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Impact of Biotech Grains on Market Structure and Societal Welfare

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We quantify the economic impact of introducing genetically modified (GM) crops. Short-run results suggest that it might be optimal to maintain the identity of a greater proportion of non-GM grain than is currently demanded by non-GM consumers. Long-run results show that GM crops almost always benefit society, but one scenario is presented where overall welfare falls.

Key Words: Bt corn, consumer welfare, genetically modified crops, identity preservation, producer welfare.

Introduction

The rapid adoption of genetically modified (GM) corn and soybeans in the United States has generated interest in the short- and long-run impacts of these crops on prices and welfare (Fernandez-Cornejo & McBride, 2002). In this summary paper, we begin with some general characterizations about the way the marketplace has responded to these innovations, and we then use these characterizations as assumptions to derive results about the short- and long-run impacts of these products. The short-run results focus on potential disruptions to the commodity market due to producers' inability to respond quickly to changes in market conditions. The long-run results assume that supply can adjust to meet consumer demands and focus on the welfare impacts of a particular innovation—Bt corn in the United States. The short-run results suggest that it might be optimal to maintain the identity of a greater proportion of non-GM grain than is currently demanded by non-GM consumers. The long-run results show that society almost always benefits from the introduction of these products, but we do present and describe one scenario where overall welfare falls. More detailed descriptions of the model and results are provided in a working paper that is available from the authors (Lence & Hayes, 2001).

Characteristics of GM Crop Markets and Modeling Assumptions

We assume the following general characteristics regarding GM crop markets to build a standard market simulation model to estimate the likely short- and long-run impacts of introducing GM crops:

1. Adoption of GM crops has been so widespread that the bulk handling facilities that had earlier been set up for non-GM crops are now used primarily for GM crops. This means that non-GM crops must now be handled in a way that preserves identity and which is significantly more expensive than the bulk handling system (Lin, Chambers, & Harwood, 2000; Bullock & Desquilbet, 2002).
2. Some consumers are indifferent between GM crops and non-GM crops, others are adamantly opposed to the new technology, and the rest prefer non-GM grain but are willing to buy GM grain if it is sufficiently less expensive than non-GM grain (Moon & Balasubramanian, 2001).
3. Some producers benefit from GM crops and adopt (Fernandez-Cornejo & McBride, 2000). Other producers do not adopt because the benefits do not outweigh the additional costs. The net benefit from adoption is modeled as a continuum across producers.
4. In the short run, the amounts of GM and non-GM grain available are fixed, because it takes time for producers to adjust to market conditions.
5. In the long run, producers supply the amounts of GM and non-GM grain that suit consumer preferences.

The model was simulated over a wide range of possible parameterizations regarding consumer preferences, production technology, identification costs, etc. Some of the most interesting results from this larger sensitivity analysis are discussed below.

Short-Run Results

Two proportions drive short-run results. The first of these is the relative share of total output that is non-GM. The second key proportion is the share of demand that comes from consumers with strong preferences for non-GM grain (i.e., individuals who are willing to pay for the additional handling costs associated with the non-GM crop). If the non-GM output share exceeds the non-GM demand share, then the non-GM surplus will be consumed by individuals who are indifferent between GM and non-GM grain, and producers will receive the same price (net of identification costs) for the two types

