

A STUDY OF HYBRID SEED CORN PRICING

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ABSTRACT

Hybrid seed corn pricing has increased significantly over the past six or seven years and continues to be a topic of conversation amongst farmers. This issue is also an area of concern for Monsanto. The hybrid corn pricing team at Monsanto is concerned that they price current products at a point to maximize profits while continuing to grow market share. The key is to price at a point that captures all the value of the differentiated products Monsanto offers.

The objective for this study is to estimate a demand model for the hybrid seed corn industry. The demand model will allow us to look at many different aspects of the hybrid seed corn industry and also evaluate the own-price and cross-price elasticities. The own-price elasticity is especially important because it will be used to determine if current pricing is revenue or profit-maximizing. A hedonic pricing model was also estimated in this study to complement the demand model. It is important for Monsanto to understand what attributes or traits are significant in pricing and demand.

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CHAPTER I: INTRODUCTION

1.1 Introduction

Hybrid seed corn revolutionized the seed corn industry in the early 1930's. This breeding process spread across the nation at a rapid pace. "The transition from open-pollinated to hybrid maize was astonishingly rapid. In Iowa, the proportion of hybrid corn grew from less than 10% in 1935 to well over 90% 4 years later." (Crow, 1998) One of the pioneers and largest firms currently involved in hybrid seed development is Monsanto.

Monsanto's corn breeding objective is to cross pollinate two inbred lines from unrelated backgrounds that result in superior performance and hybrid vigor. The desired result is a robust plant with a larger ear and uniform for most traits. Through these breeding efforts national corn yields have increased from 30bu/a in 1935 to approximately 150bu/a presently.

Over the past decade the seed corn industry has become quite competitive. For decades Monsanto's main competitor, Pioneer Hi-Bred, was the leader in seed corn germplasm and market share. In 1997 when Monsanto acquired DeKalb, Pioneer Hi-Bred held 42% of the hybrid corn seed market. The next nearest competitor was Monsanto with 14% market share. At this time many believed the corn seed giant Pioneer could not be brought down. However, at the present time Monsanto and Pioneer Hi-Bred are virtually deadlocked at 23% market share with a slight edge to Pioneer Hi-Bred but the momentum is definitely in Monsanto's favor. Monsanto achieved this significant market share gain by changing its focus to biotechnology, a big risk due to the public's perception of genetically modified seed. Monsanto changed the seed corn industry by bringing multiple seed traits to market that improve the seed performance and help the farmer with better resistance to many pests.

Some of the more well-known new traits that Monsanto has brought to market are Roundup-Ready Corn, YieldGard corn borer, YieldGard rootworm, and VT triples. Roundup-Ready corn was the first corn on the market that was resistant to the active ingredient *glyphosate*. The YieldGard trait was the first *bt* product to hit the market that has resistance to corn borers. The YieldGard trait name then went on to be called YieldGard Plus. The YieldGard Plus trait package was the first package to include corn borer and rootworm resistance in one variety. When stacked together in one seed corn hybrid this brings many benefits to a farmer including: simple and safe weed control, increased pest resistance, and a lower pesticide handling rate which leads to overall safety and health benefit.

1.2 Objectives

While there are many components to this thesis, the main objective for the project will be to gather enough data to estimate a demand curve. Doing so will allow us to look at many different aspects of the hybrid seed corn industry and also look at the price elasticity. The estimation of a demand model will aid us in finding out what are some of the most significant explanatory variables in hybrid seed corn demand. The demand model will also give Monsanto an overall snapshot of where the hybrid seed corn industry is at presently. It is important for Monsanto to know its current status in the industry and to evaluate its pricing decisions based on estimated demand models.

A second objective of the project will be to identify a hedonic pricing model using all the different traits and attributes of Monsanto's hybrids. It is important for Monsanto to understand what attributes or traits are significant in pricing and demand. Monsanto can

benefit from a hedonic pricing model by evaluating their marketing and pricing decisions based on what the pricing model tells them.

1.3 Purpose

The issue of hybrid seed pricing is important in terms of looking at the demand curve to see if Monsanto is pricing their hybrids in-line with the rest of the industry. It would also be beneficial for the company to identify a pricing model that may be more consistent or just make pricing much more efficient.

1.4 Client & Product

The client that I will be performing my thesis project for is Monsanto, my employer. I showed interest in working with a project on corn pricing and through multiple networking sessions, I was able to meet with the corn pricing lead for the company. The corn pricing lead at the time expressed several times that his main objective for the project would be to develop some kind of tool that could be used to make corn pricing decisions quicker and more efficient. The tool that the corn pricing leads would like to see was left open to my judgment along with the guidance from my major professor here at Kansas State. The corn pricing lead did have somewhat of a vision and used a comparison to the hotel industry. He used this comparison in pricing of hotel rooms. A hotel chain may have multiple sites across a region and different rooms are priced at different levels based on type of room, location of room, and day of the week. The pricing lead felt that a corn pricing tool could be similar in terms of what region the corn hybrid is placed in, what traits the corn hybrid has, what value each hybrid brings to each producer in their respective regions. I was also given some background information before starting the project.

Monsanto typically offers approximately 130 hybrid seed corn varieties ranging in relative maturity from 79 day to 121 day corn. The difference in maturity is determined by the number of growing-degree-units needed for full maturity. Of the 130 hybrids offered by Monsanto approximately 30 of these hybrid seed corn varieties are called YieldMakers. Each year Monsanto brings out a new class of YieldMaker hybrids. The YieldMaker hybrid class is “Our Newest, High-Yielding DeKalb Brand Corn Products are bred to Benefit Your Bottom Line. The DeKalb YieldMaker products have our newest genetics and trait options. These products have demonstrated their ability to deliver significantly higher yields, and consistently outperform the competition.”

(Asgrow & Dekalb, 2008)

Monsanto sales figures according to dmrkynetec’s survey figures are listed in the table 1.1 below. One key point to remember when evaluating the figures in table 1.1 is that the large increase from 2006 to 2007 is when corn acreage in the United States increased by 15 million acres.

Table 1.1 Monsanto Corn Sales vs. Total U.S. Corn Acres 2003 - 2007

	2003	2004	2005	2006	2007
Monsanto Units Planted	3,413,108	3,808,260	4,782,409	5,271,657	7,292,589
Average Price/Unit	\$97.67	\$106.50	\$111.91	\$125.31	\$129.24
Total U.S. Corn Acres	78,603,000	80,929,000	81,779,000	78,327,000	93,600,000

Monsanto’s corn pricing has two different components. Each hybrid price has a trait price and a genetics price. To aid in this project I was given the internal models that represent the trait and genetics portions of the price. The models are based off of total value that the hybrid provides to the consumer. The models compare the new hybrid to a similar

(comparator) hybrid in our product lineup at the time. The models will only allow for a 10% maximum increase in total value compared to the comparator hybrid. After the total value is found the genetics price that the company chooses is a flat 30% of the total value.

1.5 Methods

To set the baseline for the methods sections, let's first take a look at the project objectives. The first objective is to see if Monsanto is comparable to the rest of the seed corn industry in terms of their pricing strategies over the past five years. The second objective is to analyze what variables play important roles in the pricing strategy. The third objective is to analyze Monsanto and the industry in terms of elasticity. In this section, I will explain the methods used to meet these objectives.

To meet the first objective I will try to discern the market demand curve facing Monsanto. First, I will simply examine the relationship between quantity and price. Quantity will be measured as the number of units of corn sold and price is the average price a customer paid per unit of seed corn. For the Monsanto branded products I have data covering 33 different states over a 5 year time frame, this will give me one-hundred-sixty-five price quantity data points.

For a first step in the analysis, I can simply take these data points and graph them using a standard X-Y scatter graph. I will include a trend line in the graph to show the general correlation. To develop an industry scatter chart I will follow the same process as above, however I will be using the price and quantity variables from the entire industry. I will use the data from the same thirty-three states over the same five year time period.

Because the X-Y “demand” diagram only reveals a tendency for price and quantity to move together. I next, will develop a demand function that will allow me to make inferences on how individual demand factors affect the quantity demanded (or the price) for hybrid corn. I do this for each set of data, one for Monsanto and another for the industry. To develop the demand functions I will use the price and quantity variables along with other demand variables and undertake regression analysis. The regression output will provide me the information I need to develop a demand equation for the respective data sets. Once a demand equation has been developed, I can use it to undertake counterfactual simulations for the data. I can use different prices ranging from say, \$0 to \$300 in the demand equations. These price numbers will give me the respective quantity demanded at the given price with everything else being held equal. I can then chart the price and quantity numbers taken from the demand equations to develop insight into the effect of price changes on demand for Monsanto’s hybrids.

The first two charts developed will only show the scatter points across all data points, the main purpose of the scatter charts will be to see if there are any major outliers or different trends over time. The set of charts developed from the figures using the demand equations will be the respective market demand curves. These graphs will show me how a change in price will affect the quantity demanded.

I believe this is an excellent method to start the project out with. By comparing the two data sets in a chart format we will be able to see any major trends or even demand curve shifts. These charts will give me an excellent picture of Monsanto’s seed corn sales compared to the industry as a whole.

From here I will be able to analyze my third objective by using a lot of the same data and information developed above in my first method. I will be able to analyze the own price elasticity of demand for Monsanto and the industry from the same demand function used to derive the market demand curves. I can use the numbers from the demand equations to analyze the elasticities facing both Monsanto and the industry.

