefficients that an increase in corn prices tends to increase excess stock returns for companies in the seed, fertilizer and machinery sectors. The impacts on meat processing companies are negative. Of the sixteen companies considered, all are of the hypothesized sign. Seven have corn price coefficients that are significant at the 1% level while six are not significant at the 10% level. Four of five fertilizer companies have corn coefficients that are significant at the 1% level while Terra Nitrogen is not significant at the 10% level. All three farm machinery companies have strongly significant corn coefficients. Seed and meat protein companies are generally less significant. For seed companies, Monsanto and Syngenta have corn coefficients that are significant at the 5% level while Pioneer and DuPont, the chemical company that took it over, do not have significant corn coefficients. Interestingly, three of the six corn coefficients that are not significant at 10% are among the four meat protein companies.

The absolute values of the corn coefficients range from 0.01 to 0.19 with average value of 0.07, where 0.07 would imply that a 1% increase in the corn price level increases the stock

price by 0.07%. In that case, a $1.4/bushel increase from $2.00 to $3.40, which is broadly what has happened over the 2006-09 period, should increase company value by about 4.9%. The effect is not large, but bear in mind that some corn price movements may be perceived as transient, because of temporary shocks on the supply or demand side. Further, the presence of competitors will limit a firm's capacity to take advantage of higher corn prices by re-pricing corn inputs while growers can also adjust their input intensity and/or mix if re-pricing does occur.[8]

Although the included companies are quite comparable in terms of diversification and market dominance in their sectors, responses to corn price changes are heterogeneous. The corresponding estimated β_2 coefficients show an interesting pattern for seed, meat processing and machinery sectors. The coefficients, which quantify the magnitudes of biofuel policy impacts, are generally larger for relatively smaller companies. We define company size by total revenue over the 2008 accounting year, and these data are presented in Table 1. For example, the revenue of Deere & Co. was $28.3 billion while that of CNH was $18.5 billion. The respective corn coefficient estimates were 0.06 and 0.12.

This observation is consistent with the standard Cournot oligopoly model. A reason for this pattern could be that larger firms in an oligopoly market have lower unit costs and so have higher unit margins. If this is the case, a permanent increase in demand would increase small-firm unit profits by proportionately more than it would larger-firm unit profits. But for fertilizer companies, the pattern is contrary to that observed in the other sectors. The lower the revenue a fertilizer company generates, the lower the potential impact a corn price change has, except for the case of CF Industries. We do not have a satisfactory explanation for why the fertilizer

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[8] Huffman (2009) has noted the role of plant population per planted corn acre in North American yield improvements during the latter part of the twentieth century. To some extent, more plants mean less sunlight per plant. Farmers can respond to more expensive seed prices by reducing corn acres or reducing the seeding rate.

sector should be different. The results for Pioneer and DuPont should be viewed with some caution. Bear in mind that the data for Pioneer were from the pre-ethanol era and that DuPont is a diversified company with interests across a variety of petrochemical markets. Linkages between corn and oil prices could reduce the estimated stock price sensitivity to corn prices.

The estimation results for companies in the meat processing sector are relatively insignificant. This could be in part due to the offsetting impact of the ethanol by-product, distillers dried grains, which can also be used as a feedstock. An alternative explanation concerns the effect on the costs of rivals, and especially on very small farm-level meat protein suppliers. An increase in corn costs may adversely affect these smaller firms more than it does the larger firms. It is conceivable that the largest meat protein suppliers would take some solace in assuming a more dominant role in the sector as smaller firms exit. For example, the companies remaining after a market shakeout may be better positioned to profit from product development and quality control investments.

6. Concluding Comments

Using a two-factor asset pricing model, we quantify the impact of biofuels policy on stock prices of sixteen companies in various agricultural inputs and meat processing sectors. After controlling for overall market excess return, corn price increases are found to have positive effects on excess stock returns for seed, fertilizer and farm equipment companies, while the impact on meat companies is negative. Although the effects are not large, they provide some evidence that off-farm input suppliers gain from policies intended to promote corn-based ethanol.

Several possible extensions emerge from our investigation. The statistical insignificance of results for how corn prices affect meat protein excess stock returns deserves further attention. After all, one of the considered companies went into bankruptcy protection over the study

period, citing corn prices as a reason (Smith, 2009). And concerns about bankruptcy suggest that agribusiness stock price variability may also be affected by the corn price level. Evidence on this might be gleaned from how credit and credit derivative markets vary with commodity prices.

Another speculation is that agribusiness responses to corn prices would have been very different before ethanol became a significant use of corn. In recent years, corn futures markets have responded strongly to evidence on the strength of support for corn biofuels legislation and demand for biofuels. Such evidence is likely to have persistent effects on company profitability and thus on company valuation. In earlier times, supply shocks were the dominant factor moving corn futures markets. Supply shocks are less likely to persist, since corn stocks are likely to be replenished after a bad harvest because of near-horizon price rationing, additional plantings and a return to normal weather patterns. While supply-side shocks may move company profitability for a year or two, the effect on the stock price would likely be small. A test for structural change in stock price responses to corn price movements may establish whether investors agree with this line of reasoning.