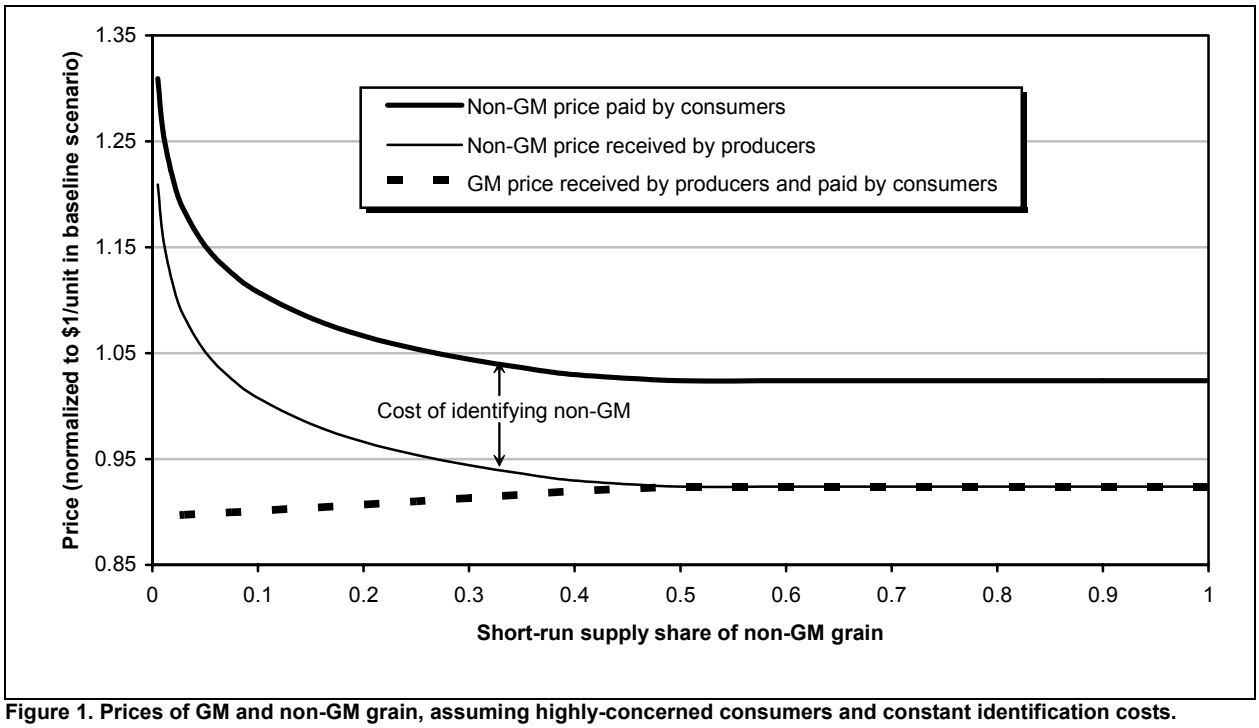

Figure 1. Prices of GM and non-GM grain, assuming highly-concerned consumers and constant identification costs. Baseline scenario consists of a zero supply of GM grain.

of grain. In this situation, non-GM grain becomes another niche crop, and the price paid by non-GM consumers will reflect the additional handling costs associated with the identity preserving handling system.

The niche market solution predominates in the simulations reflecting consumer preferences and producer benefits as observed in 2000-2002. However, a different solution emerges when the model is parameterized to represent a heightened level of consumer concern about GM crops. This scenario is interesting because it shows what might happen if a new event increased consumer concerns at a time of the year when the relative proportions of both types of grain have been fixed.

Results from this high-concern scenario assuming constant identification costs (normalized at $0.10/unit) are shown in Figure 1. The horizontal axis shows the proportion of non-GM grain that is available in the short run. The vertical axis shows the normalized prices of both GM and non-GM grain. In all instances, the price of the non-GM grain paid by consumers exceeds the price that producers receive for this grain by the constant costs associated with identity preservation. As expected, the price of non-GM grain rises when the non-GM share that is available is lower than the proportion of consumers who are willing to pay the higher price associated with this product. This effect can be seen in Figure 1 by noting that both the price paid by consumers and the price received by producers for non-GM grain increase when the supply share of this product falls below 50%. This result is very intuitive and simply reflects a relative increase in demand for a scarce product.

One surprising result from this scenario is the behavior of the GM price in Figure 1. The price of GM grain falls in both relative and absolute terms when non-GM grain becomes scarcer. The intuition behind this result is as follows. Market clearing conditions require that all grain be consumed in all scenarios. When non-GM grain is scarce, a consumer who would have otherwise preferred to purchase non-GM grain will have to be enticed into buying GM grain. In a commodity market, all GM grain must sell at the same price; this means that when some GM grain is discounted to entice a reluctant consumer, the entire crop must also be discounted. We refer to this as a "hot potato" scenario, because the way this scenario would evolve is that some grain supplier would find itself in a position where it had a relative surplus of GM grain, and it would try to sell this grain at the standard price rather than sell it at a discount to a consumer who really wanted non-GM grain. This surplus of GM grain would be passed around like a hot potato until it ended up being sold at a discounted price, but only after it had forced down the price on the entire GM crop.

