

CONSUMER RESPONSE TO BIOTECH FOOD LABELING:  
THE EFFECTS OF VOLUNTARY RBGH-FREE LABELS  
ON FLUID MILK DEMAND

by

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## ABSTRACT

Consumer response to labeling policies for genetically modified organisms (GMO) in food products is investigated by considering voluntary labeling with respect to the use of the genetically modified Bovine Growth Hormone (rBGH) in fluid milk. Existing theoretical approaches on the provision and acquisition of information are extended to develop a framework that specifically addresses the effects of labeling on the relationship between consumer knowledge, information search and product choice. A new data set is utilized in the data analysis. The data set combines national-level supermarket scanner data for fluid milk demand with information about the use of rBGH in milk production and product specific labeling.

Estimated parameter coefficients indicate that consumer beliefs previously measured in survey responses lead to an observable and statistically significant change in market behavior. Demand for fluid milk products labeled as rBGH-free is significantly higher than demand for conventional fluid milk products and increases slightly over time. A positive demand effect is identified for rBGH-free labeled products but not for unlabeled products, indicating that the provision of labeling information is necessary for market segmentation between conventional and rBGH-free products. Demand estimates with regard to organic certification of products appear to be affected by market penetration of organic products during the time period analyzed. In addition, price elasticity estimates for half gallons of milk suggest that consumers are less responsive to price changes in rBGH-free labeled milk products than in conventional milk products.

## CHAPTER 1

### INTRODUCTION

The use of biotechnology in food production, and the use of genetically modified organisms (GMO) in particular, can generate benefits for producers and consumers by lowering production costs and/or enhancing product quality. American farmers are expected to increase their biotech crop plantings this year. 74% of all soybean and 32% of corn acreage will be planted with genetically modified seeds (USDA 2002a). In addition, approximately one third of nearly 9 million dairy cows are currently supplemented with the recombinant Bovine Growth Hormone (rBGH) (Monsanto 2000). However, the use of GMO in food production has also triggered an ongoing debate about their acceptability.

To date, there has been no demonstrated scientific evidence on risks of GMO to human health. Nevertheless, distrust of these scientific assessments, the possibility of higher allergy risks, concerns about possible long-term impacts on the environment, and ethical and religious beliefs influence consumer attitudes about these products. Product labeling, particularly with respect to the provision of health and environmental information, has been used increasingly to indicate these otherwise non-observable characteristics that consumers either prefer or want to avoid (Teisl and Roe 1998).

Currently, several countries are adopting divergent labeling policies for food products using GMO. The European Union (E.U.)<sup>1</sup> and the United States (U.S.) are major protagonists in the debate about appropriate labeling policies. The E.U. passed legislation in 1998 requiring mandatory labeling for food products using GMO. The U.S. opposes mandatory labeling and instead is pursuing voluntary labeling to the extent that the information provided is truthful and not misleading. However, the U.S. also issued the world's "strictest, most comprehensive" standards for organic foods, which covers the use of genetically modified seeds and food ingredients and set firm processing and labeling standards (*Wall Street Journal* 2000).<sup>2</sup>

Economic evaluation of labeling policies with regard to the use of GMO in food products is still in its infancy. Previous studies have either focused on theoretical approaches (e.g., Caswell 1998, 2000; Golan, Kuchler, and Mitchell 2000) or measured survey responses (e.g., McGuirk, Preston, and Jones 1992; Grobe and Douthitt 1995 for the case of rBGH). Quantitative studies that test whether labeling lead to an actual change in market behavior are rare (Teisl, Roe, and Hicks 2000). As regulations regarding labeling for GMO evolve, it is important to evaluate consumer purchase responses to these policy options at both the individual and market level. This thesis focuses on voluntary labeling with respect to the use of rBGH in fluid milk. The objectives of this research are:

1. To model the effects of voluntary labeling on the relationship between consumer knowledge, information search and product choice.

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<sup>1</sup> Japan, Australia and most recently China, among others, have taken similar positions.

2. To empirically estimate the effects of labeling information for GMO (rBGH) on the aggregate level and composition of retail fluid milk demand.
3. To use the results of this study to define the scope and focus of further research regarding the use of GMO in food production and appropriate labeling regulations.

The use of rBGH in fluid milk is an appealing case for evaluating labeling effects for several reasons. First, rBGH was introduced in 1994, making it one of the first genetically modified products approved in the market. Analyzing relatively long-term data sets is especially important since market adjustments to labeling initiatives appear to occur slowly over time (Teisl, Roe, and Hicks 2000). Second, fluid beverage milk represents a fairly standardized and ubiquitous product. Finally, and most importantly, the analysis of fluid milk markets enables cross-sectional differentiation between rBGH-free labeled and unlabeled products, conventional and organic brands. National-level supermarket scanner data for fluid milk from 1995 to 1999 compiled by Information Research Inc. (IRI) were provided through a cooperative agreement with the U.S. Department of Agriculture (USDA) and Economic Research Service (ERS). Combined with independent information about whether a brand includes rBGH, and its labeling, this data is utilized to empirically test the effects of voluntary labeling on product demand.

The thesis proceeds as follows. Chapter 2 gives an overview of economic approaches to information asymmetries and presents recent theoretical and empirical work with respect to health-related and environmental product information. In Chapter 3,

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<sup>2</sup> Organic labels that follow these national standards set by the USDA appeared in stores in April 2001 and

## CHAPTER 2

## LITERATURE REVIEW

“Information is a valuable resource” (Stigler 1961, 213). In response to Stigler’s critique about the lack of attention to the role of information in economics, many studies have focused on the provision and use of information and examined implications for market structures and economic welfare.

Labeling can be defined as the provision of product-specific information to consumers and is therefore closely related to advertisement. Often, labeling is accompanied by government or other third party regulations, such as mandatory disclosure laws or voluntary labeling guidelines and industry certification requirements. In the context of food products, information about price, taste, nutritional and health related information, environmental impact, moral and ethical elements of production can be revealed on a label (Teisl and Roe 1998). Caswell and Mojduszka (1996), for example, include safety (e.g., health concerns) and food production attributes (e.g., environmental impacts) in their categorization of product quality attributes. Thus, organic production or the absence of GMO can be defined as credence attributes, quality dimensions that cannot be easily determined even after the purchase and consumption (Caswell and Mojduszka 1996, Caswell 2000b). Credible labeling can be viewed as one possible form of quality signaling that transforms these product characteristics into search attributes that can be examined before the purchase (Teisl and Roe 1998).

An overview of quality signaling, consumer search models and household production theory is presented in this literature review to form the basis of the theoretical framework. It is also important to address health and environmental related labeling to establish the focus and contribution of this study.

### The Value of Information in Markets with Imperfect Information

The disclosure of information by producers and the acquisition of information by consumers play significant roles in market efficiency. Furthermore, product related release of information by governmental agencies and media could influence decision making by market participants and the operation of markets. Most studies approach this topic by identifying information asymmetries in markets, where one party is better informed about the product than the other.

