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The Economics of Value Enhanced Crops: An Analysis of Benefit Sharing in the U.S.

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Abstract

The introduction of a second wave of product quality GMOs has the potential to provide new momentum to the agricultural biotechnology industry. The challenge facing the industry is to generate innovations that will allow them to offer a large adoption incentive while capturing sufficient revenues to support R&D investment.

Key words: value enhanced crops, genetically modified organisms, monopsony markets

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Introduction

The first widely grown plant varieties of genetically modified organisms (GMOs) were introduced to US in 1996. By the 2000 crop season, some 109 million acres were devoted to GMOs. Virtually all of this area was planted to "first generation" GMOs that modified or substituted for chemical input use in soybean, corn, and cotton. Total US revenue from GMOs fell to approximately $648 million in 2000 from $759 million in 1999 and developing world revenue stood at just $40 million. The introduction of a second wave of GMOs that modify one or more output characteristic to add value to the commodity has the potential to provide momentum to the agricultural biotechnology industry.

In this paper we review the status of value enhanced crops, sometimes referred to as product quality crops, and discuss the potential impact on farmers and industry. We examine data that are available on VEC products including GMOs developed through genetic engineering, and non-GMOs developed through conventional plant breeding approaches. The objective of the paper is to develop insight into the potential impact of VEC GMOs, which are considered by some to be a major component the next wave of agricultural biotechnology.

Status of Value Enhanced Crops in the US

APHIS is the USDA agency charged with regulating the introduction of GMOs into the environment in the US. Two main steps are involved in clearing a GMO for commercial use. The institution producing a new GMO must first either obtain a permit to conduct field trials or notify APHIS of its intent to conduct field trials of the new "regulated article[1]". After conducting field trials, the institution may petition APHIS to have an article removed from regulated status. If the petition is granted, the GMO may be commercialized. Once an article is removed from regulated status, subsequent GMOs of the same crop can be developed without additional approvals.

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[1] "Regulated articles are organisms and products altered or produced through genetic engineering that are plant pests or that there is reason to believe are plant pests." APHIS web page

Product quality has been an important focus of biotechnology research. Product quality[2] accounted for 20% of all trials, with interest peaking in the mid-1990s. In 1994 and 1995, more trials were conducted for product quality than for any other phenotype category. Within product quality trials, attention in recent years has focused on corn, soybeans, and potatoes. Despite this large number of trials, only one soybean GMO and no potato or corn value enhanced GMOs have been approved for commercial planting. The very first article to clear regulation was a value enhanced GMO, Calgene's Flavr Savr® tomato in 1992. A total of twelve value enhanced articles have been approved. Of the twelve approvals, ten have been for tomato articles, one for canola and one for soybean.

Even though the APHIS trial data indicate a significant level of investment by industry in developing VEC GMOs, none of these products has yet had achieved a significant commercial acreage. Several VEC products are in the pipeline with the potential to generate future revenue for industry and to deliver benefits to farmers. The traits provide value as manufacturing ingredients, animal feed, or improved food characteristics.

Several value enhanced corn products developed through conventional breeding methods have been marketed in the US. Many firms such as DuPont and Monsanto currently commercialize value enhanced corn products. The main value enhanced corn products are high oil corn, waxy corn, white corn, nutritionally dense corn, and high amylose corn. In addition to value enhanced corn products, several value enhanced soybeans were introduced to the market. DuPont Specialty Grains, once known as Optimum Quality Grains, commercializes all current value enhanced soybean products. In 1997, Optimum Quality Grains commercialized oilseed varieties including high protein soybeans, high sucrose soybeans, high oleic soybeans, low linolenic soybeans, and low saturate soybeans.

Value Enhanced Crop Contracting

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[2] Product quality articles are representing those found in the product quality phenotype category excluding those that may be found in the "other" or "multiple" categories.

The use of contracts has proven to reduce production and financial risks in hog and broiler production. Knoeber and Thurman (1994), Martin (1997), and Goodhue (2000) evaluate relative performance through the use of contracts in US broiler and hog industries and show that offering agents payment incentives can control moral hazard behavior.