The own-price demand elasticity is very useful to a firm because it can be a key to determining whether prices are being set at a point that maximizes firm revenue. Although maximizing profit is the goal of a firm, knowing whether prices are maximizing revenue is helpful in knowing whether a firm is on its way to meeting its profit objective. For example, because a price-quantity combination that results in a price elasticity of demand equal to -1 maximizes revenue, we know from economic theory that any price above or below this revenue maximizing price is giving the firm less revenue. If the current price is below the revenue-maximizing price, then a firm can raise its prices profitably (since costs do not go up as price goes up). If the current price is above the revenue-maximizing price, then a firm could lower its price to raise revenue but must be careful because lowering price will often raise costs (by increasing quantities to meet the increased demand from the lower price). Hence, knowing Monsanto's price elasticity now will be important in determining a price strategy for the future and the demand equation will be key to determining this elasticity.

The first step in determining the own price elasticity is to estimate what the percentage change in quantity demanded and the percentage change in price is. Next, take the percentage change in quantity demanded divided by the percentage change in price. This

figure tells us whether the demand is elastic or inelastic. If the absolute value is greater than 1 the demand is said to be elastic. An elastic demand tells us that an increase in price per unit of seed corn will lead to a considerable decrease in the number of units sold. If the absolute value is less than 1 the demand is said to be inelastic. An inelastic demand tells us that an increase in price per unit will lead to an unresponsive change in quantity demanded.

The own-price elasticity of demand is also an excellent comparison tool that can show the differences between Monsanto and the seed corn industry in the responsiveness of the consumers' demand with price changes. The elasticity values will tell us whether or not Monsanto or the seed corn industry can profitably withstand a price increase or if a price increase will be detrimental to the quantity demanded. An inelastic demand for Monsanto or the industry may tell us if Monsanto's product performance is better in comparison to the industry. If Monsanto has an inelastic demand this may mean that our products are outperforming the industry and the consumers are willing to accept a price increase, most likely because they view Monsanto's hybrid as differentiated from those of its competitors.

To look at the different variables that influence either the quantity demanded or the average price charged, I believe there are two different methods to meet this objective. The first method of the regression analysis I want to incorporate is to create a demand function that is dependent on the average price charged, Monsanto trait, along with the geographic region.

To accomplish this, I will arrange my data in a way so that I will be able to run a regression analysis including all of the variables mentioned above. Based on the regression output we

will be able to analyze which of the variables mentioned have a significant impact on the quantity demanded. For the demand regressions, I will estimate both an industry demand for all hybrids and a residual demand for Monsanto alone. After estimating Monsanto's residual demand, I will use the estimated elasticity to provide insight into whether Monsanto's current pricing is either revenue or profit maximizing.

Finally, to approach my overall objectives from a different angle, I also want to estimate a hedonic pricing model. Based on the different traits obtained in a seed corn hybrid, we can analyze which of these traits impacts the price charged. This model will look at the different internal characteristics of a corn hybrid. A corn hybrid can have up to three traits stacked into the product. A corn hybrid with no traits is considered a conventional hybrid. A one hybrid with one trait is a hybrid that has resistance to certain herbicides. Corn hybrids with two or more traits have herbicide resistance along with some sort of package of insect resistance as well. To look at the significance of the different trait combinations I will run a regression analysis using the different trait characteristics. Next, I will analyze the regression output and determine which of the trait coefficients are significant on the impact of pricing and at what level are they significant.

The hedonic regression is an important method to use to show the value among the different trait combinations. This method will probably show that the hybrids with no traits have very little value; however it will be interesting to examine the levels of significance that the trait combinations hold.

CHAPTER II: LITERATURE REVIEW

In 2002, Jorge Fernandez-Cornejo and David Spielman wrote a paper on “Concentration, Market Power, and Cost Efficiency in the Corn Seed Industry”. (Fernandez-Cornejo & Spielman, 2002) The overall objective of this paper was to develop a model and examine the effects of industry concentration on market power and costs in the seed corn industry. The authors also wanted to measure the relative strengths of these effects over the past three decades. Using data from USDA sources they developed a model that uses conjectural elasticities. The results from the model allow them to distinguish between market power and cost effects of concentration. The authors are also able to evaluate the tradeoff between the cost efficiency and market power resulting from the higher concentration within the seed corn industry. Preliminary results from this model show that a strong processing cost reducing effect overpowers the market-power enhancing effect of concentration (Fernandez-Cornejo & Spielman, 2002).

In 2002, Corinne Alexander and Rachel Goodhue did a study on “The Pricing of Innovations: An Application to Specialized Corn Traits” (Alexander & Goodhue, 2002). The main topic of this study was the potential for private seed companies to exercise market power when pricing their seed varieties in the growing agricultural biotechnology industry. Alexander and Goodhue used a calibrated optimization model of south-central Iowa corn producer’s adoption decision. They argued that innovations such as herbicide-resistant soybeans and conservation tillage have altered the nature of producers’ production decisions from independent choices on their inputs to a smaller set of decisions over production systems. Alexander and Goodhue compared the returns to a production system

obtained by the producer and the innovator using three different seed innovations: Bt corn, Liberty Link herbicide-resistant corn, and high oil corn. They compared the net returns from these three systems to that of a high-yield corn hybrid with no specialized characteristics. Their results suggest that the innovator obtains all the additional returns from the herbicide-resistant corn, but doesn't obtain everything from the Bt corn. They found the High oil corn system had lower net returns when compared to the base system which was consistent with the producer experience. "Our results suggest that patented seed innovations do not increase the market power of biotechnology firms in the relevant market for production systems. Our results do not provide support for concerns regarding monopoly pricing of biotechnology innovations. Producers' choices across production systems may effectively limit this market power" (Alexander & Goodhue, 2002, page 347).

In 1993 Enefiok P. Ekanem and W. Burt Sundquist argued that the prices paid for seed corn hybrids by farmers is a measure of the farmer's willingness to pay for certain attributes associated with each individual hybrid. The overall objective of the paper was to estimate implicit marginal prices for the following six corn attributes: yield, moisture content, root lodging, stalk lodging, stand survival and ear drop. Ekanem and Sundquist constructed a hedonic price equation using characteristic data obtained from the Iowa State University Extension Service along with solicited seed prices fifty nine seed companies. Overall they had forty companies respond with 1991 pricing data. After testing their hypotheses they found that only moisture content and root lodging had a significant effect on the prices paid for the hybrid seed corn. One of the main conclusions in this paper is that yield was not significantly related to the seed corn price. However, there are many

variables left out of the model that can be directly related to yield. They did find moisture content to have a significant effect on price. The moisture content of seed affects the test weight on the corn, and test weight is often directly related to yield. Ekanem and Sundquist argue in the paper that there are a number of non-price variables that are missing from the model such as: advertisements of seed companies, technical and agronomic support services offered, and brand loyalty. They suggest that their pricing data may be skewed as well due to the differences in actual prices paid and prices charged to farmers due to price discounts (Ekanem & Sundquist, 1993).

Alexander and Goodhue argue that patented seed innovations do not increase the market power of biotechnology firms. I would argue otherwise, the firm level data that I am using for this project would help support my case. These data show that as the average price increased across years so did the number of units sold. Monsanto's patented seed technologies provided higher value to farmers. Once farmers realize this value it allows Monsanto to raise their prices and not risk lowering the number of units of hybrid corn sold. I believe the study of Alexander and Goodhue was a little ahead of the biotech trend. The biotech seed trait boom really accelerated in the years following their study. With proper data and the current biotech knowledge, I believe their results would be quite different.

Ekanem and Sundquist's study of the relationship between the hybrid seed corn price with attributes yield, moisture content, root lodging, stalk lodging, final stand, and dropped ears, showed no significant relationship between price and yield. Ekanem and Sundquist's model was a very solid model. However, many variables have changed in the seed corn

industry since 1993. They were able to solicit 40 seed companies to participate in the project. This may be the most significant change between 1993 and 2008 would be the consolidation of seed companies. Currently in any given growing region there may only be less than 10 competitive seed companies. Ekanem and Sundquist also stated that one of their largest limitations in their study was the use of the suggested retail price sheets provided by the respective seed companies. Using the suggested retail prices they can not account for early pay or volume discounts. Using the data provided by dmrkynetec accounts for this limitation. My data accounts for all discounts provided to farmers.

With the amount of firm level data used in this project, I will be able to provide a more accurate and current snapshot of the hybrid seed corn industry. I believe these data will show the level of market power a firm has with high performing, high value products.

CHAPTER III: THEORY

Is Monsanto pricing their corn hybrids correctly? And, what does “correctly” mean? In this project I hope to answer these questions by looking at the very simple economic theory of supply and demand. The very first building block to economic theory is supply and demand. I will focus more on the demand side of this equation in great part because I simply do not have access to supply data. While that is a drawback to an analysis, if we consider that Monsanto and other hybrid producers are “monopolies” over their particular traits because of patents, then economic theory tells us that a supply curve estimation may not be practical as a monopoly does not have a supply “function” so to speak. As such, there is no theoretical problem with estimating a demand function absent a supply function. To the extent these companies are not monopolies, then this is an acknowledged drawback of the research.

The theory that I will be focusing upon is the theory of demand. The “law of demand” simply states that while other factors are held constant a decrease in demand leads to a decrease in market price while an increase in demand will lead to an increased market price.

The market demand curve, which embodies this law, is a curve indicating the total quantity of a good all consumers are willing to purchase at each possible price, holding the prices of related goods, income, advertising, and other variables constant (Baye, 2006). From data that I have collected I will be able to estimate a demand curve over the past five years for Monsanto’s corn sales, I also have enough data to estimate a demand curve over the same five years for the entire seed corn industry.

