Labeling Genetically Modified Foods: An Economic Appraisal

Elise Golan, Fred Kuchler, and Stephen R. Crutchfield
United States Department of Agriculture - Economic Research Service

Abstract. Both at home and abroad concerns about genetically modified foods have disrupted food markets and raised a number of problems for international trade. This paper addresses the issue of labeling foods produced using genetically modified ingredients from an economic perspective. The wide range of consumer attitudes with respect to food safety and genetically modified foods highlights the need for research into how consumer attitudes toward food are established. Consumer attitudes toward genetically modified foods span the distance from profound fear to unflinching acceptance - a divergence in attitudes that can not be explained by variations in preferences. The debate generated by genetically modified foods also focuses attention on how consumer attitudes influence agricultural and food markets. In the case of genetically modified foods, a seemingly small demand for non-genetically modified foods has triggered a number of market changes. For example, a number of food manufacturers have begun to market non-genetically modified food products, and a number of elevators and processors have begun to segregate genetically modified varieties of corn and soybeans from conventional varieties. We present a simple economic model showing how introduction of labeling for genetically modified foods can affect food markets, and the role that social preferences and attitudes in place at the time labeling is introduced can influence the outcome of labeling policies. We examine how consumer attitudes toward food are established and how consumer attitudes influence market structure. The implications of labeling for international trade in food products is also discussed.

1. Introduction

Whether or not foods containing genetically-modified (biotech) agricultural products should be labeled has become an issue of contention both within the US and between the US and her trading partners.[1] Economists tend to argue that labeling and market differentiation of biotech and non-biotech commodities and food product would expand consumer welfare. Such labeling would increase consumer choice and allow consumers to participate in determining the mix of biotech and non-biotech products that are produced.

In this paper we note that although labeling and market differentiation may redress problems of asymmetric or missing information, they will usually not be successful in redressing problems of production externalities. As a result, biotech labeling is probably not a sufficient policy response to correct production externalities arising with biotech cultivation and production. Because of these externalities, we show that the introduction of biotech varieties could potentially result in a reduction in net consumer welfare under certain conditions. This result is unchanged even with mandatory labeling of biotech foods. We illustrate these theoretical results by examining potential changes to consumer surplus arising after the introduction of biotech soybeans.

[1] Agricultural biotechnology is a collection of scientific techniques, including conventional hybridization, that are used to modify or improve plants, animals, and microorganisms. Recently, the term biotechnology has been used to refer more specifically to products that have been genetically engineered (biochemical manipulation of genes or DNA). This is the meaning adopted here.

Economic theory identifies a number of policy tools that may be more suited to redressing externalities than information. Bans, quotas, production regulations or standards, and Pigouvian taxes, may all be more successful than mandatory labels in adjusting consumption and production to better match socially optimum levels. The observation that labeling is not a "cure all" solution has not been adequately acknowledged in the labeling debate, despite the observation that different countries have used different mixes of policies to address potential externality problems associated with biotech cultivation and food production. As a result, labeling has become a focal point in a debate that should be expanded to examine alternative policy tools.

In the first section of the paper, we set up a comparative statics comparison to examine the impact of labeling and product differentiation in correcting for asymmetric or missing information. In the second section, we expand the analysis to examine the comparative statics results when externalities are introduced. We accompany the theoretical discussion with calculations of changes in consumer welfare triggered by the introduction of biotech soybean varieties. In the third section, we examine the reasons that labeling may not be successful in correcting externality problems. We conclude by discussing some of the reasons that labeling may continue to be a focal point of the biotech debate, and reasons to expect that a resolution to the labeling question will not end the biotech debate.

2. Consumer Preferences (or non-Preferences) for Biotech Foods, and Why Preferences Matter

Economic theory tells us that market transactions are driven by consumer preferences. The usual paradigm holds that individual consumers maximize utility subject to a budget constraint by choosing those products whose attributes

(price, quality, taste, safety, and so forth) most closely match their underlying preferences.

In the case of biotech foods, those preferences may not be as fully formed as for other goods, such as butter or eggs or milk. Currently, biotechnology is not used to produce foods with particular product characteristics that are observable and relevant to consumers. Most genetic modifications in use today are designed to reduce production cost – increase yield, decrease the need for pesticide use, and so forth. Products that have discernible characteristics consumers may value (better taste, improved nutritional quality, longer shelf life) are generally not available. Consumers then have only limited demand for biotech foods, for they may not perceive themselves and deriving any benefit.