Labeling policies can improve efficiency by making information initially held by the firm available to consumers, decreasing information asymmetries and reducing search costs (Teisl and Roe 1998). The provision and use of labeling information, however, can be costly, especially with regard to quality dimensions (e.g., Akerlof 1970; Nelson 1970).

### Economic Models of Quality Signaling

Firms have an incentive to signal product quality because it allows them either to sell more units without reducing their price or to raise their price without losing sales or

market share. The economics literature provides a variety of quality signaling and information disclosure models.<sup>3</sup>

Akerlof's (1970) classic "lemons" model illustrates the case of adverse selection, where low quality products drive out higher quality products, and the size of the market shrinks. In his model, producers of high quality goods cannot effectively signal their quality and cannot be distinguished from low quality producers who try to hide their offered quality level. As a result, producers are forced to sell all items at the same price based on the average quality, leaving no incentives to sell or produce higher quality. Adverse selection occurs, inducing welfare losses due to market failure.

Grossmann (1981) presents an alternative model in which voluntary disclosure can be effective even if *ex post* verifiable statements are very costly.<sup>4</sup> A similar model is developed independently by Milgrom (1981). Rational consumers will always assume the worst possible quality under the disclosure made by the firm. Applied to the case of voluntary labeling of food products, rational consumers will assume that unlabeled food items or items that are labeled as "may contain GMO" always contain GMO. In contrast, the decision to label a product might be associated with high costs, because firms would have to assure rational consumers that the information provided is accurate. Assuming that firms maximize their profits, a firm will only add more information to the product label as long as the costs associated with it are less than the additional revenues.

Grossmann considers the case in which the cost to sellers of signaling product quality would be larger than the difference in willingness to pay between perceived low and high

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<sup>3</sup> Here, only the most prevalent approaches are discussed.

quality products. He argues that if there are warranties or devices other than price that can indicate quality, this situation will not result in adverse selection. However, Grossmann's and Milrom's voluntary disclosure models rule out the possibility of false claims by assumption and further do not incorporate any costs to the seller themselves in determining their offered quality.

In their theoretical approach, Klein and Leffler (1982) use firm specific investments as an indicator or non-price device that guarantees higher quality. Shapiro (1982) extends this idea by arguing that an established reputation can ensure against the "lemons" problem when future decisions are based on prior experience with the seller. High quality can be sold with a premium that compensates the seller for resources spent on building up a reputation. Simultaneously, an already established reputation, especially for main brands, could be viewed as a warranty that guarantees claims made on a label. Misleading or incorrect statements would result in major losses for the firm and discipline the labeling practice by the firm. Shapiro incorporates a parameter in his model that measures the extent of information problems and "indicates that the price premium will be higher either if the quality attributes are difficult to observe ... or if consumers are cautious in updating a seller's reputation on the basis of recent quality"(Shapiro 1982, 672). In addition, Shapiro discusses welfare effects of information flows. He treats the premium for high quality products that is dependent on information problems in the market like a tax wedge and points out that these information costs and resulting welfare losses do not evolve because of market failure, but rather are costs due to imperfect

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<sup>4</sup> Grossmann shows that this result occurs when consumers have had no experience with the seller and will

information. Reducing the information costs through industry standards, third party certification or disclosure regulations will result in gains for consumers of high quality products. Consumers of low quality products might lose, on the other hand, and these regulations will also reduce the asset value of an already built up reputation, leaving ambiguous results for welfare analysis (Shapiro 1982).<sup>5</sup>

Another aspect of information and reputation is discussed by Schmalensee (1982). A consumer's previous experience with one brand and already incurred search costs create switching costs. These one-time costs are associated with switching from one brand to another and could give a pioneer firm some market power. Hence, not only are the costs of information disclosure critical to a firm's decision making, but costs of acquiring information and the use of information by consumers also influence the market structure.

### Consumer Search Models

Previous economic models on consumer search for information have primarily focused on imperfect information with respect to price dispersion. In his pioneering work, Stigler (1961) addresses the problem of consumer search by identifying sellers and their price quotations. He formulates a model of optimal sample size of price quotes prior to the search itself and focuses on cases where buyers know about the distribution of prices but not the price charged by a particular seller. Depending on the costs of canvassing an

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have no further experience.

<sup>5</sup> A number of studies on quality signaling (e.g., Jovanovic 1982; Farrell 1985; Shavell 1994; Matthews and Postlewaite 1985) also incorporate differences in voluntary versus mandatory disclosure laws. However, results on whether information provision will actually increase with mandatory disclosure laws and on allocative gains are ambiguous.

additional seller, the units the consumer wants to buy, and his expected marginal benefits of an additional price quote, the optimal level of search can be identified.

Stigler argues, "the chief cost is time" (Stigler 1961, 216). Search costs can vary across consumers based on their opportunity cost of time, their previous knowledge and their ability to process acquired information. Frequent buyers are expected to profit more from price information. A larger number of units purchased will result in a higher sample size, while an increase in search costs will decrease the sample size. Since search costs can be treated as costs of purchase, a greater amount of search will also reduce the consumption of the good. Stigler further considers the effects of advertising and states that it makes search more economical for consumers.

Although Stigler's study was very influential in introducing information problems in economics, implications of the study are somewhat limited. Stigler acknowledges that in the case where buyers do not know about the dispersion of prices, a sequential process might be more appropriate and that the problem of quality has been evaded by the assumption of homogeneous goods (Stigler 1961). Later studies (e.g., McCall 1965; Nelson 1970) focus on a sequential search strategy, where the buyer can evaluate whether to continue the search procedure or accept the quoted price. The optimal decision in these models is based on a reservation price property. The reservation price is defined for each individual buyer based on his search costs, units purchased and the price distribution. Only if the received price quote is above this benchmark, will search be continued. A buyer with high search costs will set a high reservation price. An increase in the number of units purchased and in the dispersion of prices results in lower reservation prices.

Expected gains from search will increase for the buyer in these two cases. Even though the sequential search models focus on the reservation price as a choice variable, the model can be transformed to incorporate Stigler's formulation, and comparative statics results for the expected sample size can be obtained.

Nelson (1970) treats search as the acquisition of information about price or quality and argues that the search for quality only requires more time. An interesting extension of the determination of the optimal stopping rule for search activities is further offered by Weitzman (1979). He allows for heterogeneous goods and different expected utilities. Each different item is assigned a different reservation value and more complex search rules are derived. Items will be selected and searched in the order of their expected utilities, based on the intuition that more promising alternatives will be investigated first. Only if the revealed utility is lower than the reservation value of the next best alternative, will the search be continued.

The amount of search by consumers in turn influences the structure of price quotes offered by sellers. A more intensive search will diminish the demand for relatively high priced goods and, therefore, reduces the incentive for sellers to quote higher prices. While the discussed approaches mainly focus on one side of the market,<sup>6</sup> Salop and Stiglitz (1977) developed an equilibrium price dispersion model that takes these interdependencies into account. Single-price equilibrium at the competitive price or a monopoly price strategy is possible, depending on whether all or no consumers find it valuable to search. Alternatively, a two-price equilibrium can occur if some consumers

decide to stay uninformed due to their higher search costs. Here, too, the focus is on price dispersion, and a number of restrictive assumptions are introduced, but the model could be reinterpreted to include quality differences and more complex information transmission (Salop and Stiglitz 1977).