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Table 1. Selected Firms in the U.S. Stock Market

Sector/Company	Ticker	Sample Period	12-Month Revenue (ending 12/31/08, in millions of U.S. dollars)
Seed			
DuPont	NYSE: DD	10/01/1999-06/02/2009	31,836
Pioneer Hi-Bred International, Inc.	NYSE: PHB	10/08/1975-10/1/1999	N/A
Monsanto Co.	NYSE: MON	10/24/2000-06/02/2009	11,365
Syngenta AG (ADR)	NYSE: SYT	11/15/2000-06/02/2009	11,624
Fertilizer			
Mosaic Co.	NYSE: MOS	10/26/2004-06/02/2009	10,298
Agrium Inc.	NYSE: AGU	05/05/1995-06/02/2009	10,031
PotashCorp of Saskatchewan, Inc.	NYSE: POT	04/05/1990-06/02/2009	9,446
CF Industries, Inc.	NYSE: CF	08/11/2005-06/02/2009	3,921
Terra Nitrogen Co.	NYSE: TNH	0//10/1992-06/02/2009	903
Meat Protein			
Tyson Foods, Inc.	NYSE: TSN	01/02/1990-06/02/2009	26,862
Smithfield Foods, Inc.	NYSE: SFD	03/26/1990-06/02/2009	12,478
Pilgrim's Pride Corp.	OTC: PGPDQ	12/04/2003-06/02/2009	8,525
Sanderson Farms, Inc.	NASD: SAFM	01/02/1990-	1,724

		06/02/2009	
Ag. Machinery			
Deere & Co.	NYSE: DE	01/04/1982-06/02/2009	28,292
CNH Global	NYSE: CNH	11/01/1996-06/02/2009	18,476
AGCO Corp.	NYSE: AGCO	04/20/1992-06/02/2009	8,425

Table 2. Estimation Results

Variables	DD	PHB	MON	SYT	MOS	AGU	POT	CF	TNH
β_0	<0.001	-0.01***	<0.001	-0.002**	0.004*	-0.003*	-0.003***	0.005**	-0.007***
	(0.10)	(-6.91)	(0.30)	(-2.28)	(1.93)	(-4.08)	(-5.39)	(2.47)	(-6.02)
β_1	1.00***	0.93***	0.96***	0.91***	1.06***	0.90***	0.90***	1.06***	0.80***
	(77.76)	(99.39)	(43.35)	(44.29)	(22.17)	(49.85)	(66.67)	(21.50)	(30.30)
β_2	0.01	0.02	0.06**	0.05**	0.19***	0.09***	0.08***	0.17***	0.04
	(0.42)	(1.15)	(2.22)	(2.07)	(4.25)	(3.53)	(4.05)	(3.29)	(1.07)
α_1	0.03**	0.12***	0.04***	0.03*	0.08**	0.04**	0.04***	0.07***	0.092
	(2.55)	(2.68)	(2.60)	(1.65)	(1.99)	(2.36)	(4.26)	(2.84)	(1.48)
γ_1	0.96***	0.79***	0.96***	0.96***	0.92***	0.95***	0.96***	0.92***	0.91***
	(60.06)	(9.84)	(58.62)	(40.11)	(24.25)	(40.86)	(94.41)	(43.00)	(15.79)
ω	<0.001	<0.001**	<0.001	<0.001	<0.001	<0.001	<0.001**	<0.001	<0.001
	(1.36)	(2.05)	(1.04)	(0.86)	(1.04)	(1.44)	(2.04)	(1.35)	(1.18)
Wald $\chi^2(2)$	6047.35***	9917.62***	1897.92***	1967.73***	519.82***	2489.35***	4495.48***	490.66***	922.83***
ARCH test	64.43***	132.57***	33.15***	102.83***	0.21	45.21***	48.46***	1.03	145.68***

Variables	TSN	SFD	PGPDQ	SAFM	DE	CNH	AGCO
β_0	-0.003***	-0.004***	-0.001	-0.003***	-0.004***	-0.003*	0.001
	(-4.47)	(-5.03)	(-0.31)	(-3.47)	(-7.23)	(-1.95)	(1.11)
β_1	0.92***	0.89***	0.94***	0.91***	0.91***	0.92***	1.01***
	(61.43)	(47.10)	(10.96)	(43.41)	(89.75)	(26.78)	(40.50)
β_2	-0.01	-0.04	-0.03	-0.05*	0.06***	0.12***	0.10***
	(-0.44)	(-1.58)	(-0.71)	(-1.73)	(2.84)	(3.34)	(3.31)
α_1	0.02**	0.02***	0.29	0.12**	0.07***	0.03***	0.12*
	(2.20)	(2.88)	(1.55)	(2.30)	(4.06)	(5.58)	(1.91)
γ_1	0.98***	0.98***	0.68***	0.74***	0.91***	0.97***	0.84***
	(72.88)	(140.55)	(3.88)	(5.70)	(38.03)	(180.95)	(10.88)
ω	<0.001	<0.001	<0.001	<0.001	<0.001**	<0.001	<0.001
	(1.02)	(1.01)	(1.21)	(1.61)	(2.26)	(0.82)	(1.56)
Wald $\chi^2(2)$	3776.29***	2225.88***	133.81***	1886.66***	8076.94***	722.62***	1702.5***
ARCH test	106.38***	83.74***	51.10***	19.70***	547.62***	8.84***	27.29***

Notes: 1. Single (*), double (**), and triple (***) asterisks denote significance at 0.10, 0.05, and 0.01 levels, respectively. 2. For the LM ARCH test, *, **, and *** denote that the null hypothesis of no ARCH effects is rejected at the 10%, 5%, and 1% significance levels, respectively. One lag of squared residuals is included for the test. 3. z values, calculated from Bollerslev-Wooldridge robust standard errors, are in the parentheses. 4. The null hypothesis of the Wald chi-square test is that the two coefficients of interest are simultaneously equal to zero.