In addition, there are considerable uncertainties about biotech foods that affect consumer preferences. Three factors seem to influence how consumers feel about foods with genetically-modified ingredients. The first is safety: the public is exposed through the media to information that suggests biotech foods are unhealthy or pose a safety risk. The second is environmental concern: the fear production of biotech foods may lead to undesirable environmental consequences. The third is ethical: the idea that genetic modification is somehow morally wrong.

As economists, we have little to say about the ethical issue. Moral, ethical, or religious values shape many consumer preferences for foods. Some religions proscribe eating certain foods, either totally or at certain times of the year. Some people chose to be vegetarian out of concern for animal welfare. All of these choices, however, are essentially private in nature, and affect only the individuals in question (with the possible exception of those who picket fast food restaurants for serving meat).

Environmental concerns about genetically modified foods are a very important factor in shaping consumer preferences. The environmental factor derives from a fundamental externality. One farmer's choice to use grow genetically modified crops may have consequences that he or she does not directly see, or that may not influence production decisions. Genetically engineered corn designed to be resistant to pesticides is thought by some to pose a risk to insects such as the Monarch butterfly. Some scientists are concerned that genes used to create plants with desired characteristics (such as resistance to pesticides) may "leak out" by passing to non-target species, and upset ecological balances. This is similar to problems organic farmers face: they may be subjected to "drift" of pesticides applied to other farmers' fields. This, then, give us the production externality, a form of market failure.

Finally, biotech foods are thought by some to pose a health risk to consumers. Although numerous studies have determined that such risks do not exist, and regulations are in effect which strictly govern the approval process for application of genetically modification for food crops, some scientists and activists believe that more research is needed. Some argue that it is better to be safe than sorry, that no level of health risk is acceptable until the scope and extent of that risk can be fully determined.

This raises a problem for the determination of consumer preferences. We have what economists call a case of asymmetric information: consumers are not fully informed or aware of potential health risks arising from their consumption choices. In this case, the requirement for the consumer choice paradigm that food choices are made with full information fails to hold. Supplying that information through labels could possibly address this type of market failure, although practical issues remain.[2]

Two of the three factors which influence consumer preferences for biotech foods also, then give rise to two types of market failure. We now turn to the question of how and to what extent using labels can correct these externalities.

3. Labeling and Market Differentiation Increase Consumer Welfare: The Case of Asymmetric or Missing Information

When economists think of labels, we tend to think of trade. In fact, the raison d'etre of labeling is trade. As noted by Susan Hadden in her 1986 book, *Read the Label: Reducing Risk by Providing Information*, "Trade beyond neighbors gave rise to the need for labels."[3] Quite simply, labels let us know what we're buying. As a result, labels play an important role in making the market work. Labels and the information they contain allow consumers to make purchases that best match their preferences. In this way, labels increase market efficiency: resources are allocated to the production of goods and services according to consumer preferences.

In this context, the question of whether or not consumers should have access to information about the biotech characteristics of food has a rather straightforward answer. If consumers value the information enough to cover the costs of supplying the information, they should have it.

[2] Evidence from studies of food-related health risks such as pesticide residues or bacteria suggests that consumers have a very difficult time evaluating very small probabilities of very bad outcomes (cancer or death from food poisoning.

[3] Hadden goes on to note that the very origin of writing has been traced back to tokens used in the ancient Near East to keep track of commodities and that the seals at sites of the ninth century B.C. Harappan civilization of South Asia also indicate the owner and/or contents of the containers that they closed (Hadden, 1986).

Such information would lead to a better matching of purchases and preferences and increase market efficiency.