Although these economic search models have explanatory appeal, a common criticism concerns the limited derivation of empirically testable predictions about consumer search behavior with respect to quality attributes. Several marketing studies, on the other hand, are very descriptive and mainly based on individual psychological determinants such as attitudes and beliefs (e.g., Myer 1981; Muller 1985; Johnson and Levin 1985; Urbany, Dickson, and Wilkie 1989). These studies do not account for underlying economic incentives (Moorthy, Ratchford, and Talukdar 1997). Greater detail on the benefits from search and the search procedure is needed to understand consumer behavior and its structural effects on markets with imperfect information.

Household production models that focus on product attributes and the allocation of time seem to be a useful complement to achieve further insight. Hedonic price models are closely related to household production models in that they also address product variety in a general utility framework. Furthermore, random utility models define consumer decision as a discrete choice process between different brands of a commodity.

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<sup>6</sup> It is often acknowledged that consumer search behavior will influence the price setting decisions by the firm and vice versa, but this interaction is not incorporated into the theoretical models.

Household Production Theory, Hedonic Price Models, and Random Utility Models

Traditional demand theory does not provide mechanisms to analyze different qualities of goods other than treating them as two separate goods altogether. Becker (1965) and Lancaster (1966) independently developed concepts of household production functions, where consumers do not desire goods themselves, but receive utility from product attributes or commodities that can be produced from these goods. In Lancaster's model, a vector of goods purchased in a market will be transformed into attributes by a household production function. By postulating a transformation function and defining the utility maximization problem with attributes as choice variables, the underlying structure of a standard utility maximization model is preserved and demand functions for attributes or characteristics can be derived. Rosen (1974) developed a model that allows consideration of differentiated goods through a hedonic price function that depends on specific amounts of product characteristics. In Rosen's model, product characteristics also determine the utility consumers receive from their market choices, but he does not focus on the household production process. Instead, Rosen postulates a market for goods, which already embody the final characteristics. The implications of his hedonic model are very similar to Lancaster's approach.

In a similar way, Becker reformulates the consumer "utility function of objects of choices called commodities, that they produce with market goods, their own time, their skills, training and other human capital, and other inputs" (Stigler and Becker 1977, 77). Becker incorporates the use and opportunity cost of time into this framework, defining household income as full income that includes money income and the value of time.

Consumers face both time constraints and budget constraints. By defining prices and income more generally, additional comparative statics predictions for the demand for product attributes and for the allocation of time are possible. However, the application of Becker's basic model is limited by its strong assumptions. Most notably, constant returns to scale and no joint production are assumed in the household production process to formulate and analyze effects of parametric implicit commodity prices (Pollak and Wachter 1975).

Stigler and Becker (1977) focus on a dynamic formulation of the household production function to explain the stability of tastes and addiction.<sup>7</sup> This framework is also very appealing to explain consumer behavior with respect to information search (Ratchford 2001). Of particular interest is their argument on advertising: "It is neither necessary nor useful to attribute to advertisement the function of changing tastes" (Stigler and Becker 1977, 84). The utility received by consumers from market goods depends on their knowledge of the properties of the goods. Although, direct measurement of information is extremely difficult due to its multidimensionality and problems related to information accuracy, information is indirectly integrated through consumer knowledge. Information can be produced by firm advertisement or through search activities of households. Therefore, advertising affects consumption by changing the full prices of desired attributes (Stigler and Becker 1977).

Random utility models provide another approach to analyze consumer purchase decisions between brands or varieties of products that are essentially substitutes and vary

in their quality characteristics. This approach is defined as the achievement of maximum attainable utility for a consumer, given his budget constraint and discrete alternatives. Random utility models have been extensively applied in analyzing travel demand, recreational activities and transportation mode (McFadden 1974, 1980; Haab and Hicks 1997). “The sources of randomness in the utility function are unobserved variations in tastes and in the attributes of alternatives, and errors of perception and optimization by the consumer” (McFadden 1980, 15). The consumer’s underlying preferences can be defined in many ways (McFadden 1980) and allow the integration of a household production process in this framework. The individual is assumed to choose the alternative that yields the highest utility. While the decision variable itself, the difference in utility of given alternatives, is not observable, the final result of this decision is. Therefore, the framework allows defining probability measures for the choice of a certain product or brand. Furthermore, a set of observable factors can explain the decision made by a consumer, creating an index function to estimate the probabilistic choice by a consumer, and the impact of changes in these factors on this probability.

These consumer theories can be extended in various directions. Household production approaches in particular, have received some attention in studies that focus on health and environmental related claims in food products.

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<sup>7</sup> Stigler and Becker (1977) discuss beneficial addiction such as music appreciation as well as harmful addiction like heroin.

### Health and Environmental Related Acquisition and Disclosure of Information

Previous research on health and nutrition labeling suggests that additional information provided on the package impacts consumer demand. Several studies (Smallwood and Blaylock 1991; Caswell and Padberg 1992; Caswell and Mojduszka 1996; Caswell 1998; Teisl and Roe 1998; Golan, Kuchler, and Mitchell 2000) explore possible theoretical approaches to informational labeling for food products, including explicit discussions of household production theory. Smallwood and Blaylock (1991) point out that information on the health risks of a food product changes the household production process and results in reallocations of time and purchased resources. Teisl and Roe (1998) more specifically define the process that translates label information into a consideration of product attributes as a combination of individual prior knowledge, cognitive abilities, time, and information provided during the purchase decision. Consumers are viewed as boundedly rational in a sense that they not only face budget constraints but also time constraints and cognitive constraints during the decision process (Teisl and Roe 1998).

Empirical results in this area are limited, mainly because data sets that allow isolation of labeling effects are difficult to find and market-based data has to be purchased at great expense. Previous studies that focus on nutritional labeling have reported significant effects on consumer behavior (e.g., Ippolito and Mathios 1990; Mathios 2000). Mojduszka and Caswell (2000) tested Grossman's model of voluntary quality signaling prior to the implementation of mandatory nutritional labeling in food

markets and concluded that the information provided by firms voluntarily was not complete and reliable.

These results may not be fully applicable to GMO labels. The use of GMO can be defined as a production characteristic as well as a product attribute, with consumer attitudes reflecting subjective risk perception, morals, ethical beliefs, and environmental concerns. Teisl, Roe, and Hicks (2000) investigate a related topic, the effect of eco-labeling on market structure. Eco-labeling is defined as revealed information about environmentally friendly production characteristics. Teisl, Roe, and Hicks apply their theoretical household production approach to empirically test whether dolphin-safe tuna labels altered consumer purchases of canned tuna. A special form of a compensating variation or willingness to pay measure is used to estimate the average amount of money a consumer would need to be compensated if the labeling program had not existed (Teisl, Roe, and Hicks 2000). Their results suggest that controversy about production techniques and product labeling affects consumer behavior. Also, they find effects on a firm's incentive to provide their product in accordance with desired characteristics. Another important implication is that market adjustments to additional information occur slowly over time (Teisl, Roe, and Hicks 2000).