Contracts are also utilized in the production of value enhanced crops (VEC) such as high oil corn and high oleic soybeans. A producer of VEC signs a contract providing the necessary inputs for production with a contracting agent to produce a VEC variety. In some instances, the contracting agent provides the seed necessary for production. Jackson and Curry (2000) discuss issues that the producer is to consider when establishing specialty grain and oilseed contracts. By signing the contract, the producer is able to benefit from reducing financial risk, accessing new technologies, accessing new markets, receiving price premiums, and reducing marketing risk. The contracting agent also receives benefits through the contractual agreement with the producer. These benefits allow the contractor to maintain quality control as well as supply management, to reduce financial risk, and to control technology and markets.

Contractual agreements are not free of risks to both the producer of VEC and the contracting agent. Producer risks may include long-term investments and short-term contracts, payment risk, limited returns, reduced management control, and satisfying identity preservation requirements. Contracting agent risks may include finding amenable parties, possibilities of litigation, controlling technology, and unreliable producers. Therefore, in order for producers to reduce risk and increase income, they must consider consulting a legal expert, observing production issues, observing payment and delivery issues, and observing legal issues (Jackson and Cuppy, 2000).

The type of contract most often found in VEC production is marketing premium contracts. These contracts involve producers of the variety receiving a premium above the price of commodity corn produced in similar geographic locations, which has a well-defined market price. These premiums offer an economic incentive to growers proposing to produce VEC varieties.

The Theoretical Model

We theoretically evaluate the relationship between the farmer producing VEC and the contracting agent that purchases VEC to be passed along the supply chain to the end-user as inputs. The model, which best explains this relationship, is that of the monopsony. The monopsonist may be any contracting agent that establishes a contract with the farmer of the VEC. First, we graphically evaluate the competitive market for conventional crops (figure 1). The equilibrium price and quantity of the conventional crop in a competitive market will be denoted as r^c and x^c, respectively. The supply curve is upward sloping; therefore, as x^c increases, r^c also increases. The marginal value product (MVP) represents the derived demand for the conventional crop, which is equivalent to the value of marginal product in a perfectly competitive case due the nature of price taking by farmers.

Now, we introduce imperfect competition into the model. The monopsonist serves as the price-searcher; that is, the contracting agent is searching for the lowest price possible to purchase a crop at the profit maximizing level. This profit maximizing level is where the value given to each additional product equals the cost given to each additional factor, referred to as marginal value product (MVP) and marginal factor cost (MFC).

In figure 2, we assume that the conventional crop is produced in a perfectly competitive market, but are purchased by a monopsonist. The marginal factor cost curve is upward sloping due of the additional costs of taking on additional factors. Although the monopsonist maximizes profit at the equilibrium point of MVP and MFC, the contracting agent chooses to set its price off the supply curve at the optimal level due to the lower purchasing price rather than the higher purchasing price offered in a competitive market.

In figure 3, we introduce value enhanced crops (VEC) to the model. Due to the nature of adding value to the conventional crops through enhancing the characteristics or composition of the seed, the innovator is forced to create a specialty market for VEC. However, in order for farmers to adopt such products, there must be some economic incentive to produce; that is, sell at a price that is higher than the price received for producing conventional crops in a competitive market. The assumptions for this model will be that the conventional grower and the adopting farmer share the same cost structure. Also, the monopsonist has a downward sloping derived demand curve, referred as the MVP curve and is found by the additional revenue or value added per unit of input. In this case, the MVP curve is assumed to be relatively elastic due to the numerous alternatives to purchasing VEC. However, we do assume that there is a parallel shift in the MVP due to all the additional factors affecting the demand for the specialty products. Here, the competitive factor price serves as a floor price. Although the monopsonist is willing to buy at a price as low as r^m and no higher than a price of r^*, the firm must offer a price equal to or greater than the price offered for a conventional crop in a competitive market. There must be some negotiation between the monopsonist and the seller of the input (farmer).

Although the monopsonist is able to capture all of the rent distribution, we cannot realistically believe this is able to occur due to the floor price. The adopter is going to require a price equal to or greater than the price offered for a conventional crop. Thus, we make the assumption that the cost structure is not the same. That is, there is an increase in the cost of production as well as a risk premium required by the adopter. Thus, we show in figure 4 a parallel shift in the supply curve for the specialty input with all other assumptions remaining the same. We see that there is a smaller negotiation area than in figure 3. We expect to see that even with a quite elastic demand curve, it will be tougher for the contracting agent and adopter to negotiate. We see that as expected, the negotiation area is still relatively small.