From the estimated demand curves for the industry along with Monsanto's, we can then analyze what affects a change in quantity demanded. I will be able to analyze the movement along the estimated demand curves and be able to see how a change in price will affect the quantity demanded on the estimated curves. Analysis of the data may also show over the years any shifts of the entire demand curve. Shifts in the demand curve are often influenced by the price of competitive products, income shifts of consumers, consumer expectations, advertising, and many other factors.

From here we can take a look at what a demand function looks like for Monsanto and the industry. According to Michael Baye, a demand function is: "A function that describes how much of a good will be purchased at alternative prices of that good and related goods, alternative income levels, and alternative values of other variables affecting demand" (Baye, 2006).

I can look at the demand function in a couple different ways. I can analyze the quantity demanded strictly as a function of price, by doing this I will be able to see if price influences Monsanto's corn hybrid demand more or less compared to the rest of the industry. However, demand is influenced by many other factors, many of which are stated above. One key factor I want to include in Monsanto's demand function would be the competitive prices variable. Is Monsanto's corn hybrid demand positively or negatively affected by prices in the rest of the industry, and by how much?

Another method for looking at the changes in quantity demanded is to look at the own price elasticity of demand. "Own price elasticity is a measure of the responsiveness of the

quantity demanded of a good to a change in price of that good; the percentage change in quantity demanded divided by the percentage change in the price of the good.” (Baye) By measuring these values for Monsanto and the industry we will be able to see where both lie in terms of if their demand is elastic or inelastic.

The definition behind elastic and inelastic demand is as follows: “Demand is said to be elastic if the absolute value of the own price elasticity is greater than 1: $|E_d| > 1$, demand is said to be inelastic if the absolute values of the own price elasticity is less than 1: $|E_d| < 1$ ” (Baye, 2006).

By comparing the elasticity values between Monsanto and the industry, we will be able to answer the question: Are both markets similar in responsiveness to a change in price? If these values are not similar then this may show that Monsanto’s corn hybrids may outperform the industry and can withstand a change in price compared to the industry or vice versa.

Another angle of economic theory to look at with this project is to look at the monopolistic competitive environment that Monsanto competes in today. According to Baye there are three conditions that must exist in an industry to qualify them as a monopolistic competitive (Baye, 2006):

1. There are many buyers and sellers
2. Each firm in the industry produces a differentiated product
3. There is free entry into and exit from the industry

In my opinion, Monsanto competes in a corn seed industry that falls into all three of these qualifications. There are many farmers along with many seed companies across the nation. However, the trend of number of farmers and seed companies is decreasing. The key qualification for the hybrid seed corn industry is number two, that each company produces a differentiated product. This is the key concept that separates the industry from a perfectly competitive environment. For this reason, each firm in the seed corn industry will have to fight to convince their consumers that their respective products are superior to the other products on the market. Each firm in the seed corn industry protects their products using patents. Patent protection qualifies a firm as a monopoly. All firms maximize their revenue by pricing their products where marginal revenue equals marginal costs, however in the case of monopoly or monopolistic competition, marginal revenue is not equal to price. In other words, a perfectly competitive firm's marginal revenue is simply the market price, but a firm with a differentiated product can set price above marginal revenue and earn economic profit. According to the monopolistic competitive theory, if Monsanto is currently profiting from their products, the rest of the industry will eventually develop differentiated products to compete. As for the free entry and exit into the seed corn industry is a complicated condition for this industry. Anyone can enter into the industry without significant costs by licensing their hybrids from a licensee company and focusing on a strong sales and marketing program. To be competitive in the industry a firm would need to invest significant funds into a research and development program to completely differentiate themselves from the competition. If Monsanto has a differentiated product, then its own-price elasticity will be different from infinite.

It would be beneficial in this project to obtain some cost figures associated with the companies' cost of selling a unit of seed corn. This would help us identify if the company is selling where marginal revenue equals marginal cost ($MR = MC$). This would answer a big question of: Does Monsanto act like a monopoly? However, marginal cost turns out to be very difficult to estimate in reality even with very good firm-level data. Nevertheless, marginal revenue can be determined based upon the regression estimate of the price elasticity of demand using the formula:

$MR = P [1 + (1/E)]$, where P is the price and E is the elasticity of demand. If we assume that marginal cost can be approximated by some average, per-unit cost, c , then setting $MR = MC = c$ allows us to determine a profit maximizing price of $P = c [E / (1 + E)]$.

With some estimates of c and my estimate of Monsanto's price elasticity of demand, E , we can compare Monsanto's current price with the theoretical, profit-maximizing price, P .

Nevertheless, even without a good estimate of c , we can still determine whether Monsanto's current price is consistent with *revenue* maximization as under revenue maximization, the optimal price elasticity is $E=1$. As discussed above, elasticity above (in absolute value) 1 indicates a firm that wants to raise revenue should lower its price and elasticity (in absolute value) below 1 means that a firm should raise its price to maximize revenue.

CHAPTER IV: DATA AND DEMAND ESTIMATION

In this chapter, we specify a demand model for seed corn hybrids and report the results from estimating this model using third party research data from the years 2003 -2007. Data are from 34 U.S. states containing 681 observations in total. We examine two demand models. First, we look at the aggregate demand of seed corn hybrids purchased across the surveyed 34 states. Second, we undertake a demand formulation for Monsanto alone. We can, however, motivate both models in a similar fashion.

Let Q_y represent the number of seed corn units purchased by a typical farmer during a particular year, y . The theory of consumer demand suggests a model in which Q_y is dependent upon the representative price of a unit of seed corn, P_y . The theory of demand informs us that the expected coefficient for price (P_y) would be negative. This model is expressed as:

$$Q_y = f(P_y) \tag{4.1}$$

In addition, the seed company's corn hybrid trait is an important variable in determining the consumer demand, Q_y . Let T_y represent a dummy variable used to determine the company's trait. We included the dummy variable that if the respective corn hybrid carried a Monsanto trait the dummy variable would equal 1. If the dummy variable equals 0 this would represent a trait that was derived from a Monsanto competitor company. Based on industry knowledge we expect the coefficient of T_y to be positive (i.e. demand for

Monsanto traits are higher all other things held constant). This addition to the model can be expressed as follows:

$$Q_y = f(P_y, T_y) \quad (4.2)$$

Another addition to the demand model that we feel is relevant is the geographic region.

We included the geographic regions by breaking the surveyed states out into five regions.

The five regions we included (as dummy variables) are the corn-belt (R_{i_y}), North (R_{n_y}),

South (R_{s_y}), and West (R_{w_y}). The region we chose to leave out of this model was the East

region. Of these regions we expected the corn-belt region to have a positive coefficient

along with the largest coefficient in terms of numerical value. This addition to the model

can be expressed as follows:

$$Q_y = f(P_y, T_y, R_{i_y}, R_{n_y}, R_{s_y}, R_{w_y}) \quad (4.3)$$

In a demand model for corn hybrid seed consumption, variables that may shift demand could be: current commodity prices, future commodity prices, weather, seed technology, or current farming practices. There are many other variables that affect the demand for seed corn and the shift variables as well.

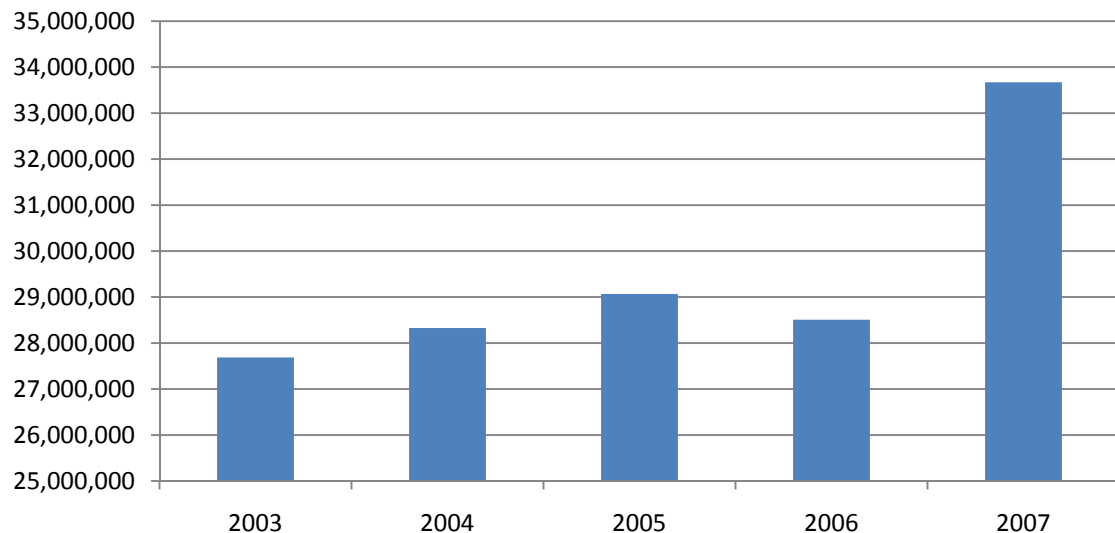
It is virtually impossible to account for all of these variables in a single model. Most of these shift variables are highly correlated, changing together over time and to the extent they would also be correlated with geographic regions are in some respects captured by the dummy variables. The aggregate demand model does not include the prices of other seeds, however, we attempt to include a competing seed price in the Monsanto demand model.

Nevertheless, we recognize the absence of any or all of these variables as a drawback to the estimation and future research should take this into account.

4.1 Demand Model Summarization

This section will summarize the effects of price, trait, and geographic region on the demand of hybrid seed corn, measured by 80,000 kernel bags. Data for the demand and price variables were obtained by *dmrkynetec*, “the leading global provider of market research and consulting services within agriculture” (Home: *dmrkynetec* Corporation).