The study has several data limitations. Only aggregate changes in consumption of canned tuna after the introduction of labels by the major manufacturers could be measured and no cross-sectional differentiation between labeled and unlabeled tuna was possible. Also, the data did not allow the estimation of separate effects of labeling and media coverage of dolphin safe tuna harvesting methods.

The distinction between GMO and non-GMO food products is also partially akin to the distinction between organic and non-organic foods. Non-GMO products are often viewed as cheaper alternatives to organic foods. Empirical studies on the demand for organic food products indicate that some consumers are willing to pay high price premiums, but that the demand for these products is more price elastic than for conventional products (e.g., Thompson and Kidwell 1998; Glaser and Thompson 2000). Glaser and Thompson (2000) investigate the demand for organic and conventional milk. National-level scanner data identifies price premiums on organic milk that range from 25% to 103%. Furthermore, the high own-price elasticities on organic milk suggest that price promotions and long term reductions in price could increase sales considerably (Glaser and Thomson 2000).

In general, these findings suggest significant market effects from differentiating GMO and non-GMO commodities through product labeling. Economic research addressing labeling issues with respect to GMO is still in an early stage. Previous studies have either focused on theoretical discussions (e.g., Caswell 1998, 2000a, 2000b; Golan, Kuchler, and Mitchell 2000) or measured survey responses (e.g., Hoban and Kendall 1992; Hallman and Metcalfe 1996; FDA 2000; Baker and Burnham 2001)<sup>8</sup> rather than market behavior. Studies based on survey responses strongly suggest that there is potential for market segmentation between GMO and non-GMO products. The use of GMO in food production appears to be an important consideration for a substantial segment of the population (Baker and Burnham 2001).

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<sup>8</sup> See also Cummis and Lilliston (2000, 4) for an overview on national polls.

At the center of the labeling debate are questions regarding how much information to provide to enable efficient consumer choices and how to provide this information. Surveys indicate that an overwhelming majority of consumers wants the use of GMO in food products labeled, and that some consumers are willing to pay price premiums to avoid these foods (FDA 2000). Nonetheless, consumers may not necessarily translate their awareness of GMO product characteristics into consumption changes and may not follow their assertions about their purchase behavior. As regulations regarding labeling for GMO evolve, it is important to evaluate consumer response to voluntary informational labeling at both the individual and market level.

#### The Case of rBGH

One of the first genetically modified products approved in the market, milk produced with rBGH was fully introduced in 1994.<sup>9</sup> While this hormone occurs naturally in cows, the injection of the genetically modified version has been shown to increase milk production (Monsanto 2000). Prior to its approval, extensive scientific studies suggested that milk from cows given rBGH was safe for human consumption. Despite this evidence, public concern and controversy about the use of rBGH was strong and the issue received wide media coverage.

The use of rBGH in milk production is an appealing case for evaluating labeling effects. The potential for studying relatively long-term data sets at this point is especially important since market adjustments to labeling initiatives appear to occur slowly over

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<sup>9</sup> The FDA approved general use in November 1993 but, in response to consumer concern, Congress placed a moratorium on its use until February 1994 (Aldrich and Blisard 1998).

time (Teisl, Roe, and Hicks 2000). Fluid beverage milk represents a fairly standardized and homogeneous product and voluntary labels with regard to rBGH are somewhat uniform following guidelines set by the FDA in 1992 (FDA 2001). In addition, the analysis of fluid milk markets enables cross-sectional differentiation between rBGH-free labeled and unlabeled products, conventional and organic brands.

Most economic studies in this area focus on implications for the supply of dairy products, such as adoption rates, increases in producer income, additional costs associated with this new technique and structural changes. Consumer acceptance and demand effects are not as widely studied. Here too, surveys about consumers' preferences the dominant approach (e.g., McGuirk, Preston, and Jones 1992; Grobe and Douthitt 1995; Misra and Kyle 1998). Results suggest sizable effects on the demand for fluid milk, potential for market segmentation and possible price premiums with respect to rBGH-free dairy products. A study conducted by Aldrich and Blisard (1998) investigated these predictions empirically. Monthly-pooled time series and regional milk sales data from 1978 to 1996 were used to examine an expected temporary reduction of fluid milk consumption due to the use of rBGH. However, at this aggregate level and within the relatively short time frame after the introduction of rBGH, no statistically significant effects on consumer purchases could be found.

### Summary

This chapter has reviewed the theoretical and empirical literature with respect to product labeling and labeling of GMO, non-GMO, and organic commodities. Three

important theoretical approaches that address the effects of the provision and acquisition of information on market efficiency - quality signaling models, consumer search models and household production models - have been examined.

Labeling can be viewed as one possible form of quality signaling by the firm that establishes markets for different product qualities. The acquisition and use of information by consumers and the effects on market structure are discussed in consumer search models. These models mainly concentrate on price dispersion and do not allow the derivation of empirically testable predictions for consumer search with regard to quality attributes. Household production models are useful extensions of consumer search models because they address different product qualities and the allocation of time. Additional information about product attributes enables a more complete household production process. Hedonic price models and random utility models also offer insights in how to incorporate product attributes and consumer uncertainty about these attributes into a utility maximization framework. The theoretical model developed in this thesis extends these approaches to specifically address the relationship between consumer knowledge, information search, and product choice. Testable predictions for effects of product labels on consumer purchase can be derived from the model that is presented and developed in the next chapter.

Previous empirical work on health and environmental related acquisition and disclosure of information is mainly based on survey responses. This research is still in its infancy, especially with regard to regulations on the use of GMO in food production. More detailed market-based research that allows cross-brand comparisons and separating

labeling effects can provide significant insights for both policy makers and researchers. The empirical analysis presented in Chapter 4 of this thesis examines the effects of voluntary labeling for rBGH on consumer behavior using retail-level scanner data that provides enough detail to investigate changes in consumer purchase behavior. Additional information is collected on the use of rBGH in milk production and whether or not a product is labeled as rBGH-free. This new data set permits tests of hypothesis about consumer reaction to rBGH-free labels. In addition, a longer time frame after the introduction of rBGH enables the analysis of dynamic adjustments in consumer demand.

## CHAPTER 3

## THEORETICAL FRAMEWORK

This chapter provides a framework for modeling the effects of product labeling on consumer behavior by addressing the relationship between consumer knowledge, information search, and product choice. To motivate the development of the model, the manner in which attributes like the absence of GMO enter an individual's utility function is briefly discussed. Consumers can receive utility from the absence of GMO in food products through subjective attributes-related quality assessments like lower health risks, including allergy prevention, less environmental impact and accordance with their ethical beliefs. These quality dimensions cannot be easily determined even after the purchase and consumption. The acquisition of information by consumers, or the provision of information by producers can transform these credence attributes into search attributes. Knowledge about these product attributes enables a more accurate product choice and can therefore affect consumer utility. Different levels of labeling are possible to make additional information available to the consumer. Information can be provided voluntarily by producers, a claim could be certified by an independent third party, or mandatory disclosure might be required. Although this study focuses on the effects of voluntary labeling of rBGH, aspects of these different labeling dimensions are addressed in the framework.