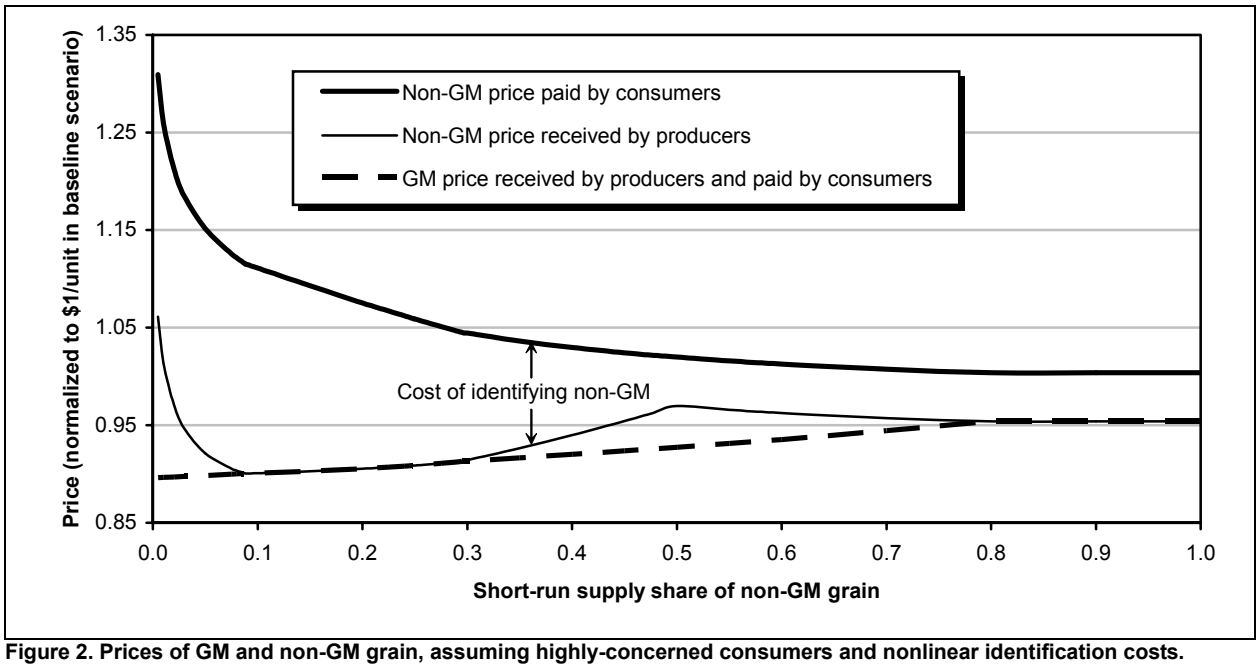

Figure 2. Prices of GM and non-GM grain, assuming highly-concerned consumers and nonlinear identification costs. Identification costs = max(0.05, -0.15 + 0.4 z) dollars per unit, where z is the short-run share of GM grain. Baseline scenario consists of a zero supply of GM grain.

A practical way to avoid this hot potato scenario would be to maintain a small reserve of non-GM grain for years when consumer concern grows after the crop is planted. So long as there is sufficient non-GM grain to satisfy this marginal concerned consumer, no discount will be needed to clear the GM grain market.

It is important to note that the scenario depicted in Figure 1 assumes constant identification costs. This assumption has been recently challenged by Kalaitzandonakes, Maltsbarger, and Barnes (2001), who provide strong arguments supporting the hypothesis that identification costs increase with the share of GM grain. To see the implications of their hypothesis, Figure 2 depicts results for identification costs that are constant at $0.05/unit for GM shares below 50%, and increase linearly from $0.05/unit up to $0.25/unit as the GM share rises from 50% to 100%.

The fundamental difference between Figures 1 and 2 is that in the latter the non-GM price received by producers is not monotonically decreasing with the share of non-GM grain. This raises the perverse possibility that non-GM producers may see the premium (and the price) received for their grain fall as non-GM grain becomes scarcer—as shown in Figure 2 for non-GM grain shares between 29.6% and 50%. Further, it is even possible for non-GM producers to get no premium at all as the non-GM shares drops below some threshold level (see non-GM and GM producer prices for non-GM shares between 8.75% and 29.6% in Figure 2).

The explanation for this counterintuitive price behavior is as follows. The difference between the non-GM price paid by consumers and the GM price received by producers is a pure rent to the relative scarcity of non-GM grain. This pure rent increases monotonically as non-GM grain becomes scarcer. If identification were costless, non-GM producers would capture all of such pure rent. In the presence of costly verification, however, such pure rent must be reduced by the identification costs. This is true because the pure rent can only be extracted by identifying non-GM grain. Hence, if identification costs increase faster than the pure rents as non-GM grain becomes scarcer, the net rent obtained by non-GM producers (i.e., the difference between the prices received by non-GM and GM producers) must go down as the share of non-GM grain shrinks.