In most cases, information of value to consumers will be supplied by the market. Private firms have an incentive to supply voluntarily *all* of the positive information that is relevant to consumers' purchasing decisions. Because skeptical consumers expect that labels are as optimistic as truth permits, they will infer that every attribute that the firm does not discuss is negative; either the product does not possess the desirable attributes or the attributes are of low quality (Grossman, 1981). Competition among firms also works to inform consumers about both desirable and undesirable product characteristics. For example, the producer of a food product low in fat might voluntarily advertise that fact. A competitor with a similar product low in both fat and sodium would have had an incentive to advertise its product's two desirable attributes. Consumers would then be suspicious of products that failed to make both claims. This competitive disclosure, which Ippolito and Mathios (1990a) named the "unfolding" theory, results in explicit claims for all positive aspects of products and allows consumers to make appropriate inferences about foods without claims.

The unfolding theory also leads to the conclusion that firms' advertising may inadvertently alert consumers to negative aspects of products. For example, absent any labeling requirements, the food product that advertises itself as "non-biotech" alerts consumers to the probability that other food products contain biotech ingredients. The unfolding theory implies that the presence of advertising (including labels) is a signal of quality and that competitive products without such advertising are alerting consumers to its absence.

In some cases, the fact that information is not supplied by the market indicates that the information is not valuable to consumers in making their purchasing decisions. In other cases, the fact that information is not supplied by the market may be due to the fact that such information involves a negative credence attribute that is shared by a whole product category. That is, if no firm has the technical (economic) capability of eliminating the negative credence attribute, no firm will have an incentive to reveal this attribute. In these cases, one could argue that mandatory labeling is necessary to enhance market efficiency.

Whether due to voluntary market disclosure or mandatory labeling, information and product differentiation expand consumer choice, allowing consumers to make purchases that best match their preferences. Labeling thus increases market efficiency. Labeling also reduces search costs for consumers, thus facilitating trade.

The typical narrative illustrating the process of differentiation describes a market in which the introduction of a new good expands choice and increases consumer welfare. For the biotech story, this narrative begins by assuming a market in which all products are some indistinguishable mix of biotech and non-biotech commodities and products. Here, and in all of our examples, we restrict our analysis to first generation biotech varieties. These varieties have cost-reducing producer attributes, but no consumer attributes. The majority of biotech varieties currently on the market are first generation.[4] As a result of the fact that commodities are undifferentiated in the initial period, consumers are limited to one consumption choice: biotech foods. Assume perfectly competitive markets so that initially, this market equilibrium is described by:

$$(1)\ P_{o(biotech)} = MC_{o(biotech)}.$$

Some consumers prefer to consume non-biotech foods, and in order to meet the non-biotech demand, some producers market non-biotech commodities and food products, and label them as such. By definition, first generation biotech varieties are cost reducing, so producers specializing in non-biotech commodities have higher production costs. As a result,

$$(2)\ MC_{o(biotech)} < MC_{non\text{-}biotech},$$

and eventually the market settles at two prices for two goods:

$$(3)\ P_{o(biotech)} < P_{non\text{-}biotech}.$$

The introduction of the non-biotech products creates gains for those consumers who value these quality attributes. Those who value the information about non-biotech status pay for the information. Information and market differentiation leads to better matching of preferences with purchases and increases the efficiency of the market.

4. Labeling and Market Differentiation May Not Increase Consumer Welfare: The Case of Production Externalities

Although labeling and market differentiation may lead to an efficient market outcome in the case of asymmetric or missing information, this may not necessarily be the case when production externalities are involved. Biotech

[4] An analysis of second generation biotech varieties, those with attributes of value to consumers, would be quite different. Producers would have an incentive to label and segregate these commodities and food products in order to gain any price premiums arising from their valuable attributes.

cultivation and production may impose externality costs on non-biotech producers. The most serious of these externalities may occur at the farm level, where farmers must take precautions to assure that their crops are not cross pollinated by biotech crops. In fact, all along the production and distribution system, non-biotech producers may need to absorb additional costs to ensure that their products remain non-biotech. These costs may include costs for separate storage and transportation facilities; additional cleaning expenses; and testing and certification services. Other potential externalities include resistance development in target and non-target insects and weeds, the effect of pest-resistance crops on non-targeted species, and genetic flow from one species to another so that wild plant populations develop biotech traits such as herbicide and pest resistance (for a comprehensive examination of potential health and environmental externalities, see Nelson et al., 1999).

These costs are not simply related to the scale of biotech cultivation. So long as there is one biotech farmer, there is a potential for mixing biotech and non-biotech products. That is, to have non-biotech products, non-biotech industries and consumers must incur the same costs regardless of whether there is one biotech farm or whether biotech production methods predominate.