Area and Premiums for Value Enhanced Crops

Most of the value enhanced crops are new to US agricultural markets, competing with established grain crops for crop acreage and market acceptance. The area devoted to VECs in the US remains relatively small, and non-transgenic varieties accounted for more than 95% VEC area planted in the US in

1998 (Penn). In 1995, the harvested acreage of value enhanced corn made up just 3.3% of total US harvested acreage, increasing to 5.5% by 1999. Estimated acreage ranging from approximately 2.2 million acres in 1995 to about 3.7 million acres in 1999.

High oil corn, the fastest growing value enhanced corn product on the market, has experienced an increase of 830,000 acres during the period of 1995 to 1999. However, the estimated acreage for 2000 has decreased by 25% and is projected to decrease an additional 15% by the end of 2001[3]. This is a result of low feed fat prices, which has decreased the demand for high oil corn. Although waxy corn has experienced numerous fluctuations over the period ranging from 420,000 to 575,000, it follows with an increase in 1999 due to an increase in the demand for silage and feed for dairy and other livestock remaining stable in 2000. Nutritionally enhanced corn, or high protein corn, has remained relatively stable from 1995 to 1998; however, acreage has increased to 200,000 acres in 1999 due to increased demands for livestock feed applications. Although some varieties had poor agronomic performance, the estimated acreage in 2000 has increased by 25,000 acres. The estimated acreage for high amylose corn was on average 35,000 acres from 1995 to 1998 with an increase of 10,000 acres in 1999 remaining relatively stable in 2000.

Over the period of 1997 through 1999, value enhanced soybean growers began to increase production. In 1997, acreage for all value enhanced soybean products was estimated as 10,000 acres. However, there was an increase in acreage planted for high sucrose, high oleic, and low saturate varieties by 20,000, 20,000, and 40,000 acres, respectively.

An array of arrangements between germplasm suppliers, farmers and end-users has been used to establish VECs. Some arrangements provide farmers with a contract price guaranteeing them a premium over conventional grain prices. Licensing agreements have become more important not only for genetically modified organism products but also for non-genetically modified products. Seed companies are preserving the identity of their products.

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[3] Percentages are based on information provided by the U.S. Grains Council 2000 – 2001 Value Enhanced Grains Report. Data for the year 2001 are based on projections.

Contractual agreements play an important role in the marketing development of value enhanced corn products. Premiums for value enhanced corn were relatively stable from 1995 to 1998, but did decline slightly in 1999. Premiums for high amylose were $1.20+ per bushel in 1999. All of high amylose acreage was produced under contract priced on a per-acre basis. DuPont Specialty Grains offers high oil contracts (harvest delivery and buyer's call) through an online service, Optimum Sales Connection and Resources (OSCAR). Although seed costs are estimated at $27 - $30 per acre, the contractor usually provides seed to the farmer.

Growers are given on average higher premiums through the buyer's call contract than under the harvest delivery contract. Although growers are required to pay a $30 premium per seed unit, those who utilize the OSCAR service are eligible for seed cost refunds. Data on premiums for nutritionally enhanced corn were unavailable from 1995 – 1997, but the premium of $0.15 per bushel in 1998 increased by $0.05 in 1999 due to an increase in the demand for protein ration substitutes in livestock feed. In 1995, the average premium for waxy corn was $0.15 per bushel increasing to $0.20 per bushel the next year. By 1997, waxy corn experienced premiums of $0.28 per bushel and remained stable until 1999 with a decline of $0.05. Due to increased demand for white corn both domestically and abroad, premiums have remained relatively high during the period, despite increased acreage. In 1999, growers began producing white corn in the open market due to a seasonal drought in South Africa with premiums as high as $0.60 per bushel. However, those premiums fell to an average of $0.23 per bushel by the end of 1999 and the beginning of 2000.

DuPont Specialty Grains is the commercializing company providing the seed. High protein soybeans premiums ranged from $0.12 to $2.25 per bushel in 1999 with a weighted-average premium of $0.25 per bushel. High sucrose, high oleic, and low linolenic soybeans all show average premiums of $0.40 per bushel. The range of premiums for low saturate soybeans is $0.00 to $0.25 with an average of $0.25 in 1999.

Farm and Industry Revenue and Surplus Estimates

The rate with which VEC crops have spread has been modest to date, despite the availability of several products with useful output traits. This stands in contrast to the rapid adoption of the first generation GMOs. Previous studies that measured the benefits of insect resistant cotton and herbicide tolerant soybeans found relatively large benefits to farmers, and found that farmers obtained a larger share of total economic benefits than either industry or consumers. The size of farm benefits and the fact that benefits were attainable with very simple changes in farm production systems were important determinants of the steep diffusion curve. To achieve similar results, second VEC GMOs will need to offer crop alternatives that are both profitable and that have low production and marketing risks.