Long-Run Results

In the long run, the issues described above will disappear as producers respond to the price signals sent by consumers by planting the optimal amounts of GM and non-GM crops. However, market prices must eventually reflect the cost advantages associated with GM grain production.

Table 1. Long-run effects from introducing GM technology.

		Elasticity				Equilibrium output			Non-GM price		Welfare change	
Scenario	IP cost	Supply	Demand	Cost advantage	Consumer concern	GM	Total	GM price[a]	Producer	Consumer	Producer	Consumer
1	0.1	0.3	–0.3	High	High	0.815	1.007	0.884	0.944	1.044	0.023	0.023
2	0.1	0.3	–0.6	High	High	0.818	1.010	0.892	0.951	1.051	0.037	0.015
3	0.2	0.3	–0.6	High	High	0.940	1.008	0.888	0.918	1.118	0.029	0.010
4	0.1	0.6	–0.3	High	High	0.820	1.010	0.876	0.936	1.036	0.020	0.032
5	0.1	0.6	–0.6	High	High	0.825	1.015	0.884	0.943	1.043	0.029	0.024
6	0.1	0.3	–0.3	High	Low	0.913	1.013	0.905	0.944	1.044	0.049	0.043
7	0.1	0.3	–0.6	High	Low	0.917	1.018	0.918	0.958	1.058	0.066	0.028
8	0.2	0.3	–0.6	High	Low	0.986	1.017	0.916	0.935	1.135	0.062	0.026
9	0.1	0.6	–0.3	High	Low	0.920	1.018	0.891	0.929	1.029	0.034	0.057
10	0.1	0.6	–0.6	High	Low	0.928	1.027	0.904	0.943	1.043	0.050	0.044
11	0.1	0.3	–0.3	Low	High	0.712	1.001	0.910	0.944	1.044	0.004	0.001
12	0.1	0.3	–0.6	Low	High	0.714	1.001	0.911	0.945	1.045	0.006	0.001
13	0.2	0.3	–0.6	Low	High	0.900	0.997	0.905	0.913	1.113	–0.006	–0.006
14	0.1	0.6	–0.3	Low	High	0.714	1.001	0.909	0.943	1.043	0.004	0.002
15	0.1	0.6	–0.6	Low	High	0.717	1.002	0.910	0.944	1.044	0.005	0.002
16	0.1	0.3	–0.3	Low	Low	0.853	1.006	0.930	0.945	1.045	0.022	0.019
17	0.1	0.3	–0.6	Low	Low	0.856	1.008	0.937	0.952	1.052	0.030	0.012
18	0.2	0.3	–0.6	Low	Low	0.996	1.006	0.933	0.936	1.136	0.024	0.009
19	0.1	0.6	–0.3	Low	Low	0.857	1.008	0.924	0.939	1.039	0.016	0.025
20	0.1	0.6	–0.6	Low	Low	0.862	1.012	0.930	0.945	1.045	0.023	0.019

[a]*The GM price received by producers is equal to the GM price paid by consumers, because there are no identity preservation costs involved.*

Table 1 shows the simulation results from a range of twenty scenarios, each of them identified by the number in the first column and parameterized as shown in columns two through six. The second column shows identity preservation (IP) costs expressed as a proportion of crop value. For example, the value of this parameter is 0.1 if preserving identity costs $0.20/bu and corn price equals $2.00/bu. The third and fourth columns show supply and demand elasticities, respectively. These represent the range of elasticity values found in the literature. The "Cost Advantage" column reports the net cost advantage to producers assumed in each scenario. The "low" cost advantage scenario is parameterized to represent the actual net cost savings generated by Bt corn. "Consumer Concern" denotes the extent to which consumers prefer non-GM over GM grain. "Low" consumer concern represents a quantification of U.S. consumer preferences in 2000-2002. The amount labeled "high" represents a level of concern that might exist after a major media scare, such as that which existed in the immediate aftermath of the Starlink corn problem ("Biotech-corn Problems," 2000; "Technology quarterly," 2001; "Altered U.S. corn," 2001). Lence and Hayes (2001) explain these cost and concern measures in detail.

The remaining columns show some of the simulation results. The first of these shows the quantity of GM grain relative to a baseline amount of 1. The next column shows the total amount of grain (GM plus non-GM). This is typically higher than the baseline amount because the introduction of this technology reduces farm prices for both GM and non-GM grain (see columns 9 and 10). Column 11 shows the price paid by consumers for non-GM grain; this is simply the price received by farmers reported in column 10 inflated by the identity preservation cost in column 2.