Figure 4.1: Industry Corn Hybrid Seed Consumption by Year



Above in figure 1.1 is a chart of annual corn hybrid consumption from 2003 to 2007. The farm demand for hybrid seed corn data was obtained by *dmrkynetec* by surveying customers across most of the United States. Based on *dmrkynetec*'s survey results the numbers used for demand are their best estimates of actual consumption in each region surveyed. Hence, each of the 681 observations used in this model is an estimate of the number of units of each trait consumed in each state surveyed. In this demand model we

used the aggregate demand per state (sum of all units consumed from 2003 through 2007) as the dependent variable (Q_y). Individual yearly demands were also estimated, but because of “holes” in the demand for particular states and/or years, the aggregate demand model is presented as our working model. We also experimented with models containing yearly dummy variables to account for shifts in demand due to time. The mean aggregate demand was 216,022 units (e.g. average annual demand of 43,204.4 units) with a standard deviation of 746,138. The minimum aggregate demand figure used was 47 units and the maximum observation used was 10,828,457 units. When looking only at Monsanto’s quantity, the mean is 234,794 units with a minimum of 46 units and maximum of 4,770,335 units.

The price data that are used in this demand model are the calculated average price across all years for each state. This price variable (P_y) is calculated by taking the sum of total revenue across all years and dividing that sum by the aggregate demand calculated above. The mean price found in the 681 observations was \$114 with a standard deviation of \$18. The minimum price used was \$50 and the maximum was \$160.90. When looking only at Monsanto’s price, the mean is \$117.11 with a minimum of \$50.16 and maximum of \$156.60.

The trait value (T_y) is a constructed dummy variable (discussed previously) that was inserted to aid in the differentiation of Monsanto derived traits versus competitor derived traits. If the observation obtained traits derived from Monsanto that observation received a value of 1 in the trait variable, if not it received a value of 0. Table 1.1 lists Monsanto’s base traits. A corn hybrid can have multiple combinations (stacks) of base traits in a single

hybrid. A single stack typically refers to a corn hybrid with a single herbicidal trait. A double stack hybrid typically includes a herbicidal trait in combination with an insecticidal trait. A hybrid with a triple stack refers to a combination of traits that include one herbicidal and two insecticidal traits. The two insecticidal traits consist of one above ground trait and one below ground trait. (More discussion and estimation involving these individual traits is reserved for the chapter on hedonic price modeling.)

Table 4.1 Monsanto Derived Traits and Characteristics

Trait Abbrev.	Trait name	Herbicidal/Insecticidal Trait	Above/Below Ground
RR	Roundup Ready Corn	Herbicidal	
RR2	Roundup Ready 2 Corn	Herbicidal	
YGCB	Yield Gard Corn Borer	Insecticidal	Above
YGRW	Yield Gard Rootworm	Insecticidal	Below
YGPlus	Yield Gard Corn Borer w/ Rootworm	Insecticidal	Both
YGVT3	Yield Gard VecTran Triple	Both	Both

As discussed previously, the geographic region variables (Corn-Belt R_{iy} , North R_{ny} , South R_{sy} , and West R_{wy}) are additional dummy variables that I inserted to differentiate the where the consumption took place across the United States. The states included in each region are as follows:

R_{iy} – Corn-Belt Region = Iowa, Illinois, and Indiana

R_{ny} – North Region = Michigan, Minnesota, North Dakota, South Dakota, Wisconsin

R_{sy} – South Region = Alabama, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, Texas, Virginia

Rw_y – West Region = California, Colorado, Idaho, Kansas, Nebraska, New Mexico, Oklahoma, Washington, Wyoming

East Region = Delaware, Maryland, New York, Ohio, Pennsylvania

(*Note the following states representing about 0.5 million acres were not surveyed by *dmrkyntec* and, therefore, are not included in the results: AZ, CT, FL, ME, MA, MT, NV, NH, NJ, OR, RI, UT, VT, WV.)

Table 4.2 below describes and gives the definition of the units used for each variable in this demand model.

Table 4.2 Demand Models – Description of Variables

Variable	Definition	Units
Q _y	Annual consumer consumption of corn hybrid seed (Q _y represents the entire industry in the industry demand, but just Monsanto’s demand in the residual demand model)	1 unit = 80,000 kernel bag
P _y	Aggregate price paid for 1 unit of corn hybrid seed (industry or Monsanto’s price, depending on the model)	Dollars per Unit
T _y	Trait that is carried in each corn hybrid variety (used only in the aggregate model)	Dummy Variable for Monsanto Traits
R _{iy}	Geographic Region for Corn-Belt States	Dummy Variable for Corn-Belt States
R _{ny}	Geographic Region for Northern States	Dummy Variable for Northern States
R _{sy}	Geographic Region for Southern States	Dummy Variable for Southern States
R _{wy}	Geographic Region for Western States	Dummy Variable for Western States
P-comp	A proxy for the price of a product competing with Monsanto (used only in the Monsanto demand regressions). Calculated as the average price of a competing hybrid in each state.	Dollars per Unit

4.2 Demand Model Estimation

In order for this model to be fully functional, we must first choose the best fitting functional form. We estimate both an industry (aggregate) demand and Monsanto's firm (or residual) demand. For both types of demand models we evaluated three different functional forms: linear, semi-log, and double-log, a common functional form in non-linear estimations of demand models. For the aggregate demand models, the three estimations that were evaluated were equations 4.4, 4.5 and 4.6 representing the linear, semi-log and double-log, respectively:

$$Q_y = b_0 + b_p * P_y + b_t * T_y + b_i * Ri_y + b_n * Rn_y + b_s * Rs_y + b_w * Rw_y + e_y \quad (4.4)$$

$$\ln(Q_y) = b_0 + b_p * P_y + b_t * T_y + b_i * Ri_y + b_n * Rn_y + b_s * Rs_y + b_w * Rw_y + e_y \quad (4.5)$$

$$\ln(Q_y) = b_0 + b_p * \ln(P_y) + b_t * T_y + b_i * Ri_y + b_n * Rn_y + b_s * Rs_y + b_w * Rw_y + e_y \quad (4.6)$$

For Monsanto's residual demand, the only difference was that Q_y and P_y are only for Monsanto's seed and we included a proxy for the price of a substitute seed from competitors, P-comp. While we had data on many traits, we chose to simply average the prices of all non-Monsanto seed sold in a particular state. Hence, the competitors' price is really a proxy for all other hybrid seed facing Monsanto in a particular state. In all of the models 4.4 – 4.6 the b coefficients were estimated using the regression analysis tool in Microsoft Excel. The coefficient on price, b_p , is especially important because it will be used to discern the price elasticity of demand. In equation 4.4, b_p represents the effect of Q_y with a one unit increase or decrease in P_y . Because the price elasticity of demand is defined as

$$E_p = (\% \text{ change in } Q_y) / (\% \text{ change in } P_y)$$

$$= [dQ_y/dP_y] (P_y/Q_y),$$

To calculate the average elasticity for the linear model, I multiplied the coefficient (b_p) by the average price divided by the average quantity: $E_p = b_p (\text{avg}P_y / \text{avg } Q_y)$.

In equation 4.5, b_p represents the change in Q_y in percentage terms. Specifically Q_y will change by b_p percent for every unit that P_y increases. . To calculate the average elasticity for the semi-log model, I multiplied this coefficient by the average price: $E_p = b_p (\text{avg}P_y)$.

In equation 4.6, the b_p coefficient directly represents the elasticity of price: a one-percent change in P_y will result in a b_p -percent change in Q_y : $E_p = b_p$. The term e_y (the regression equation error) in each equation represents the changes in consumption that are not accounted for by the changes in the independent variables.

Table 4.3 Statistics of the Variables used in the Industry Demand Models

Variable	N	Mean	Standard Deviation	Minimum	Maximum
Q _y	681	216022	746687	47	10828458
P _y	681	114.16	18.21	50.16	160.90
T _y	681	0.43	0.50	0.00	1.00
R _i	681	0.15	0.36	0.00	1.00
R _s	681	0.26	0.44	0.00	1.00
R _w	681	0.23	0.42	0.00	1.00
R _n	681	0.19	0.40	0.00	1.00

Table 4.4 Statistics of the Variables used in the Monsanto Demand Models

Variable	N	Mean	Std Dev	Min	Max
Monsanto Q _y	293	234794	505163.6	46.6083	4770335
Monsanto P _y	293	117.106	16.22696	50.1576	156.603
R _i	293	0.11644	0.3213	0	1
R _s	293	0.2911	0.455047	0	1
R _w	293	0.24315	0.429722	0	1
R _n	293	0.18493	0.388909	0	1
Pcomp _y	293	109.952	6.111916	93.1615	116.882

4.3 Aggregate Demand Model Estimation Results and Model Evaluation

We estimated models 4.4 – 4.6 using the ordinary least squares (OLS) estimation procedure. The results of the estimations are included in Table 4.4. The next step in this process is to check each of the models with numerous tests.

The first test looks at the variation of hybrid seed corn consumption explained by each of their respective models. We examine this variation by looking at the adjusted R² statistic for each model. The adjusted R² statistic measures the percentage of variation of hybrid

seed corn consumption around its mean that is explained by the independent variables included in the models. If we look at table 4.4 we can see that the linear model only explains 8 percent of the variation in hybrid seed corn consumption. In both the semi-log and double-log models the adjusted R^2 values jump to 16 percent and 15 percent respectively. While these results may seem low, they are typical for cross-sectional data as we have in this case.