For many VEC products no market exists at present (Boland et al, 1999). To capture any benefits from the derived demand for the output trait, the trait developer may be required to create a new market by forging vertical linkages with processing or merchandising firms, adding to the biotechnology firm/seed firm linkage that was required in the past. Farm prices will be the result of negotiation between farmers and merchandising firms.

Because these are new products, relatively little information is available on prices, revenue and production outcomes. In particular we were unable to assemble almost no information on the value of VEC products as animal feed or industrial inputs, i.e. on the derived demand. This forces us to omit any surplus captured by firms after the grain leaves the farmgate. It is certain that some rents accrue to grain merchandisers and to firms processing VEC products, so in this respect we are not measuring the total surplus creation. The information that we have assembled on farm costs and revenue comes from two main sources, a comprehensive study by the US Grains Council and from the Illinois Specialty Farm Products website.

Industry revenue from sales and surplus estimates of value enhanced corn and soybeans are presented in table 1 and table 2. Revenue and surplus estimates for high oil, waxy, white, nutritionally dense, and high amylose corn are shown in table 10. The total area for the selected value enhanced corn is approximately 3 million acres with the largest percentage of acreage planted in high oil corn seed.

Premiums to farmers for the value added grain varieties range from $0.20 to $1.10 per bushel. Yield estimates represent the four-year-average for central Illinois farms from the Illinois Farm Business Records (Illinois Specialty Farm Products). Average yields for all products were between 60 and 100% of conventional corn seed. Seed companies are able to capture revenue for all varieties except white and high amylose corn. The white corn seed market has become competitive enough that seed no longer sells at a premium. High amylose corn is organized under a production contract in which the seed is provided and title to grain is retained through a production contract. Seed company surplus calculations are not calculated because we were unable to obtain the information needed to calculate profit from marketing the grain, but presumably there is some margin for the seed companies. The estimated change in farmer surplus ranges between $29.40 per acre for high oil corn to $102.30 per acre for high amylose corn. Seed companies captured $17 million in revenue from high oil corn, and a total of only $3.3 million from the other three products. Farmers captured over $37 million, with their share of surplus ranging from 63% for high oil corn to 95% for waxy corn.

The total area for high protein, high sucrose, high oleic (transgenic), low linolenic, and low saturate soybeans is just 130,000 acres with the largest area planted in low saturate seed (table 2). Premiums to farmers for the oilseed varieties range from $0.25 to $0.40 per bushel. Average yields for all value enhanced soybean products range between 88 and 100% of conventional soybeans. Prices of value enhanced soybean seed range from $0.00 to $6.00 per acre more than conventional seed prices. The change in farmer surplus for value enhanced soybean ranges from $11.50 per acre for low saturate and $18.40 per acre for high sucrose and high oleic (transgenic), respectively. Seed companies sell high protein and high oleic soybean seed at no premium over conventional varieties. This is an interesting development, suggesting that they may in some cases view value enhanced soybean varieties as a means of capturing additional market share, rather than as a means of boosting per unit profit. Total net revenue to seed companies ranges from $0.00 for high protein and high oleic varieties to $300,000 for low saturate soybeans – a total revenue of only $380,000 for all products. The value enhanced soybean area in the

U.S. suggest that farmers are capturing anywhere between 66% and 100% of the farmer surplus and seed company net revenues.

Table 3 summarizes estimates of VEC area and revenue by crop. Value enhanced corn at present is far more important than value enhanced soybeans, with value enhanced soybean representing just 4.3% of the total VEC acreage. Total farmer surplus is estimated at about $97 million for corn and $2 million for soybeans. Ninety-eight percent of seed company VEC revenues are from corn products. Clearly, although transgenics show promise, our results demonstrate that seed companies are not yet capturing significant revenues from transgenic seed sales.