The last two columns show the impact of introducing GM technology on producer and consumer welfare. These are expressed in relation to a baseline value of 1. Hence, a measure of consumer welfare change of 0.03 suggests that consumers are 3% better off. Except for scenario 13, the welfare implications are as expected.

On the aggregate, consumers and producers typically benefit slightly from the introduction of the technology. The sum of the two welfare gains is typically greatest when identity preservation costs are low, and when the cost advantage is high. Welfare gains are particularly large when the cost advantage is high and consumer concern is low (i.e., scenarios 6 through 10).

Given that the model assumes that each agent behaves optimally and in a voluntary fashion, the aggregate welfare gains found in most scenarios are to be expected. Producers who achieve cost reductions that are greater then the market price reduction will benefit. Consumers who are indifferent between the two types of grain, or who have only a weak preference for non-GM grain will also benefit because of the low GM prices. However, there are consumers and producers who lose. The former are the consumers who strongly prefer non-GM grain, because the price paid for non-GM grain increases.[1] The latter are producers who do not adopt the GM technology (because the prices received for all grains fall), and producers who adopt but whose cost savings are not enough to offset the reduction in price.

One surprising result is to be found in scenario 13. Here, identity preservation is expensive, the cost advantage is low, and consumers exhibit high concern about GM crops. The cost advantage is sufficient to entice most farmers to adopt, but the amount of consumer concern is such that almost 10% of the crop is handled via the alternative (and expensive) handling mechanism. The price reduction associated with the technology is not enough to offset the costs associated with moving this much grain through the alternative system, and as a result both producer and consumer welfare measures are lower.

The parameters that give rise to scenario 13 are unusual in that identity preservation is much more expensive and the amount of consumer concern is substantially higher than have been experienced in the US corn market to date. However, such a situation could arise if tolerances were set so low that identity preservation costs increased substantially from current levels (Bullock & Desquilbet, 2002) and if the degree of consumer concern were to increase. This result is important because it shows that there can be situations when a ban on the production and trade of some products might be welfare increasing. For example, the parameters that led to this scenario might justify a ban on products made with child or prison labor, or tuna caught in a manner that is not safe for dolphins. We plan to explore this situation further in a follow-up study.

1. *Our findings regarding consumer welfare are consistent with the results of Giannakas and Fulton (2002). They showed that identification costs and the level of consumer aversion to GM products are key factors determining whether the introduction of GM products increases or reduces aggregate consumer welfare.*

References

Altered U.S. corn found in samples sent to Japan. (2001, January 18). *The New York Times,* p. W1.

Biotech-corn problems lead to recall of 300 products, disrupt farm belt. (2000, November 2). *The Wall Street Journal,* p. A5.

Bullock, D.S., and Desquilbet, M. (2002). The economics of non-GMO segregation and identity preservation. *Food Policy*, *27*, 81-99.

Fernandez-Cornejo, J., and McBride, W. (2002). *Adoption of bioengineered crops* (Agricultural Economics Report No. 810). Washington, DC: United States Department of Agriculture Economic Research Service.

Fernandez-Cornejo, J., and McBride, W. (2000). *Genetically engineered crops for pest management in U.S. agriculture* (Agricultural Economic Report No. 786). Washington, DC: United States Department of Agriculture Economic Research Service.

Giannakas, K., and Fulton, M. (2002). Consumption effects of genetic modification: What if consumers are right? *Agricultural Economics*, *27*, 97-109.

Kalaitzandonakes, N., Maltsbarger, R., and Barnes, J. (2001). Global identity preservation costs in agricultural supply chains. *Canadian Journal of Agricultural Economics*, *49*, 605-615.

Lence, S. H., and Hayes, D.J. (2001). *Response to an asymmetric demand for attributes: An application to the market for genetically modified crops* (Center for Agricultural and Rural Development [CARD] Working Paper 01-MWP 05). Ames, IA: Iowa State University.

Lin, W.W., Chambers, W., and Harwood, J. (2000) Biotechnology: U.S. handlers look ahead. *Agricultural Outlook*, *270*, 29-34. Washington, DC: United States Department of Agriculture Economic Research Service.

Moon, W., and Balasubramanian, S.K. (2001). Public perceptions and willingness-to-pay a premium for non-GM foods in the US and UK. *AgBioForum*, *4*, 221-231. Available on the World Wide Web: http://www.agbioforum.org.

Technology quarterly: Biochips down on the farm. (2001, March 24). *The Economist*, p. 6.

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