### Background and General Model

Traditional demand theory does not provide mechanisms to analyze consumer choice that concentrates on different product attributes. Newer consumer theories, like the household production function approach, hedonic price models, and random utility models have been developed to address this issue. The incorporation of time constraints and effects of advertising in household production functions makes this framework particularly relevant to the topic of product information.

Becker's (1962) reformulation of consumer theory postulates that households maximize a utility function with respect to product attributes or commodities produced with market goods, their own time, and other inputs through a household production process. Rosen's (1974) approach differs in that he assumes the attributes themselves are already included in the final market good and influence the commodity price. Becker and Stigler (1977) conclude that advertising affects consumption by changing the prices of desired attributes. Teisl and Roe (1998) argue that more information enables a more complete household technology. Teisl, Roe, and Hicks (2000) follow the approach outlined by Becker and Stigler (1977). Utility depends not only on a product's inherent attributes but also on consumer knowledge about these attributes. Advertising information - in their case, environmental labeling with regard to dolphin friendly tuna - enters the utility function directly.

The approach in this thesis differs slightly from those of previous studies in its formulation and interpretation of the theoretical framework. The search for desired product attributes is integrated into the household production technology as a choice

variable. The costs associated with this search process are defined as time costs (Stigler 1961). Furthermore, as in random utility models (McFadden 1974), the utility maximization process includes a random term that leads to the derivation of probability measures for the consumer choice of a certain product. Since choice variables in this model can be described as continuous rather than discrete, adding a random term transforms the model into an expected utility model.<sup>10</sup> While the source of randomness is defined by variation in perception or uncertainty about product attributes, it can be affected by variables such as search time. Consistent with search models, an increase in the market share of products with the desired attributes, labeling information about these attributes, and previously acquired human or consumption capital can all reduce the random component in the utility function.<sup>11</sup> The general form of the constraint maximization process can be described as:

$$\max_{\underline{x}, r} E[U(\underline{x}, r)] + \lambda \left( Y - \sum_{i=1}^n p_i x_i - \sum_{k=1}^l w t_{s_k} \right). \quad (3.1)$$

The household faces budget constraints and time constraints:

$$Y = \sum_{i=1}^n p_i x_i, \quad Y = I + w t_w, \quad (3.2)$$

$$T = t_w + \sum_{k=1}^l t_{s_k}. \quad (3.3)$$

The vector  $\underline{x}$  defines final goods purchased and the prices of these goods are indicated by  $p_i$ . Time spent searching for desired product attributes is defined by the vector  $t_s$ . The elements  $t_{s_k}$  represent search time allocated to the  $k$ th good for which an attribute search is conducted. The difference in this index from that for the bundle of goods indicates that

<sup>10</sup> Random utility models are mainly applied in travel demand and recreational activity analyses, generally discrete choices. Thus, the models are not transformed into expected-utility models.

<sup>11</sup> For simplicity, the functional form for the random term is expressed in the specific model for the choice of conventional or rBGH-free fluid milk rather than the general model.

search is not needed on all consumption goods. Income ( $Y$ ) is defined as full income (Becker 1962). It consists of non-labor income,  $I$ , and the maximum achievable income,  $wT$ , given a constant wage rate ( $w$ ) and devoting all available time ( $T$ ) into participation in the labor force. Time can, however, be used to either work ( $t_w$ ) or search ( $t_s$ ).<sup>12</sup> Thus, the budget constraint only includes realized income ( $Y'$ ), the amount of money available to purchase goods. Combining equation (3.2) and (3.3) yields:

$$\sum_{i=1}^n p_i x_i + \sum_{k=1}^l w t_{sk} = I + wT = Y, \quad (3.4)$$

which is incorporated in equation (3.1).

In contrast to Becker's and Rosen's framework, this model defines final products as choice variables; product attributes are not explicit in this model. However, since the choice of  $x$  depends on its attributes<sup>13</sup> or perceptions of its attributes and time spent searching to learn about them, they are implicitly included. The model is formulated using final goods rather than attributes as choice variables to allow the derivation of testable predictions for demand structures of different types of fluid milk.

### The Choice between Conventional and rBGH-free Fluid Milk Products

For the special case of choosing between different fluid milk products, the model can be reformulated as:

$$\max_{\underline{x}, \underline{m}, t_{rBGH}} E[U(\underline{x}, \underline{m}, e)] + \lambda \left( Y - \sum_{i=1}^n p_i x_i - \sum_{j=1}^2 p_j m_j - w t_{rBGH} \right), \quad (3.5)$$

where

$$\underline{m} = \{m_1, m_2\} \text{ and } e(M, L, H, t_{rBGH}).$$

<sup>12</sup> For simplicity, other uses of time such as leisure are ignored in this model.

The vector  $\underline{x}$  is now defined to include all consumption goods except fluid milk products. The consumption of specific brands of fluid milk is denoted by vector  $\underline{m}$ . For simplicity, it is assumed that households can select only between  $m_1$  and  $m_2$ , and that either  $m_1$  or  $m_2$  will be chosen but that both will not be consumed.<sup>14</sup> The fluid milk product produced without the use of the genetically modified Bovine Growth Hormone (rBGH) is represented by  $m_1$ , and  $m_2$  denotes a conventional fluid milk product.<sup>15</sup> The household is assumed to search only on the absence of rBGH and not on any other product attributes for different milk products or other purchased products.<sup>16</sup> Thus, only time spent searching for information on the absence of rBGH ( $t_{rBGH}$ ) is included as a choice variable. However, the absence of rBGH in  $m_1$  is not known to the consumer with certainty. Therefore, the consumer's choice between  $m_1$  and  $m_2$  will be influenced by a random component. This random term or error structure,  $e$ , is only a function of terms related to rBGH. Market share of rBGH-free brands ( $M$ ), labeling information ( $L$ ), earlier acquired human or consumption capital on the absence of rBGH ( $H$ ) and time spent searching ( $t_{rBGH}$ ) are assumed to be negatively related to the variance of this random term. An increase in labeling information provided on the package, for instance, will reduce uncertainty about the absence of rBGH.

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<sup>13</sup> Following Rosen's definition, attributes are assumed to be already included in the final goods.

<sup>14</sup> The choice of a fluid milk product in this model has a discrete and continuous component. The household faces a discrete choice between  $m_1$  and  $m_2$ . The household will also choose the optimal amount of  $m_1$  or  $m_2$  that maximizes his utility.

<sup>15</sup> While this model is designed to analyze a stage of the market where consumers have already made a decision about whether not to purchase milk, it could be applied to the initial market participation decision in future research. For this purpose, the definition of  $m_2$  needs to be extended to include no milk purchase at all or non-dairy substitutes such as soy-based drinks.

<sup>16</sup> This assumption is made to allow predictions for this specific search procedure and its effects on the demand for different brands of fluid milk.