Because biotech production may impose externalities on non-biotech producers, labeling and product differentiation may not lead to an efficient market outcome. To see this, suppose that the initial market equilibrium for a competitive market for a commodity is described by:

$$(4)\quad P_{o(\text{non-biotech})} = MC_{o(\text{non-biotech})}.$$

Unlike the previous scenario, in this case, the initial period describes a situation in which, all commodities and foods are non-biotech. Then, a first-generation, cost-reducing biotech variety of the commodity is introduced, where:

$$(5)\quad MC_{\text{biotech}} < MC_{o(\text{non-biotech})}.$$

Through competitive market forces, at least some of the lower biotech production costs are eventually passed on to consumers in the form of lower prices, so that:

$$(6)\quad P_{\text{biotech}} < P_{o(\text{non-biotech})}.$$

Some consumers do not view the biotech and non-biotech products as equivalent and demand non-biotech products. In order to meet the non-biotech demand, some producers market non-biotech commodities and food products. However, in order to insure the non-biotech quality of their products, these producers must now contend with a set of externalities generated by the cultivation and production of biotech commodities and foods. The externality costs imposed by biotech production lead to a higher marginal cost for non-biotech production than in the initial period:

$$(7)\quad MC_{o(\text{non-biotech})} < MC_{\text{non-biotech}}.$$

Eventually these additional production costs will be passed to consumers and the non-biotech market will settle at higher price than the initial non-biotech price:

$$(8)\quad P_{o(\text{non-biotech})} < P_{\text{non-biotech}}.$$

In the final equilibrium, two different prices emerge:

$$(9)\quad P_{\text{biotech}} < P_{o(\text{non-biotech})} < P_{\text{non-biotech}}.$$

In the final equilibrium, those consumers who are indifferent between biotech and non-biotech foods now pay P_{biotech} for foods that they previously purchased at $P_{o(\text{non-biotech})}$. As compared with the initial equilibrium, these consumers benefit from the reduction in food prices, with the exact size of their welfare gain depending on the number of consumers and the intensity of their preferences. Those consumers who prefer non-biotech foods now pay the price higher, $P_{\text{non-biotech}}$, for the exact same foods that they previously purchased at price $P_{o(\text{non-biotech})}$. After the introduction of first-generation biotech varieties and the subsequent segregation of biotech and non-biotech commodities and products, these consumers end up paying higher prices for the same foods. These consumers are worse off than before the introduction of the first-generation biotech technologies. If the decrease in consumer surplus arising from the rise in the non-biotech price is larger than the increase in consumer surplus arising from the drop in the price of biotech foods, then the inequality in (9) describes a net decrease in consumer welfare with respect to the initial market equilibrium.

The final equilibrium condition described in (9) is very different from that described in (3). The equilibrium in (3) describes a situation in which consumer welfare necessarily rises. The equilibrium described in (9) explicitly accounts for the production externality and introduces the possibility that net consumer benefits may not be positive after the introduction of first generation biotech foods – even if these foods are differentiated. The reason for this drop in consumer welfare for those consumers preferring non-biotech is due to the fact that biotech cultivation and production imposes externalities on non-biotech cultivation and production. The problem is not simply one of scale economies: it persists even if the non-biotech market is the larger of the two. The gap between $P_{o(\text{non-biotech})}$ and $P_{\text{non-biotech}}$ includes the precautions that biotech producers must take to assure that cross pollination does not occur and that even a few grains of biotech commodity are not incorporated into their product.

The rise in the price of non-biotech foods occurs whether the differentiation process is triggered by voluntary labeling of non-biotech foods (and unfolding) or by mandatory labeling of biotech foods. This is because currently, consumers who care most about the biotech status of a food are those who prefer to consume non-biotech food. As a result, even if biotech producers are required to label their products with "may contain biotech material" or "does contain biotech material," it will still be left to non-biotech producers to certify that their products are indeed non-biotech. Biotech producers do not have the incentive to strictly segregate, test, or certify that their products do not contain non-biotech ingredients because their consumers are indifferent between biotech and non-biotech products. In most cases, even with mandatory biotech labeling, non-biotech producers and consumers will bear the costs of segregation, and labeling will be unsuccessful at internalizing externality costs.