Table 4.5 OLS Estimates for Industry Demand Models

Independent Variables	Equation 4.4	Equation 4.5	Equation 4.6
Intercept	967291.14	12.30	22.92
T-stat	5.27	23.04	10.06
Aggregate Price	-8059.65	-0.03	-2.96
T-stat	-5.26	-6.62	-6.11
Elasticity	-1.42	-3.00	-2.96
Monsanto Trait	106730.57	1.32	1.32
T-stat	1.89	8.06	7.99
Iowa-Illinois-Indiana	491335.94	1.63	1.62
T-stat	4.94	5.62	5.56
South	-8011.72	0.12	0.12
T-stat	-0.09	0.49	0.46
West	57855.02	0.24	0.24
T-stat	0.64	0.94	0.90
North	192828.77	1.15	1.14
T-stat	2.06	4.21	4.18
Adjusted R2	0.08	0.16	0.15
Durbin-Watson	1.90	1.64	1.63

Price

The next step is to evaluate the estimated coefficients and compare them to my expectations based on industry knowledge and consumer demand. First we look at the

price coefficients and in each model we note the expected negative sign. Based on their t-statistics of -5.26, -6.62, and -6.11 respectively the coefficients are significantly different from zero at a 99 percent confidence level. The own-price elasticity of the price variable (calculated at average prices and quantities) is -1.42 for the linear model. The elasticities for the semi- and double-log models are larger and very similar at -3.00 and -2.96 respectively. The price elasticity tells us that for every one percent increase in price, with all other variables being held constant, the quantity demanded will decrease by the percent of the elasticity value. For example in the double log model the price elasticity is -2.96, when the price increases by one percent the quantity demanded will decrease by 2.96 percent. More discussion of the importance of the elasticities will be presented in the next section.

Traits

The Monsanto trait variable also ended up with an expected positive sign based on industry knowledge. The t-stat looks much better in the semi-log and double-log models with an 8.06 and 7.99 respectively. With these t-stats we can say with confidence that the coefficients in these two models are significantly different than zero. When looking at all of the different region variables, I do see a couple things that stand out. As expected in the semi-log and double-log models all of the signs are positive. I expected this when comparing the included regions to the excluded East region. If I would have left out the Iowa-Illinois-Indiana region I would have expected all region signs to be negative. As expected the Iowa-Illinois-Indiana variable has the largest coefficient values of all the regions. Along with the higher coefficient values that variable also has t-stats of 4.94, 5.62,

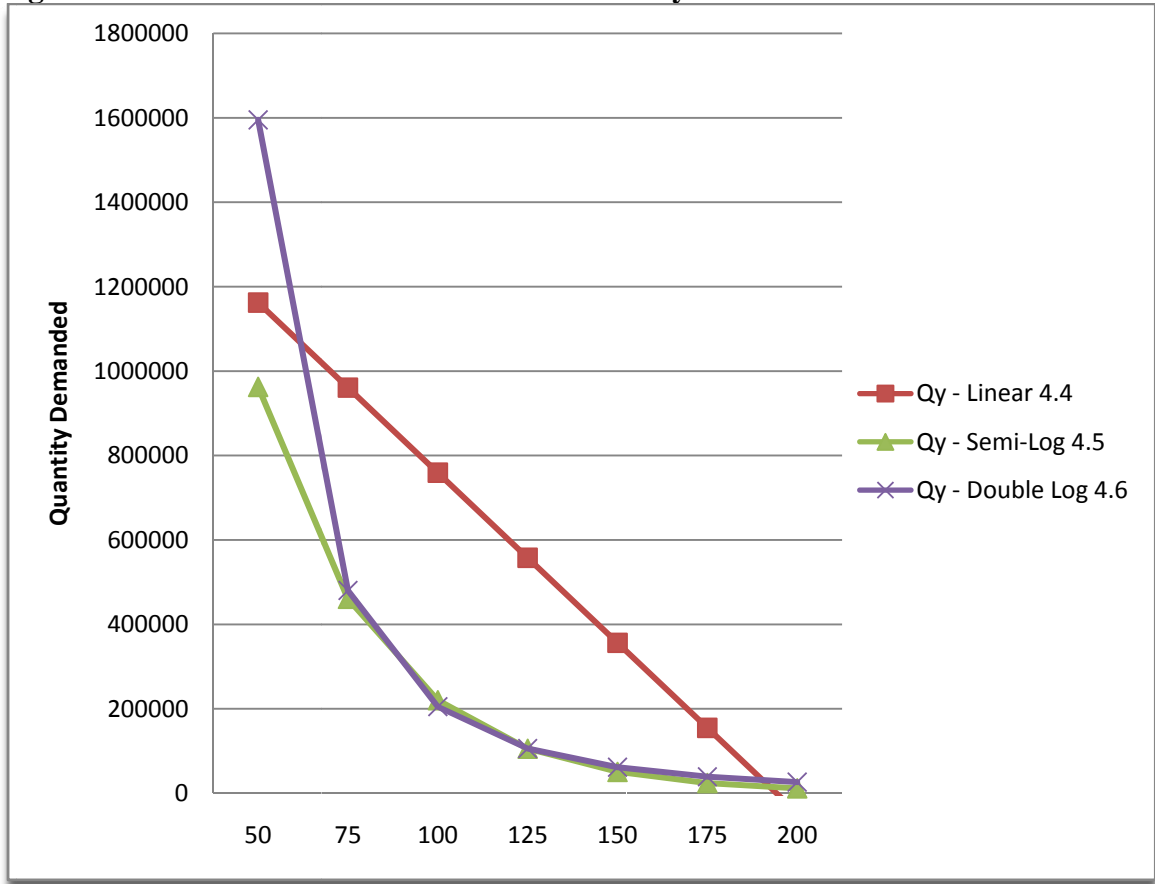
and 5.56 in all three models which tells me with confidence the coefficient values are significantly different than zero. I also expected high coefficient values for the North region as well. Based on industry knowledge, this region is a very strong area for corn in southern Minnesota. This area is also very strong for Monsanto as a company as well.

The next area I want to look at is the Durbin-Watson statistic, the values for this are included at the bottom of Table 4.4. We can test a null hypothesis of no positive serial correlation by comparing the critical d values with the calculated Durbin-Watson statistic. Using table B-4 from our econometrics text book we can determine the critical d values. Using the 5 percent one sided level of significance with 681 observations and six explanatory variables we can concur with $d_L = 1.55$ and $d_U = 1.80$. (Studenmund, 2006)

With a Durbin-Watson statistic of 1.89 in the linear model we don't reject the null hypothesis since $d > d_U$ which shows no sign of positive serial correlation. Using the same critical values found in table B-4 the semi-log and double-log models are inconclusive for positive serial correlation since their Durbin-Watson statistics are between the two critical values. (i.e. $d_L < d < d_U$)

Overall I believe the semi-log and double-log models provide us a much better model than the linear model in equation 4.4. Models 4.5 and 4.6 have much better adjusted R^2 values along with higher t-stats for the key explanatory variables. Choosing between the models of semi-log and double-log is a tossup, both are very similar. Looking at Figure 4.2 below we can see how similar both are in terms of an estimated demand curve.

Figure 4.2: Estimated Demand Curves for Industry Demand Models



4.4 Monsanto's Demand Model Estimation Results and Model Evaluation

We also estimated models 4.4 – 4.6 using the ordinary least squares (OLS) estimation procedure using only Monsanto's sales and excluding the Monsanto trait dummy variable and including a proxy for the price of competing products. See below Monsanto's estimated models equations 4.7 – 4.9.

$$Q_y = b_0 + b_p * P_y + b_i * Ri_y + b_n * Rn_y + b_s * Rs_y + b_w * Rw_y + b_{pcomp} * Pcomp_y + e_y \quad (4.7)$$

$$\ln(Q_y) = b_0 + b_p * P_y + b_i * Ri_y + b_n * Rn_y + b_s * Rs_y + b_w * Rw_y + b_{pcomp} * Pcomp_y + e_y \quad (4.8)$$

$$\ln(Q_y) = b_0 + b_p * \ln(P_y) + b_i * Ri_y + b_n * Rn_y + b_s * Rs_y + b_w * Rw_y + b_{pcomp} * Pcomp_y + e_y \quad (4.9)$$

The results of the estimations are included in Table 4.6.

Table 4.6 OLS Estimates of Monsanto Demand Models

Variable	Eq 4.7		Eq 4.8		Eq 4.9	
	Coefficient	T-Stat	Coefficient	T-Stat	Coefficient	T-Stat
Intercept	215875.2000	0.4099	11.2271	4.9163	15.2101	3.5030
Monsanto Py	-2902.6196	-1.6941	-0.0155	-2.0916	-1.1916	-1.4378
R _i	595878.6266	5.5841	2.3592	5.0983	2.3456	5.0495
R _s	22899.2333	0.2641	0.2359	0.6273	0.2345	0.6211
R _w	118043.3137	1.3313	0.0189	0.0492	0.0064	0.0167
R _n	321098.6013	3.4227	1.5377	3.7798	1.5179	3.7153
Pcomp _y	1770.7708	0.3811	0.0057	0.2841	0.0045	0.2244
Adj R ²	0.1320		0.1356		0.1287	
Elasticity MonP	-1.4477		-1.8199		-1.1916	
Elasticity Substitute	0.8292		0.6295		0.0045	

When evaluating equations 4.7 – 4.9 the first test we want to analyze is the amount of variation explained by each of the estimations. Just like the aggregate models the adjusted R² statistic allows us to analyze these three estimations. All three adjusted R² statistics are very similar, but equation 4.8 has a slight edge with 13.56% of variation explained in the semi-log estimation. Again in these estimations the adjusted R² statistics may seem lower than normal, this is typical for cross sectional data. One thing to notice is that the R² for the Monsanto models is higher than the R² for the industry models, which tells us that we are better able to fit a regression to Monsanto’s demand than to the entire industry.