Summary and Conclusions

Transgenic value enhanced products show promise of adding momentum to the diffusion of GMO crops in the US. A large number of promising new products are in the pipeline. The data that we have examined in this study however, demonstrate that the impact on farmers and seed companies has been modest to date and we foresee this trend of slow growth to continue. At least three major challenges face the industry as it tries to replicate the rapid market growth that characterized first generation GMOs. The first requisite will be to attract farmers to adopt by offering large per acre profits compared to alternative crops. VEC products will have to perform well for farmers. Because of the probable yield drag generally associated with VEC products, significant price premiums will be needed. This will be particularly difficult given the fact that discounts are becoming more common for food quality GMO soybeans at present. The adoption of VEC GMOs may also be slower than for input trait GMOs because they introduce uncertainty into the production process. Roundup Ready soybeans or Bt cotton merely require farmers to plant a different type of seed, with little change in yield. Several of the VEC products have lower expected yields, and farmers may have difficulty forming yield expectations for these new crops. Unless they are compensated for this increase in production risk, farmers will not adopt. Finally, it may take time for the most appropriate marketing arrangements to evolve. Again, first generation GMOs could be sold into commodity markets in all parts of the country, while VEC products will require significantly more coordination between seed firms, farmers and end users. These marketing institutions may be slow to develop and will require that some of the surplus created by VEC innovations be shared downstream in the marketing chain.

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Figure 1: Base Model (assuming perfect competition)

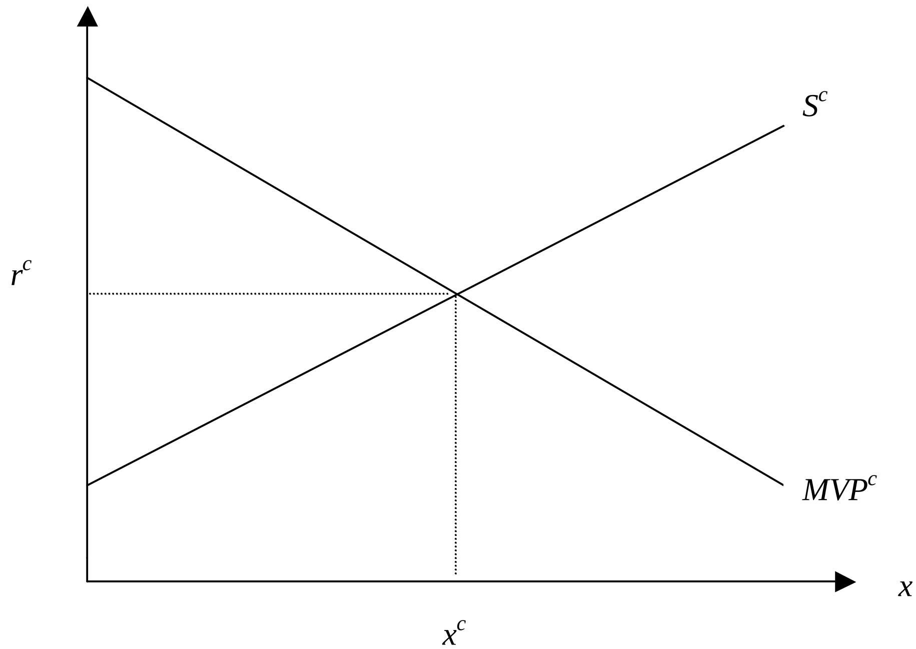

Figure 2: The Monopsonist's Model (assuming imperfect competition)