To get a notion of the magnitude of the types of changes in consumer surplus generated by the market equilibrium described in (9), Golan and Kuchler (2000) did an empirical analysis of the sort of tradeoffs emerging or being predicted in the market for soybeans. To calculate consumer surplus gains due to lower prices arising from biotech adoption, they used biotech price change amounts based on results from Falck-Zepeda, Traxler, and Nelson (2000). This study develops a soybean world supply/demand model to examine the surplus created by the introduction of biotech soybeans.[5] Even including rather strong positive yield effects, the largest price decrease calculated in the Falck-Zepeda, Traxler, and Nelson study $.0009/lb. They used this number for a "large biotech market effect" price change. If all consumers are indifferent between biotech and non-biotech food, then the consumer surplus generated by this price change would be $74 million. Although our calculations are very rough, they are similar to the amounts calculated by Falck-Zepeda, Traxler and Nelson ($76 million).

They next considered the situation in which 5 percent of consumers prefer non-biotech foods. The price premium for non-biotech soybeans was taken from the upper end of the 1-5% premiums reported during the summer of 1999 (see ERS, 2000). They set the "small non-biotech market effect" price increase at $.005/lb, roughly a 4% increase over the $.13/lb base price.[6] This price increase triggers a decrease in consumer surplus of $21 million. The accompanying increase in consumer surplus due to the lower cost of biotech beans is $71 million. The net change +$50 million.

If the dynamics of the market were such that more and more consumers preferred non-biotech foods, then the relative size of the consumer welfare loss due to higher non-biotech prices would begin to outweigh the gains due to the lower biotech price. This result is somewhat damped by the observation that as the non-biotech market share grows, the price premium for non-biotech would probably shrink (with processing economies of scale). This result is reinforced by the observation that, as the size of the biotech market shrinks, the yield and acreage effects that helped spur the large $.0009 decrease would be diminished (as would processing economies of scale). As a result, the biotech price decrease would probably not be as large as market share declined. The fact that the price decrease due to biotech is much smaller than even the small non-biotech premiums that have been observed in the U.S. market, implies that when as little as 25 percent of the market prefers non-biotech, then losses to consumers may outweigh gains.

Although the trade-offs in consumer welfare are interesting in that they reveal the rather low level of non-biotech demand and the small differences in relative prices that are capable of triggering a fall in net consumer welfare, these shifts in consumer surplus are actually relatively small. To give a notion of what these shifts actually mean to the consumer, in terms of the plate of food that he or she puts on the table every night, they translated these numbers into changes in the price of a pound of beef.

The first step was to calculate how much soy is in a pound of beef. Golan and Kuchler have estimated the changes in retail beef prices which may flow from these changes in the prices of biotech and non-biotech soybeans used in animal feed. To translate these amounts into beef price changes, they made the simplifying assumption that beef production, distribution, and marketing system is competitive and operates at constant marginal costs. On this basis, the entire calculated cost increase or cost decrease would be passed to consumers. A price fall of $.0009/lb biotech soybeans therefore results in a decrease in the price of beef of roughly $.0018/lb. A $.005 rise in the price of non-biotech soybeans translates into an increase in the price of beef of $.01/lb.[7] These price changes are quite small. According

[5] Moschini, Lapan, and Sobolevsky (2000) investigate similar questions.

[6] This level of price increase is not without precedent: the price premium for food quality soybeans is about 20 percent (Bender et al., 1999).

[7] We calculated the beef price decrease brought about by the introduction of GMO-soybeans as follows: 750 lbs. soybean meal/470 pounds of beef) x (1.27 lbs. soybeans/pound of soybean meal) x (-.0009 dollars per pound of soybeans) = -$.0018¢ per pound of beef. The beef price increase faced by the non-GMO consumers was calculated similarly: 750 lbs. soybean meal/470 pounds of beef) x (1.27 lbs. soybeans/pound of soybean meal) x (.005 dollars per pound of soybeans) = $.01 per pound of beef.

to these calculations, the benefits of biotech soybeans do not translate into big changes for the consumer (these results, though still small would be larger if biotech corn was also considered). The cost of non-biotech soy-fed beef is also not very large.