The first order derivative with respect to time spent searching for information on the absence of rBGH indicates benefits and costs of search in this model:

$$\frac{\partial E[U(\underline{x}, m, e)]}{\partial t_{rBGH}} + \lambda(-w) = 0. \quad (3.6)$$

Expected utility increases if a household invests in additional search. By reducing uncertainty about the absence of rBGH through search, a more accurate choice can be made. The first term in (3.6) indicates these benefits and has a positive sign. The second term characterizes the costs associated with additional search. As discussed above, these costs are defined as time costs or opportunity costs of search time. The Lagrangian multiplier  $\lambda$ , the marginal utility of income, is assumed to be positive. Since the wage rate is also positive, the second term in (3.6) will have a negative sign.

Two important conditions further determine the benefits of search for a household and its final product choice:

$$U(\underline{x}, m_{rBGH-free}) - U(\underline{x}, m_{rBGH}) = \delta, \quad \delta \geq 0, \quad (3.7)$$

$$E[U(\underline{x}, m_1, e) - U(\underline{x}, m_2)] = \delta'. \quad (3.8)$$

Condition (3.7) describes the difference in utilities for a given household between consuming a milk brand that does not include rBGH and one that does, holding the choice of vector  $\underline{x}$  constant. This difference is assumed to be greater than or equal to zero and known to consumers. It can vary between households based on their perceived health risks, environmental concerns and ethical beliefs. Consumers who consider the use of rBGH in their purchase decision have a  $\delta$  greater than zero. If a consumer is indifferent between rBGH-free and conventional milk products,  $\delta$  equals zero. Equation (3.8) defines

$\delta'$  as the expected utility difference between consuming  $m_1$  and  $m_2$ , because consumers may not be certain about the rBGH-characteristic in  $m_1$ . Only if the difference in utilities is large enough to offset search costs will a household acquire information about the absence of rBGH. In return, additional time spent searching with regard to rBGH will reduce randomness in the product choice.

Given that second order conditions are satisfied, optimal values for the choice variables can be found from the first derivatives of the constrained optimization problem:

$$\underline{x}^* = \underline{x}(Y, \underline{p}, w, \delta, M, L, H), \quad (3.9a)$$

$$\underline{m}^* = \underline{m}(Y, \underline{p}, w, \delta, M, L, H), \quad (3.9b)$$

$$t_{rBGH}^* = t_{rBGH}(Y, \underline{p}, w, \delta, M, L, H), \quad (3.9c)$$

$$\lambda^* = \lambda(Y, \underline{p}, w, \delta, M, L, H). \quad (3.9d)$$

Using these relationships to substitute the optimal values  $\underline{x}^*$ ,  $\underline{m}^*$ ,  $t_{rBGH}^*$  and  $\lambda^*$  into the objective function yields two possible indirect utility functions ( $V_1^*$ ,  $V_2^*$ ) with regard to the consumer choice of fluid milk.<sup>17</sup> The following equation can be derived:

$$V_1^*(Y, \underline{p}, w, \delta, M, L, H) - V_2^*(Y, \underline{p}, w, \delta, M, L, H) = V^*(Y, \underline{p}, w, \delta, M, L, H). \quad (3.10)$$

Milk product  $m_1$  will be selected by a household if:

$$V^*(Y, \underline{p}, w, \delta, M, L, H) > 0. \quad (3.11)$$

The probability of this selection is:

$$P(V^* > 0) \equiv P(m_1 > 0). \quad (3.12)$$

<sup>17</sup>  $V_1^*$  represents the stochastic indirect utility if  $m_1$  is chosen, and  $V_2^*$  represents the indirect utility if  $m_2$  is chosen.

The following prediction can be derived from this framework by differentiating (3.12) with respect to labeling ( $L$ ).<sup>18</sup>

$$\frac{\partial P(m_1 > 0)}{\partial L} \equiv \frac{\partial P(V^* > 0)}{\partial L} = \frac{\partial P(V^* > 0)}{\partial V^*} * \frac{\partial V^*}{\partial L} > 0. \quad (3.13)$$

Both terms in equation (3.13) can be signed for households that have a positive  $\delta$ . The probability that  $V^*$  is greater than zero increases as  $V^*$  increases. Furthermore, an increase in labeling information about the use of rBGH increases  $V^*$ , the expected difference in indirect utilities with regard to  $m_1$  and  $m_2$ . A rBGH-free label on the package reduces uncertainty about the use of rBGH in  $m_1$ . The expected utility of consuming  $m_1$  ( $V_1^*$ ) increases with the provision of additional labeling information about the use of rBGH, while  $V_2^*$  stays unchanged since no additional information is provided on the label that influences the perceived utility of  $m_2$ . This effect is illustrated using cumulative density functions in Figure 1.

The cumulative density functions are defined as:

$$F(V^*) = \int_{-\infty}^{V^*} f(z) dz. \quad (3.14)$$

<sup>18</sup> Income effects from an increase in labeling are assumed to be zero in this derivation. Although provision of labeling information may decrease search time for some households, income effects due to saved search time are likely to be very small. This assumption is supported by very small income elasticities for milk estimated in previous studies (e.g., Heien and Wessels 1988).

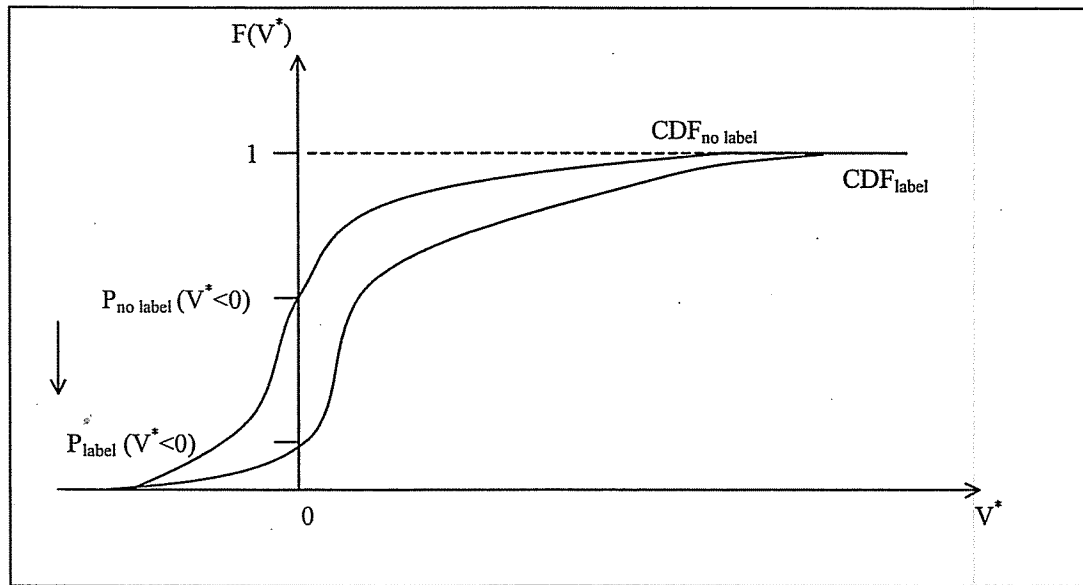


Figure 1. Cumulative density functions.