The next test we put the estimations through is evaluating the coefficients and t-statistics. We compare the values across estimations and also use industry knowledge to make some conclusions. The first thing I take a look at is the sign on all the coefficients. In all three of

the estimations the signs, positive and negative, are consistent across all three of the estimations. I expected the sign on Monsanto P_y to be negative based on the law of demand and from the previous estimations in aggregate section. Equation 4.8 (semi-log) is the only estimation that has a t-statistic for Monsanto P_y that is significantly different from zero at a 95% confidence level.

The next variable that I want to focus on is the competitor price variable. There are a couple things to note with this variable, the first being the sign on the coefficients and the second are the t-statistics. A positive sign for the coefficient consistent across all three estimations is good to see with this variable. The positive sign tells Monsanto that whenever the competition raises their price it will lead to a higher quantity demanded for Monsanto. We got the expected sign on the coefficient; however none of the t-statistics for P_{comp} were significantly different from zero in any of the models.

When looking at all three of the estimations as a whole, equation 4.8 (semi-log) gives us the most stable estimation. Equation 4.8 not only has the highest adjusted R^2 value but also has the most t-statistics that are significantly different from zero. Equation 4.8 has three out of the six explanatory variables with t-statistics that are significantly different from zero. Equation 4.7 (linear) and 4.9 (double log) only have two out of the six explanatory variables that are significantly different from zero.

The elasticities are the last statistics that we will analyze for this section. When evaluating the price elasticities on all three estimations we find that all fall into the elastic region with absolute values greater than 1. All three price elasticity values are similar, but equation 4.9

gives us the smallest elastic model with a -1.19 while equation 4.8 has the most elastic value with a -1.82. One thing these price elasticities tell us, regardless of model, is that the residual demand facing Monsanto is not perfectly elastic. In other words, Monsanto does have a differentiated product.

Next we analyze the elasticity of the substitute or the cross-price elasticity. Typically with close substitutes we find the elasticity values with a positive sign. The positive sign means when the substitute price increases this leads to a percentage increase in targeted demand. In terms of the cross price elasticity, equation 4.9 gave us a very inelastic value of 0.005. An inelastic value as 0.005 in cross price elasticity leads to a very small positive influence in the quantity demanded. Equation 4.7 provides the highest cross-price elasticity with a value of 0.83.

What is most interesting about all of these models is that the own-price elasticities are in the elastic region of the demand curve (i.e. elasticities above 1, in absolute value). This is an important finding because it means two things. First of all, if Monsanto is acting like a monopoly over its own traits (as would be expected given patents making these hybrids differentiated) then Monsanto is pricing in the theoretically correct region of the demand curve. Secondly, given that revenue maximization occurs when the price is set where the elasticity is equal to -1 , then we know that Monsanto can increase revenue by *lowering* price. Whether lowering price is also *profit* maximizing depends on how much cost increases with additional units produced and sold due to the declining price.

CHAPTER V: OPTIMAL PRICES

In this chapter the ultimate objective is to define where Monsanto's revenue and profit maximizing values are in terms of the demand estimations modeled in the previous chapter.

5.1 Revenue maximizing price

We can use the theory of demand and our estimates from the demand regression to find the revenue maximizing price. This is easily shown using the linear model, but an example is useful. Suppose we set all of the variables, except Monsanto's hybrid corn price, in the linear Monsanto demand model to their averages. Then, multiplying these averages by their respective coefficients from the linear demand model and summing gives the average intercept (constant) for the demand function. Doing so gives a value of 574,708.3. Hence, on average our linear demand curve has the following form:

$$Q = 574708.3 - 2902.62P$$

Total revenue is $P \times Q$ so now write quantity and the TR function in terms of price,

$$TR = P * (574708.3 - 2902.62P) = 574708.3 P - 2902.62P^2,$$

and marginal revenue is the derivative of total revenue dTR/dP or:

$$MR = 574708.3 - 5805.24P.$$

Because we know that total revenue is a maximum whenever its derivative is zero, setting

$MR = 0$ gives $P^* = \$98.99$ and substituting this into the demand curve gives $Q^* =$

287,377.95 for a total revenue of \$28,447,543.27 (recall, this is aggregating all years in our data).

Using this quantity, this price and the coefficient of -2902.62 in the elasticity formula gives an elasticity of approximately -1, exactly what the revenue maximizing elasticity should be. In other words, a price of \$98.99/unit is the expected revenue-maximizing price for the average Monsanto hybrid, holding other things equal. We can also use the demand curve to find the revenue maximizing prices in each year or for any guess of competitor prices or changes in traits by using the demand function.

5.2 Profit maximizing price

As discussed previously, $MR=P [1+ (1/E)]$, where P is the price and E is the elasticity of demand. If we assume that marginal cost can be approximated by some average, per-unit cost, c, then setting $MR=MC=c$ allows us to determine a profit maximizing price of

$$P = c[E/ (1+E)].$$

In terms of cost of goods sold, selling, and general/administrative these costs typically vary with each different hybrid and what brand of seed bag the hybrid is targeted for. Monsanto typically uses an educated guess in models that help them forecast cost and sales. In these models Monsanto typically uses 30% of sales for cost of goods sold and 10% of sales for SGA. For example, if Monsanto sells a \$100 bag of hybrid seed corn, 40% or \$40 represents total production and selling costs.

With Monsanto's estimates of costs and my estimate of Monsanto's price elasticities of demand from the regression equations, E, we can compare Monsanto's current price with the theoretical, profit-maximizing price, P. For example if Monsanto's per-unit cost of

producing and marketing a corn hybrid is \$40/unit, then with an elasticity of -1.44 the profit maximizing price should be:

$$P = c[E / (1+E)] = 40[-1.44 / (1-1.44)] = \$130.91/\text{unit}.$$

Not surprisingly, the profit maximizing price is higher than the revenue maximizing price because costs need to be taken into account. If you recall from table 4.4 the average price paid for Monsanto derived hybrids is \$117.11, almost \$14 lower than the profit maximizing statistic figured above.

CHAPTER VI: HEDONIC MODELS

In this chapter, we specify a hedonic pricing model for hybrid seed corn and report the results from estimating this model using the same third party data as discussed in previous chapters. Typically a hedonic pricing model is used to assess the value in assets that have many different attributes. Commonly you see a hedonic pricing model used in the real estate industry. Based on all the different attributes within a house a real estate agent or banker can easily find out the true value of a specific house with different bundles of characteristics. (i.e. # of bathrooms, square feet, etc.) Hence, we hope to accomplish the same goal only within the hybrid seed corn industry. We plan to base this hybrid seed corn model off the value-added traits that seed companies breed into our corn hybrids that we see in today's market. In 1990, Ekanem and Sundquist evaluated a very similar model. However, their study had a major limitation with their pricing data used and is rather outdated. Monsanto's firm level third party data accounts for all discounts given to the farmer, hence the model should be more accurate.

In this model let P_y represents the actual price charged by a hybrid seed company to its customers, this variable will act as the dependent variable. I have chosen eleven key variables to act as the explanatory variables for this model. There are three key categories to examine when choosing variables to fit this model. The first category of traits is herbicide tolerance traits. The second area of focus is an above-ground insect tolerance and the third is a below-ground insect tolerance. When selecting the value added traits, I wanted to gather an even mix of Monsanto traits combined with the competition. Below in

Table 6.1 is a brief description of the independent variables that I felt would best fit this model.

Table 6.1 Hedonic Price Model – Description of Variables

Variable	Trait name	Herbicidal/Insecticidal Trait	Proprietary Company
IMI _y	Imidazolinone Resistant Corn	Herbicidal	BASF
GT _y	Glyphosate Resistant Corn	Herbicidal	Syngenta
LL _y	Liberty Link Resistant Corn	Herbicidal	Bayer
RR _y	Roundup/Glyphosate Resistant Corn	Herbicidal	Monsanto
AGCB _y	Agrisure Corn Borer	Insecticidal	Syngenta
AGRW _y	Agrisure Root Worm	Insecticidal	Syngenta
HXCB _y	Herculex Corn Borer	Insecticidal	Dow
HXRW _y	Herculex Root Worm	Insecticidal	Dow
YGCB _y	YieldGard Corn Borer	Insecticidal	Monsanto
YGRW _y	YieldGard Root Worm	Insecticidal	Monsanto
CV _y	Conventional Non-Traited Corn	None	N/A

This model is expressed below in equation 6.1

$$P_y = f(IMI_y, GT_y, LL_y, RR_y, AGCB_y, AGRW_y, HXCB_y, HXRW_y, YGCB_y, YGRW_y, CV_y) \quad (6.1)$$