To calculate consumer surplus changes from the beef price change numbers, they then assumed a constant price elasticity of demand. The estimated price elasticity of beef demand was set at -.6212 (Huang, 1993). We calculated U.S. beef consumption by multiplying per capita consumption--67.9 lbs. retail cut equivalent--by population--270,290,000 (both in 1998, Putnam and Allshouse, 1999). Larry Duewer (ERS) provided an estimate of the 1998 retail price of choice beef, 277.1 cents/lb. When 5 percent of the market prefers "non-biotech" beef, the drop in consumer surplus due to the higher price of non-biotech soy is $9 million. The accompanying rise in consumer welfare due to the drop in the price of biotech soy is $32 million. By the time 25 percent of the market prefers non-biotech beef the net consumer welfare change is negative, with a drop of $46 million and an increase of $25 million.

5. Labeling and Externalities – Why Doesn't It Work? What Are the Other Options?

The fact that biotech production imposes externality costs on non-biotech producers implies that labeling will not be a successful policy to maximize consumer welfare. Unfortunately, externality problems may actually be the main reason that many consumers and consumer groups are calling for labeling. Consumer surveys reveal that one of the primary reason that consumers object to biotech foods is the potential for environmental damage and one of the main reasons they support biotech agriculture is its potential to reduce chemical use in agriculture (Hoban, 1999).

In the United States, the use of labels to address externality problems is a rather recent development, dating from 1973, when the Food and Drug Administration (FDA) mandated nutrition labels for foods making health claims (with an objective of improving public health and reducing public expenditures on health and safety).[8] Since then, labels have been suggested as a means of keeping the environment green and thriving (eco-labeling); bolstering domestic sales (country-of-origin labeling for lamb); reducing diet-related illnesses (nutrition labeling); and saving endangered animals (dolphin-safe labeling for tuna). In such cases, in which individual consumption choices generate externalities, the intent of labeling is to help align individual consumption decisions with socially optimal levels.

In externality cases, labeling advocates argue that social welfare may be maximized by a labeling choice that differs from the one generated by private costs and benefits. For example, the potential social benefits of providing dietary information on labels may include a healthier, more productive population and reductions in medical costs. These potential benefits may be larger than the increase in profits that compose a private firm's labeling benefits. As a result, the social benefits of labeling may outweigh the social costs even though the private benefits do not outweigh private costs. The opposite could also be true; the net social benefits of labeling could be negative while the net private benefits could be positive. For example, the social costs of labeling alcoholic beverages with the information that a drink a day lowers the risk of heart disease may outweigh the private costs. The social costs of such a label could include increased rates of birth defects, car accidents, and alcohol-related health costs, while private costs simply include the costs of redesigning labels. The social costs associated with this label may outweigh the social benefits of a lower incidence of heart disease, though clearly, the private benefits of such a label (increased sales) may definitely outweigh the costs.

In externality cases where private firms do not supply relevant information, the government may decide to intervene in labeling decisions to try to maximize net social benefits. Government mandated labeling can be a useful tool for achieving social objectives because of the potential power of information to influence consumption decisions. In this role, labeling falls into that category of government policy dubbed by Magat and Viscusi (1992) as "information provision programs to alter people's economic behavior."

Some consumer and producer groups argue that because of the potential externality costs of biotech cultivation and consumption, the government should require labeling of all biotech food products. They argue that consumers have a right to know if their food has been genetically engineered, and that if the potential social costs of biotech-food production were considered in determining food consumption choices, including potential public health costs and environmental externalities, consumers would reduce their consumption of biotech foods.

One of the primary difficulties in trying to maximize net social benefits through labeling is that
although individuals may alter their consumption behavior in response to information on social costs and benefits, this change will rarely reflect all social welfare effects. Even if certain individuals alter their behavior to completely reflect social costs and benefits, the fact that different individuals place different values on different "social" objectives means that, again, these objective will probably not be met.

[8] Historically, since the passage of the Pure Food and Drug Act in 1906, labeling laws in the United States have served three main purposes: ensuring fair competition among producers; increasing consumers' access to information; and reducing risks to individual consumer safety and health (Hadden, 1986).