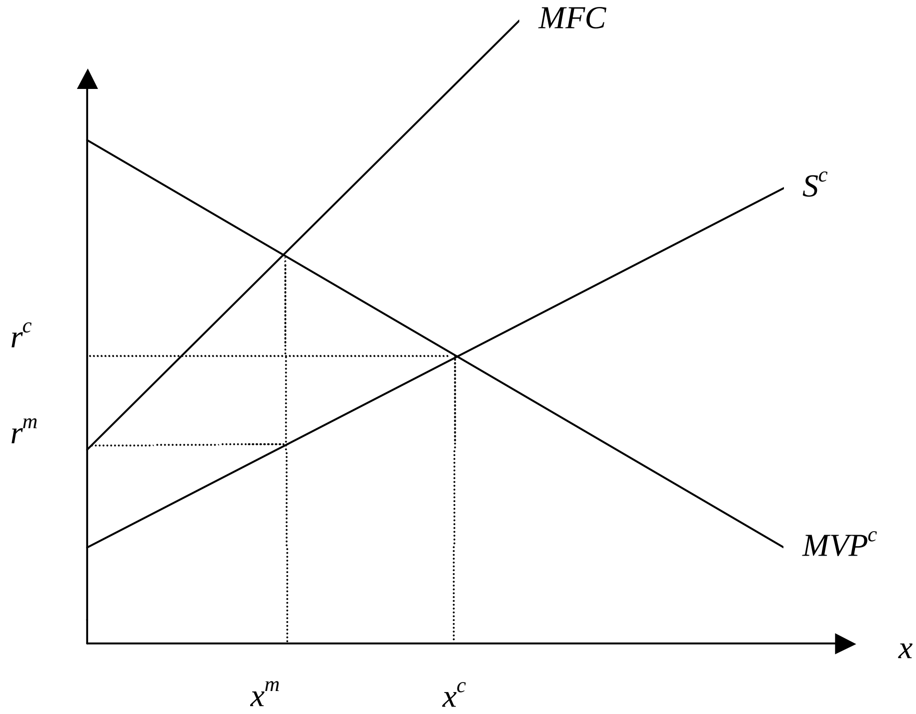

Figure 3: Same Cost Structure Model for Commodities and VEC

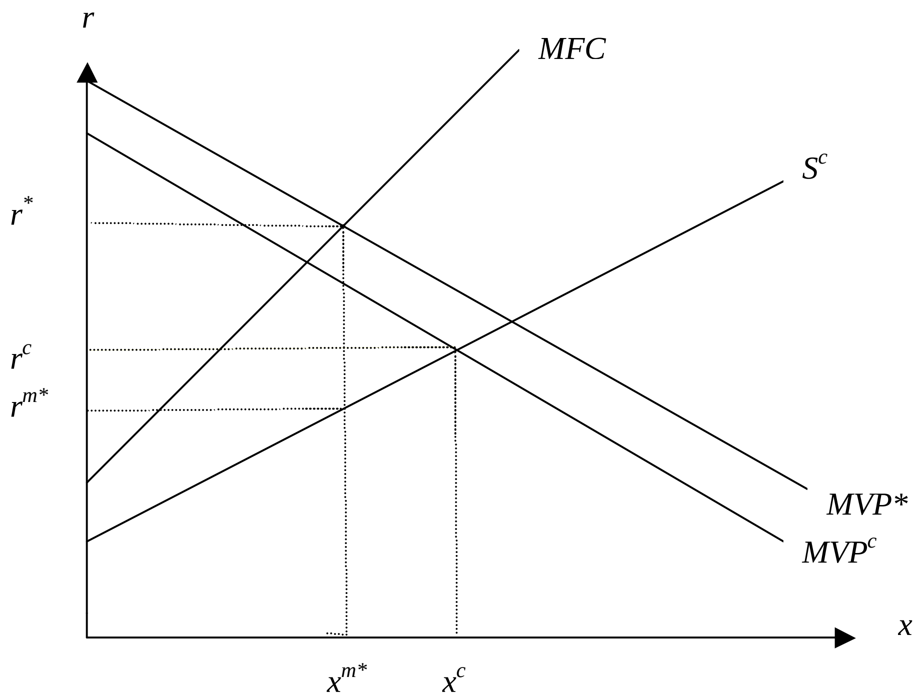

Figure 4: Different Cost Structure Model for Commodities and VEC

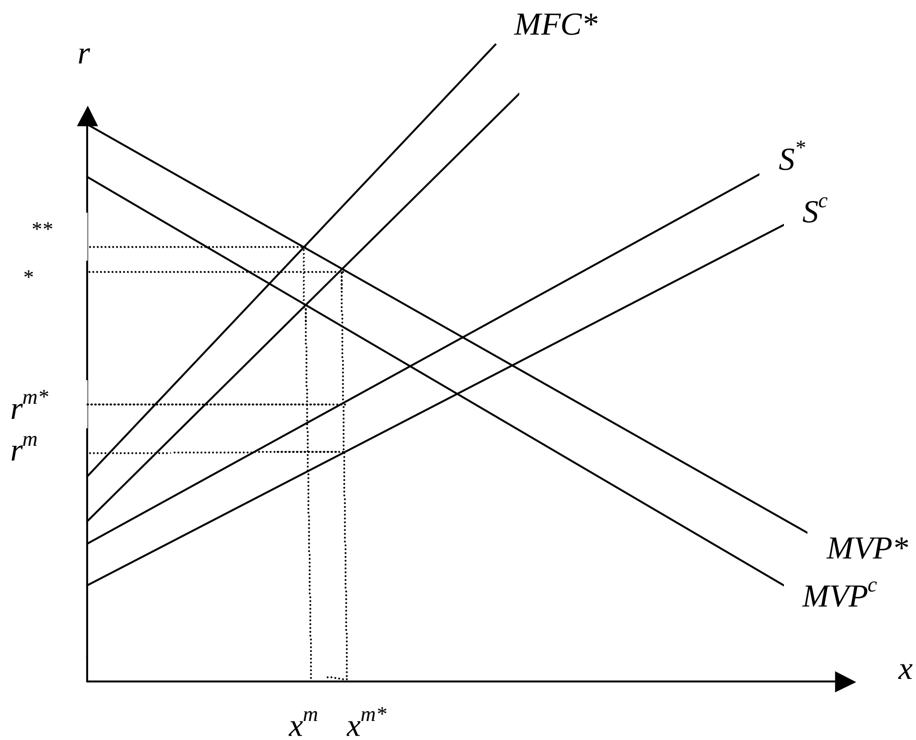

Table 1: Industry and Farmer Revenue and Area from Value Enhanced Corn

	High Oil	Waxy	White	High Amylose	Nutritionally Dense
Area in U.S. (thousand acres)	1,000	550	1,100	45	200
Grain Premium to Farmers ($/bu)	$0.20	$0.23	$0.23	$1.10	$0.20
Grain Yield from Conventional Seed (bu/acre)	155	155	155	155	155
Grain Yield from VEC (bu/acre)	147	155	147	93	148
Value Enhanced Seed Price ($/acre)	$50.00	$35.00	$33.00	a	$44.00
Conventional Seed Price ($/acre)	$33.00	$33.00	$33.00	$33.00	$33.00
Net Revenue to Seed Co. ($/acre)	$17.00	$2.00	$0.00	a	$11.00
Change in Farmer Surplus ($/acre)	$29.40	$35.65	$33.81	$102.30	$29.60
Seed Companies' Total Net Revenue ($ million)	$17.00	$1.10	$0.00	a	$2.20
Total Farmer Surplus ($ million)	$29.40	$19.60	$37.20	$4.60	$5.90
Farmer Surplus + Seed Co. Net Rev. ($)	$46.40	$20.70	$37.20	$4.60	$8.10
Seed Companies' Share of Farm Surplus	37%	5%	0%	a	27%
Farmer Share of Total Surplus	63%	95%	100%	a	73%

Source: Illinois Specialty Farm Products and U.S. Grains Council.

[a]Seed provided and title to grain retained through production contract; information needed to calculate profit to seed company not available.