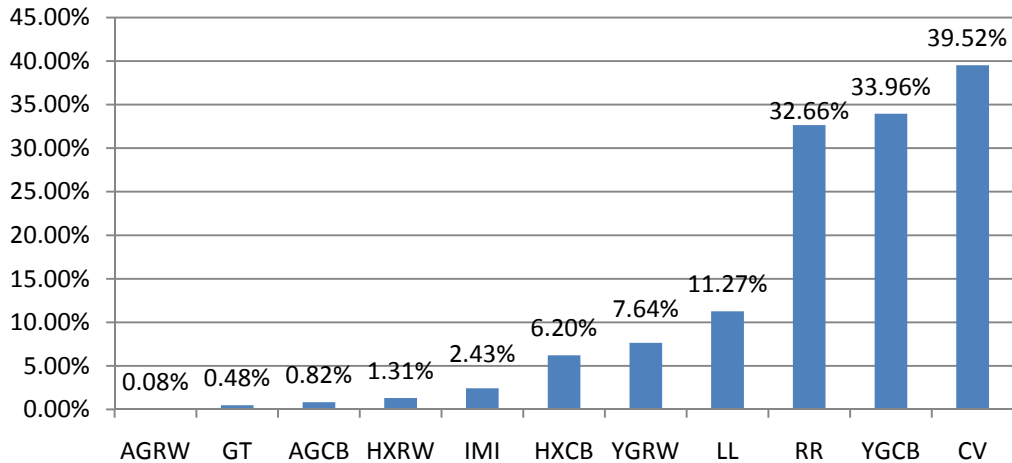
For this model we used the same 681 observations of data that were used in chapter 4 to estimate the aggregate demand model. In this chapter we constructed eleven dummy variables to account for each of the key traits that I included. One might question how we can use dummy variables for these traits when any hybrid seed corn variety can have any combination of these traits in one seed package. It would be a very confusing and unorganized price model if we chose to use a dummy variable for each of the trait

combinations contained in the data. To account for everything possible I broke the sections down into each of the key components of a stacked hybrid. For example if the data shows a YieldGardPlus/RR hybrid sold then this observation would get a value of 1 in the RR, YieldGardPlus, and YGRW columns since YieldGard Plus is a stacked combination of YGCB and YGRW technologies. I believe that breaking down the stacked combinations into each of the components will give Monsanto a better estimation of what attributes have the most significant impact on the price charged to each farmer.

6.1 Price Model Summarization

The purpose of this section is to summarize the effects that the selected traits have on the price paid for hybrid seed corn by farmers. Like I noted in the previous section that the data used for this model is the same survey results from the third party company *dmrkynetec*. The total number of 80,000 kernel units observed in this data set across years 2003 to 2007 is 147,111,105.

Figure 6.1: Percentage of Total Corn Units Sold by Individual Traits



In figure 6.1 above is a graph that depicts each individual trait and the percentage of the total units the respective trait was contained in.

Herbicide Traits

The largest percentage of the total units is the non-trait conventional hybrid corn with 39.52%. Conventional corn hybrids are the hybrids that do not include a biotech trait.

The non-trait corn may have the largest percentage of the total, however this category of hybrids is rapidly declining. Sales of conventional corn fell from 15,945,533 units in 2003 to 6,950,887 in 2007. This rapid decline is due to rapid adoption of herbicide resistant corn such as Roundup-Ready, Liberty Link, and GT resistant corn.

Of the biotech herbicide traits the Roundup-Ready trait has the highest percentage of total at 32.66%. The Roundup-Ready trait provides resistance to the active ingredient *glyphosate*. The Roundup-Ready trait was introduced by Monsanto and also includes their second generation Roundup-Ready 2 technology. This trait has seen a quick

adoption over the 5 years observed from 3,347,205 units in 2003 to a whopping 19,288,945 units in 2007.

The next closest herbicide trait in terms of percentage of total is the Liberty-Link trait with 11.27%. The Liberty-Link trait was introduced by Bayer and licensed out to Syngenta and Pioneer. This trait provides resistance to the active ingredient *glufosinate*. Liberty-Link resistant hybrid corn has also shown an increasing trend across years, however just has not penetrated the number of units that the Roundup-Ready trait has. Unit sales of this trait increased from 1,648,950 in 2003 to 6,708,324 units in 2007.

Next in line is the IMI trait (also known as Clearfield) with 2.43% of the total units sold. This trait provides tolerance to *imidazolinone* herbicides. This trait was introduced and licensed out by BASF. This trait saw a peak in sales in 2004 with 966,429 units and then a rapid decline to 466,656 units in 2007. This downward trend will continue as the bulk of current hybrid stacks will favor the Roundup-Ready and Liberty-Link traits.

To wrap up the herbicide traits we end with the GT trait with .48%. This trait is Syngenta's version of *glyphosate* resistant corn. One may ask if this is the same trait as the Roundup-Ready trait, it is not. Two different biotech genes were used for each respective trait. This is a fairly new trait for Syngenta with an introduction in 2005 with a modest 63,016 units. They have increased units sold to 381,075 in 2007.

Insect Traits – Above Ground

For above-ground insect protection, I have included Agrisure CB (AGCB), Herculex CB (HXC), and YieldGard CB (YGCB). The above-ground insect protection focuses on the control of lepidopteran insects. These insects feed on the leaves, stalks, silks, or even the ears. The YieldGard CB technology has led the way in the market place for numerous

years. Next to the conventional number of units sold, YieldGard CB has the second highest number of units sold from 2003 to 2007 with 33.96%. This technology has had a steady run in the market place with 8,037,216 units sold in 2003 up to 13,002,377 units in 2007. Herculex CB (HXCB) has the next highest percentage of total units with 6.20%. HXCB was a relatively new technology in 2003 with only 246,558 units sold. This technology has had a very good increasing trend across all years observed with a total of 5,009,005 units sold in 2007. HXCB consistently shows a doubling trend with each year's increase. However, the 5,009,005 units sold in 2007 are still fewer than 40% of the total units of YGCB sold in 2007.

To wrap up the above-ground insect traits, the Agrisure CB (AGCB) technology crosses the finish line with only .82% of total units sold. This technology was introduced in 2005 with 3434 units sold. This technology also shows the increasing trend and wrapped up 2007 with 1,093,657 units sold.

Insect Traits – Below Ground

The below-ground insect traits focus on controlling the corn rootworm larvae. The corn rootworm traits included in this model are YieldGard RW (YGRW), Herculex RW (HXRW), and the Agrisure RW (AGRW) technologies. The rootworm technology was relatively new to the industry in 2003 with only 78,197 units sold with the YGRW technology. Being first to market, YGRW technology leads the way with 7.64%. As stated before YGRW sold only 78,197 units in 2003 and then blew up to a whopping 6,509,956 units sold in 2007. This number of units sold in 2007 also includes Monsanto's second generation rootworm technology called YieldGard VecTran RW

(YGVV). Due to lower introduction numbers and only one year of sales data, I chose to keep the model simple and included this data in the YGRW column.

The Herculex RW trait comes in second in sales with 1.31% of the total units sold. This technology was introduced in 2006 with 320,164 units sold that year. The trait increased in sales the following year by over 5 fold with a total of 1,603,437 units. The Herculex RW trait had the largest introduction of the three technologies, however the YGRW trait had six times the amount of units sold in 2007.

Agrisure RW (AGRW) rounds out the below ground seed technologies with only .08% of the total units sold. AGRW came to market in 2007 with 123,249 units sold.

Table 6.2 below gives a great visual of the number of units sold for each trait across years 2003 to 2007. The table allows you analyze the sales trends of all the traits across years.

Table 6.2 Individual Trait Sales Trends 2003 - 2007

	2003	2004	2005	2006	2007
IMI	790951	966429	829250	517301	466656
GT	0	0	63016	266502	381075
LL	1648950	1860619	2812853	3547551	6708324
RR	3347205	5502916	8703157	11118105	19288945
AGCB	0	0	3434	107278	1093657
AGRW	0	0	0	0	123249
HXCB	246558	524134	1236467	2107664	5009005
HXRW	0	0	0	320164	1603437
YGCB	8037216	8770612	10151649	9995109	13002377
YGRW	78197	485157	1294986	2868081	6509956
CV	15945533	14295157	11350994	9593095	6950887

6.2 Price Model Estimation Results and Model Evaluation

In order for this model to be fully functional, we must first choose the model and functional form that has the best fit. For this hedonic price model I evaluated two functional forms, a linear and semi-log. Below are the two estimations that were evaluated, equation 6.2 represents the linear form while equation 6.3 represents the semi-log form.

$$P_y = b_0 + b_{IMI} * IMI_y + b_{GT} * GT_y + b_{LL} * LL_y + b_{RR} * RR_y + b_{AGCB} * AGCB_y + b_{AGRW} * AGRW_y + b_{HXCB} * HXCB_y + b_{HXRW} * HXRW_y + b_{YGCB} * YGCB_y + b_{YGRW} * YGRW_y + b_{CV} * CV_y + e_y \quad (6.2)$$

$$\ln P_y = b_0 + b_{IMI} * IMI_y + b_{GT} * GT_y + b_{LL} * LL_y + b_{RR} * RR_y + b_{AGCB} * AGCB_y + b_{AGRW} * AGRW_y + b_{HXCB} * HXCB_y + b_{HXRW} * HXRW_y + b_{YGCB} * YGCB_y + b_{YGRW} * YGRW_y + b_{CV} * CV_y + e_y \quad (6.3)$$

Table 6.3 OLS Estimates of Hedonic Price Models

	Equation 6.2	Equation 6.2	Equation 6.3	Equation 6.3
Variable	Coefficient	T-stat	Coefficient	T-stat
Intercept	95.7484	66.6022	4.5655	332.5277
IMI	-3.5764	-2.1767	-0.0429	-2.7316
LL	3.5391	2.0223	0.0296	1.7689
GT	16.8693	7.3995	0.1506	6.9185
RR	11.2670	8.9239	0.1004	8.3263
AGCB	10.6939	4.2024	0.1028	4.2301
AGRW	25.9639	6.0819	0.2118	5.1939
HXCB	13.6267	6.9936	0.1232	6.6204
HXRW	16.7065	8.3138	0.1393	7.2587
YGCB	10.7803	8.9386	0.0962	8.3511
YGRW	17.3601	12.3766	0.1449	10.8198
CV	-7.9310	-3.0292	-0.0913	-3.6519
Adj R²	0.5089		0.4762	
DW	0.9771		1.0363	

In both models the b coefficients were estimated using the regression analysis tool in Microsoft Excel. Both models were estimated using the ordinary least squares (OLS) estimation. The results of both models are included above in Table 6.3. To determine which model gives us the most accurate fit we will perform a number of tests.