The cumulative density function for  $V^*$  without product labeling is denoted by  $CDF_{no\ label}$  and  $CDF_{label}$  represents the cumulative density function when the absence of rBGH in fluid milk is labeled. The provision of labeling information can be viewed as a mean preserving reduction in spread and shifts the cumulative density function downward. As the variance of the random component of  $V^*$  decreases, the probability that  $V^*$  is positive increases.<sup>19</sup> Therefore, the comparative statics prediction in (3.13) can be signed. The provision of additional labeling increases the probability that  $m_I$  will be chosen.

As noted above, different levels of the provision of labeling information are possible: Some producers provide information voluntarily ( $L1$ ). An independent third party might additionally certify information provided by producers ( $L2$ ). Alternatively, mandatory disclosure might be required ( $L3$ ). Mandatory labeling usually applies to the

<sup>19</sup> Alternatively, as illustrated in Figure 1, the probability that  $V^*$  is negative decreases.

disclosure of an undesirable characteristic; milk brands produced using rBGH would be labeled as such. The probability that the rBGH-free brand will be chosen is assumed to increase along these levels, because the information provided is viewed as more reliable:

$$P(m_1 > 0|L1) < P(m_1 > 0|L2) < P(m_1 > 0|L3). \quad (3.15)$$

The focus of this thesis is on the effects of voluntary labeling on consumer choice, because only voluntary labeling is currently used to inform consumers about the use of rBGH in fluid milk. However, products that are certified organic implicitly certify that the milk was produced without the use of rBGH. Effects of organic certification can also be investigated in Chapter 4.

Predictions about price effects cannot be derived from this constrained maximization problem because prices enter the constraint. Yet, if income effects are relatively small, Marshallian demand functions may not differ significantly from Hicksian demand functions. Small income elasticities for fluid milk estimated in previous studies (e.g., Heien and Wessels 1988) therefore suggest that own-price effects for fluid milk products are positive for Marshallian demand functions derived from this model.

Actual price premiums single households may be willing to pay for rBGH-free milk will depend on both their perceived utility difference between rBGH-free and conventional milk, and the household's income. In addition, some households may be willing to pay a premium for labeling information, because it reduces their uncertainty about true product attributes and saves time otherwise invested in search.

Another interesting prediction can be derived. If the difference between the received utilities from the rBGH-free and the conventional brand,  $\delta$ , increases, the probability that  $m_1$  is chosen will increase.<sup>20</sup>

$$\frac{\partial P(m_1 > 0)}{\partial \delta} > 0. \quad (3.16)$$

For example, new scientific information that either supports (contradicts) subjectively perceived health and environmental risks would increase (decrease) expected individual difference ( $V^*$ ). The predicted probability increase (decrease) in (3.16) should occur with or without additional labeling information, since for some households this information would be sufficient enough to change their search behavior.

The following chapter discusses the econometric specification to test prediction (3.13) with regard to the effects of voluntary labeling of the absence of rBGH in fluid milk production. Furthermore, the effects of organic certification and own-price effects will be empirically investigated. The information prediction in (3.16) cannot be examined directly in this study due to a lack of influential new research findings in the available time period. However, the inclusion of time trends in the regression specification can indirectly be used to detect possible changes in consumer attitude over the time period of interest.

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<sup>20</sup>This prediction can be seen from the differentiation of (3.12) with respect to  $\delta$ :

$$\frac{\partial P(V^* > 0)}{\partial \delta} \equiv \frac{\partial P(V^* > 0)}{\partial V^*} * \frac{\partial V^*}{\partial \delta}$$

## CHAPTER 4

## ECONOMETRIC SPECIFICATION, DATA, AND RESULTS

An important objective of this study is to provide insights into market level consumer response to labels through the analysis of a new data set. Quantitative studies that evaluate labeling effects on market behavior rather than survey responses to hypothetical situations are rare, especially with respect to GMO labeling. Data sets that permit the isolation of labeling effects are hard to find and market-based data must be purchased. The retail-level scanner data for fluid milk used in this thesis enables an empirical investigation on the market level. This scanner data is combined with additional information on whether a product is produced using the genetically modified Bovine Growth Hormone (rBGH), labeled as rBGH-free or organic.

The econometric specification of the estimation equations is developed in the first section of this chapter. The specification utilizes the theoretical framework in Chapter 3 and is based on a conditional logit model used in previous econometric studies. Data acquisition and construction of the final data set are then described in detail. Finally, empirical estimates of model parameters and price elasticities are presented and discussed.

### Econometric Specification

The econometric specification used to test the theoretical predictions derived in Chapter 3 is based on conditional logit models.<sup>21</sup> These models are frequently employed in empirical work on travel demand (e.g., McFadden 1974, 1980; Haab and Hicks 1997). In a more related application, Mathios (2000) uses McFadden's model as a basis for his evaluation of effects of mandatory disclosure laws on the market for salad dressing. The econometric specification of the estimation equations introduced here follows McFadden's (1974) and Mathios's (2000) derivations.

Let  $V_i^*$  represent the indirect utility function derived in the theoretical framework where the index  $i$  identifies the indirect utility function associated with the  $i$ th fluid milk brand. The observed consumer choice corresponds to the milk product that maximizes the consumer's indirect utility. Let the consumer's indirect utility for choice  $i$  be.<sup>22</sup>

$$V_i^* = A_i\beta - \varepsilon_i. \tag{4.1}$$

The vector  $A_i$  indicates the attributes of a certain milk brand and the vector  $\beta$  represents the individual weights placed on these attributes by the household. The error term in equation (4.1) is assumed to arise mainly from errors in perception of attributes and represents the uncertainty associated with the indirect utility for alternative  $i$ . The choice of  $m_i$  implies that:

$$A_i\beta - \varepsilon_i > A_j\beta - \varepsilon_j \quad \text{for all } j \neq i. \tag{4.2}$$

<sup>21</sup> These models are also sometimes labeled as multinomial or multivariate logit models.

<sup>22</sup> The focus of this analysis is the choice of fluid milk brands based on their attributes. This focus, plus the assumption that the choice of  $x$  will be unchanged for different indirect utility functions, allows suppressing a constant term that relates to other goods consumed in this specification.