Table 2: Industry and Farmer Revenue and Area from Value Enhanced Soybeans

	High Protein[a]	High Sucrose[a]	High Oleic[b]	Low Linolenic[a]	Low Saturate[b]
Area in U.S. (acres)	10,000	30,000	30,000	10,000	50,000
Premium to Farmers ($/bu)	$0.25	$0.40	$0.40	$0.40	$0.25
Yield from Conventional Seed (bu/acre)	48	48	48	48	48
Yield from VEC (bu/acre)	48	42	46	46	46
Value Enhanced Seed Price ($/acre)	$19.00	$21.00	$19.00	$21.00	$25.00
Conventional Seed Price ($/acre)	$19.00	$19.00	$19.00	$19.00	$19.00
Value Enhanced Net Revenue to Seed Co. ($/acre)	$0.00	$2.00	$0.00	$2.00	$6.00
Change in Farmer Surplus ($/acre)	$12.00	$16.80	$18.40	$18.40	$11.50
Seed Company Total Net Revenue ($)	$0	$60,000	$0	$20,000	$300,000
Total Farmer Surplus ($)	$120,000	$504,000	$552,000	$184,000	$575,000
Farmer Surplus + Seed Co. Net Rev. ($)	$120,000	$564,000	$552,000	$204,000	$875,000
Seed Companies' Share of Total Surplus	0%	11%	0%	10%	34%
Farmer Share of Total Surplus	100%	89%	100%	90%	66%

[a]1998 actual acreage

[b]1999 estimated acreage

Source: Illinois Specialty Farm Products; Penn

Table 3: Summary of VEC Area and Revenue

	Corn	Soybeans	Total
Area	2,895,000	130,000	3,025,000
Farmer Surplus	$96,722,000.00	$1,935,000.00	$98,657,000.00
Seed Company Revenue	$20,300,000.00	$380,000.00	$20,680,000.00
Seed Company Revenue from GMOs	$0.00	$0.00	$0.00