The first test looks at the variation of the price charged per hybrid seed corn unit explained by each of their respective models. To examine this variation we analyze the adjusted R² statistic for each model. The adjusted R² statistic measures the percentage of variation in the price charged per unit around its mean that is explained by the independent variables.

We can see in table 6.3 that the linear model (equation 6.2) has the most variation around the mean explained with 50.89%. The semi-log form has 47.62% of its variation explained around the mean.

Herbicide Traits

The next step in the analysis of these two models is to evaluate the coefficients and t-statistics. For the herbicide traits the t-statistics are all significantly different than zero at a 95% confidence level. As expected the IMI and CV coefficient is negative. These traits are older technology and the sales trend is headed down. Surprisingly the GT trait has the largest coefficient with a 16.86. I expected the RR technology to have the highest coefficient. I believe there is one key reason why the GT trait has a significantly higher coefficient. This technology was newly introduced in 2005 which may lead to some deception because of no sales data prior to 2005. With increasing production costs and inflation the average price of a unit of hybrid seed corn increases from \$97.50 in 2003 to \$118.44 in 2007. Another surprising stat to look at in this category is the t-statistic for the LL trait. LL technology has shown a significant increase in sales across all years and ended up with the lowest positive coefficient and t-statistic. In this category, the t-statistics and coefficients look better in the linear model (equation 6.2).

Above-Ground Insect Traits

All three above-ground insect traits (AGCB, HXCB, YGCB) have expected significant positive coefficients. HXCB nipped YGCB for the highest coefficient with a 13.62, YGCB came in with a 10.78. This is surprising to me since YGCB has 60% more sales than HXCB. This may be an area that Monsanto could raise their price on this trait. However, this trait is being modified with a second generation technology with expected release for 2009. I am also surprised with the lower coefficient on the AGCB trait. This trait was not established across years, hence I expected a larger coefficient for the same reason stated above with the GT technology. All three t-statistics are significant at a 99% level. Again in this category, all statistics look much better in equation 6.2.

Below-Ground Insect Traits

For the rootworm technologies the AGRW trait has a very large coefficient of 25.96. The next closest trait was YGRW with a coefficient 17.36. T-statistics for these two traits are 6.08 and 12.37, both are significantly different from 0 at a 99% confidence level. As we saw with the GT trait, the AGRW statistics could be skewed due to only one year of sales data with a small introduction in 2007. YGRW has the highest t-statistic due in part that this trait was well established in the market place across all years. HXRW has a very similar coefficient to YGRW with a 16.70 and a t-statistic of 8.31. The coefficient seems a low in comparison to YGRW due to the fact they have only 2 years of sales data. Here again in this section I am seeing better t-statistics and coefficients in equation 6.2.

Summary

Overall I believe the linear model provides us a much better model than the semi-log model. Equation 6.2 is consistently showing better t-statistics in all explanatory variables. Equation 6.2 also explains 3% more variation around the mean. However, the linear model is showing a lower Durbin-Watson statistic with a 0.98 when compared the 1.03 for the semi-log model. Still, these may be marginal differences as the two models are very similar in terms of the signs for the coefficients and the magnitude of their effects on price.

CHAPTER VII: CONCLUSION & RECOMMENDATIONS

7.1 Conclusion

The overall objective of this thesis was to evaluate the hybrid seed corn industry in terms of pricing and compare how Monsanto is reacting in the market. I approached this objective from two different angles. In chapter IV, I estimated six demand models. The first three models estimated a snapshot of the entire hybrid seed corn industry, while the last three models estimated where Monsanto sits in the market in comparison to the rest of the industry. In chapter VI, I proceeded with a hedonic pricing model, where I broke out the different attributes (traits) in our current hybrid seed varieties and estimated a model to see the value in each of the traits.

When evaluating the demand for entire hybrid seed corn industry I found a model that when finished was stable. I used six independent variables in the model: price, Monsanto trait, and four regional dummy variables. In our final model, four out the six explanatory variables were significant at the 99% level. The adjusted R^2 value for this model was 16%, this may seem low but this is common with this type of cross sectional data. The model also showed a couple common trends in the industry. The first trend is with a positive coefficient on the Monsanto trait variable. This tells me that farmers are paying more for Monsanto's technology which shows the value in the products. The second trend showed that of the four regional dummy variables, Iowa-Illinois-Indiana variable had the largest coefficient which is to be expected from the corn-belt.

In the last part of chapter IV, I focused on estimating a demand model for Monsanto traits. In this model I dropped the Monsanto trait dummy variable and added a proxy competitor price variable. I filtered the industry data set to find an average competitor price for each state sampled and inserted that price into the data set with all of Monsanto trait sales. For these estimations we focused on the stability of the model along with the elasticities. The model with the best fit showed three out of six independent variables significant at the 95% level with an adjusted R2 value of 14%. The model also showed a price elasticity of -1.82 and a cross price elasticity of 0.63. The key point here is the positive cross price elasticity value, which tells me that when the competition increases their prices Monsanto's hybrids will be in higher demand.

Using the estimations above, I could then find the revenue and profit maximizing prices of a bag of Monsanto hybrid seed corn. To find these values we used our linear demand curve. For the revenue maximizing price I estimated a total revenue function and then took the derivative of that to find the marginal revenue function. We know that the revenue maximum is when marginal revenue equals zero. When setting the marginal revenue function to zero when find a revenue maximizing price of \$98.99/ unit Monsanto hybrid seed corn.

When evaluating the profit maximizing price we have to take production and sales cost in to account. By setting marginal revenue equal to our costs, I can determine the point where Monsanto can maximize their profits. By inserting Monsanto's average production and sales costs, I found a profit maximizing price of \$130.91/unit. In comparison to the average price paid to Monsanto per unit was \$117.11. Firms often choose a price in reality

lower than their profit-maximizing price in order to establish or maintain market share, but the difference here suggests that Monsanto could profitably raise prices, though whether doing so at this stage of Monsanto's market plan will need to be evaluated.

In chapter VI, I used the same data set to estimate a hedonic pricing model. I broke the data set into eleven independent dummy variables for each type of trait represented. There are three main categories of traits represented in the model: herbicide, corn borer, and rootworm traits. In the herbicide category I included BASF's IMI, Syngenta's GT, Bayer's Liberty Link, Monsanto's Roundup Ready, and conventional corn. For the corn borer protection traits I included Syngenta's Agrisure trait, Dow's Herculex trait, and Monsanto's YieldGard trait. On the rootworm traits I included Syngenta's Agrisure trait, Dow's Herculex trait, and Monsanto's YieldGard and YieldgardVT traits. For this price model I estimated two functional forms, a linear and a semi-log form. I found the linear model to be the more stable of the two. When analyzing the model the coefficients were as expected. I expected negative coefficients on the IMI and conventional corn due the declining sales of each. Surprisingly, Syngenta's traits had the highest coefficients in two out of the three categories. This is misleading due to the fact that these traits are newer and didn't have a full five years of sales data. Also as expected all of Monsanto's traits showed high significant coefficient values with a full 5years of sales data on all traits. The linear model also had an adjusted R^2 value of 51%.

Overall I feel that I have provided some very valuable information for Monsanto. With a couple minor tweaks and additions I provided three valuable tools for the company to use when evaluating pricing decisions for 2010.

7.2 Recommendations

In this study I believe we gathered a lot of valuable information for the data that was provided. However, with some more effort, time, and data this project could be a market changing tool.

My first recommendation would be to work internally with Monsanto to be able to use company level, highly confidential data. The data set used was *dmrkynetec*'s best estimated values but sampled data is never as accurate as internal data. This of course would have to be accessed and analyzed with the proper authorities and access to this type of data. It would also be beneficial to analyze how the marketing plan fits into this model. If Monsanto is purposely pricing hybrids below the optimum profit maximizing price then the model is more accurate than I thought. Based on the information provided in this project I believe there is value left on the table. I think an analysis of the current pricing model would be beneficial, specifically in the area of the percentage of the value captured. I do believe that we adequately explained the actual movements (price paid per unit of seed), which is what Ekanem and Sundquist were lacking in their hedonic model. My next recommendation would be to include a couple more independent variables in the model to see how the estimates react. Variables that I would include would be an actual competitor price for close substitute hybrids. This information could be found with a more detailed data set from *dmrkynetec*. Data that is broken out more by each brand would be quite beneficial. Another variable that I am curious to see the estimates would be the commodity price of #2 yellow corn. You could use this variable as a time lagged variable to see what kind of correlation there might be with the average price charged per unit.

My third and final recommendation would be to incorporate all of the above recommendations and analyze the project with 2008 and 2009 data. Two more years of sales data would provide two key benefits. The first benefit would be that many of the newer traits that were introduced in 2004 and 2005 would have additional data points. This will give Monsanto a better idea in terms of value and pricing of those traits. The second key benefit to adding 2008 and 2009 data would be that the estimates will have taken into account some of the largest seed price increases to date. As I am writing this thesis, farmers are faced with close to \$300/unit hybrid corn for the 2009 growing season. I also believe that including data through the 2009 season will give a great picture of the big trait evolution. 2009 and 2010 are the projection years for the next wave (2nd generation traits) to hit the market.

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