For example, though some consumers may only purchase free-range chickens, the fact that most consumers continue to purchase coop chickens means that the goal of more humane treatment of chickens is not achieved. Even if all individuals equally value the social objective, differing preferences for the targeted consumption good may lead to less than optimum results. For example, even if consumers agree that a slimmer, fitter population is a good social (and personal) objective, some consumers' preferences for fatty foods and inactivity may outweigh their valuation of the social objective.

Labels may also be unsuccessful in changing behavior enough to meet a social objective if consumers opt to free ride on others' socially responsible behavior. For example, though a consumer may feel that sea turtles should be protected and that strict laws protecting their lives should be enforced, he or she may decide that partaking of one small bowl of turtle soup will not really make a difference. Labels may also be unsuccessful in reaching social goals because collective benefits are rarely evenly distributed. So, even if individuals have similar preferences over the social outcome, the fact that some benefit more that others probably means that not everyone will change their consumption behavior to match the social optimum (Hadden 1986, pg 38).

Another difficulty with labeling, a difficulty that we have glossed over up to now, is due to the observation that it is difficult to convey information through labels. Magat and Viscusi (1992) argue that informational regulations such as labeling generally are not very effective and there are some circumstances, such as when people do not read or do not care about the information on the label, in which they may not be effective at all. Empirical studies have found labels to be both successful (Ippolito and Mathios, 1990b and 1995) and unsuccessful (Variyam, Blaylock and Smallwood, 1995 and 1997; Moorman, 1996) in educating consumers and changing consumption behavior.

Empirical studies highlight the observation that not just the information itself, but also the format and context in which it is presented are important elements in maximizing the possibility that labeled information will reach its audience. Clear, concise labels are most successful at informing consumers. Labels that attempt to convey information about hazards or relationships that are ill defined will be less successful. Not only is it difficult to convey such information on a label, it is difficult for consumers to decipher it. Consumers have a particularly difficult time making sense of small probabilities or of information about an issue that does not have scientific or political consensus (for analysis of how consumers react to risk information see Slovic, Fischhoff, and Lichtenstein, 1980; Viscusi and Magat, 1987; and Magat and Viscusi, 1992).

Economic theory identifies a number of policy tools that may be more suited to redressing externalities than information (Just, Hueth, and Schmitz, 1982). Bans, quotas, production regulations or standards, and Pigouvian taxes, may all be more successful than mandatory labels in adjusting consumption and production to better match socially optimum levels. Such policy could include production regulations involving buffer strips and refuges. Different governments may use different mixes of policy tools to help regulate externalities. The extent to which any of these other tools are employed to control externalities leaves less of the task to labeling policy.

5. Conclusions and Implications for Trade

The existence of biotech production externalities weakens the strength of labeling and product differentiation to maximize market efficiency and increase consumer welfare. For the case of biotech soybeans, we show that after the introduction of biotech varieties, a net loss in consumer surplus can occur even when only 25 percent of the market prefers non-biotech foods. This result does not change with mandatory labeling of biotech crops and foods. However, these results could be changed by other policy tools.

Stakeholders in biotech trade disagree over many issues, including the extent of potential biotech externalities and the role of the government, scientists, and consumers in determining the proper level of regulation. These basic disagreements have contributed to complicating negotiations over trade in biotech foods and commodities. Labeling has become a flash point in these negotiations because of the lack of consensus on how to address externality concerns.

In many regulatory policy debates, there is little consensus on the appropriate regulatory response. Some groups may advocate complete product bans while others advocate no government intervention at all. These debates could be national or international and could lead to difficult problems in harmonizing standards for a wide range of goods. In these cases, labeling may represent not just the best compromise solution but also the path of least resistance, both domestically and internationally. In this capacity, the labeling option has a political appeal that is independent of its merits (a point made by Magat and Viscusi, 1992, with respect to hazard-warning programs).

The danger with using labeling to avoid political stalemate in the biotech debate is that not only will such labeling usually fail to correct externalities, it will also fail to provide consumers with any real information. This may particularly be the case when the inability to reach a political consensus arises from a lack of scientific consensus. As pointed out by Hadden (1986, pg 196), "Policymakers like labeling precisely because it leaves these difficult choices to the individuals who will benefit

from or suffer the risk" She goes on to note that "It is unreasonable to expect individuals to process information that has confounded the experts."

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