The residuals in (4.2) are assumed to be independent and identically distributed and have a logistic distribution (Mathios 2000).<sup>23</sup> Under this distributional assumption, the choice probability for the  $i$ th fluid milk product ( $m_i$ ) can than be written as:

$$P(m_i > 0) = \frac{e^{A_i\beta}}{\sum_{i=1}^I e^{A_i\beta}}, \quad (4.3)$$

where  $e$  is a natural exponential function ( $e=2.71828\dots$ ). The relative odds of a consumer choosing product  $i$  over some reference brand,  $m_r$ , is:

$$\frac{P(m_i > 0)}{P(m_r > 0)} = \frac{e^{A_i\beta}}{e^{A_r\beta}}. \quad (4.4)$$

In the data set utilized in this study, the number of units of a fluid milk product sold in selected supermarkets over a 13-week or 4-week period is observed.<sup>24</sup> The evaluation of effects on the individual consumer level is not possible. Therefore, the left-hand side of equation (4.4) is redefined as unit sales of product  $i$  divided by unit sales of a reference brand. Redefining the left-hand side variable this way, and taking the logarithm, equation (4.4) can be rewritten as:

$$\ln\left(\frac{\text{unitsales}_{m_i}}{\text{unitsales}_{m_r}}\right) = (A_i - A_r)\beta'. \quad (4.5)$$

Equation (4.5) forms the basis for the estimation equations used in the empirical analysis of this study. The right-hand side of equation (4.5) is transformed into a linear function of the parameters and can be estimated using linear regression methods.<sup>25</sup> In this

<sup>23</sup> McFadden (1973) has shown that  $F(\varepsilon_i) = e^{-e^{-\varepsilon_i}}$  for residuals independently identically distributed with a Weibull distribution.

<sup>24</sup> The data is discussed in detail in the next section.

<sup>25</sup> See also Mathios (2000) for a linear transformation of the conditional logit model.

formulation, the attribute difference vector  $(A_i - A_r)$  denotes differences in attributes between the  $i$ th product and the reference brand. This attribute difference vector includes price differences as well as information on whether a brand is produced without rBGH but not labeled as such, labeled as rBGH-free, or organic. The reference brand is a conventional milk product.<sup>26</sup> The vector  $\beta'$  defines aggregated average weights rather than individual consumer weights as in equation (4.4).

The prediction derived from the theoretical model presented in Chapter 3 was that the coefficient for rBGH-free labeled products would be positive. If a milk product is labeled as rBGH-free, it is more likely to be chosen by consumers that have a difference in utility between rBGH-free and conventional milk. The coefficient for organic brands is also predicted to be positive and of greater magnitude than the coefficient for rBGH-free and labeled products, since information regarding organic production is certified by an independent third party.<sup>27</sup> Additional factors may also determine the consumer choice of organic products over conventional products. For instance, concerns over pesticide residues or support of smaller scale organic farming might increase preferences for organic products. No clear predictions regarding the sign of  $\beta'$  can be made for products that are rBGH-free and not labeled. Whether this coefficient would actually be positive and smaller in magnitude than the coefficients for rBGH-free labeled products depends on the degree to which households invest in a search procedure. If search costs are higher

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<sup>26</sup> A conventional product is non-organic and may be produced using rBGH.

<sup>27</sup> A necessary condition for a product to be certified organic is that it has to be produced without the use of GMO.

than the actual difference in utility between rBGH-free and conventional brands, then rBGH-free but unlabeled brands are only chosen by chance.

### Data

A cooperative agreement with the U.S. Department of Agriculture (USDA) and Economic Research Service (ERS) provided access to national-level scanner data for retail sales of fluid milk compiled by Information Resources, Inc. (IRI). Aggregate sales of specific fluid milk products identified by universal product code (UPC) were collected in the IRI database for 13-week periods from January 1995 to December 1997 and for 4-week periods from January 1998 to December 1999.<sup>28</sup> Over 13,000 supermarkets that either belong to national chains or operate independently in one of 64 metropolitan areas around the country were tracked.<sup>29</sup> These observations were aggregated by IRI to national totals. Only national total sales for fluid milk products were included in the accessed IRI database.

This analysis focuses on beverage milk, excluding buttermilk and flavored milk. Prices and unit sales for fluid milk products offered by 13 different milk processors were collected. Prices in the IRI database were temporally and spatially aggregated over the time period and supermarkets in which the item was available. These averages are based on list prices. Thus, they do not take advertised sales into account. The unit sales variable

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<sup>28</sup> The change in the way the data was collected can create difficulties in the data analysis. It is addressed in the specification of final estimation equations and presentation of empirical estimates.

<sup>29</sup> IRI uses the food industry's definition of a supermarket: A grocery store with dairy, produce, fresh meat, package food, and non-food departments and annual sales of \$2 million or more. Sales from health food stores, food cooperatives, or natural food stores are not included.

measures the total number of sales reported in each time period in all of the selected supermarkets.

The data were organized into different product categories based on fat content (skim, 1%, 2%, whole) and container size (1 gallon and ½ gallon) to permit comparisons of homogeneous products. For instance, all gallon whole milk products were grouped together and form one of eight fat content and container size categories.<sup>30</sup> While the IRI data did not include supermarket specific private brands (e.g., Albertsons or Safeway store brands), several unspecified generic private label products were included. These private label entries were also organized into eight fat content and container size categories. Within each category, the generic private label entries were aggregated by computing price and unit sales averages to form reference brand series. Eight such reference brands, one for each fat content and container size category, were obtained.

To refine the econometric analysis, two additional variables were created within each fat content and container size category. The logarithm of quantity ratios between each milk product and its reference brand is used as the dependent variable in the estimation equations. The price difference between each milk product and its reference brand is included as an independent variable in the attribute difference vector in equation (4.5).

The quantitative data obtained from the IRI database were combined with information on the rBGH-characteristic at the product level obtained through a telephone survey. Milk processors were contacted to acquire information about the use of rBGH in

milk production, their labeling practice on the product level and the time period during which a policy with regard to rBGH was chosen. As noted in the previous section, a milk product can be conventional, rBGH-free but not labeled as such, rBGH-free and labeled, or certified organic. This categorical data is defined using three dummy variables.

The selection of the 13 milk processors and their products included in the empirical analysis was based on their inclusion in the IRI database as well as on the availability of information about rBGH and labeling characteristics.<sup>31</sup> Not all available milk processors are included in the IRI database, possibly because of limited size, local scope or unavailability in recorded supermarkets. Among the 13 selected processors, three sold organic products, two offered milk that is rBGH-free but not labeled as such, seven labeled fluid milk products as rBGH-free and five carried conventional milk products.<sup>32</sup> None of the processors included in the analysis changed their policy with regard to rBGH use or labeling for specific products over the time period in which the data was collected. Both rBGH-free non-labeled and rBGH-free labeled milk products were available over the entire time period. Organic milk sold in gallon containers was not included in the IRI data set until April 1998.

A market size variable for each milk product was also added to the data set. It accounts for differences in the size of the market served by the 13 milk processors in this aggregated national-level data set. Annual state population estimates from 1995 to 1999

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<sup>30</sup> The data could not be sorted based on container material (paper or plastic). Information on container material could not be obtained for all observations. In particular, the generic private label entries did not provide enough detail such as UPCs to retrace this information.

<sup>31</sup> Not all of the milk processors contacted were willing to provide reliable information about their rBGH policy.

by the U.S. Census Bureau (1999) for states in which the product is available (single states, regions or nationwide) were used to capture this information. If a brand is only available in a single state, only the population estimate for this state is used. If a brand is available in more than one state or in one region, the relevant population estimates are added. If a brand is available nationwide, the nationwide population estimate is used. These population estimates were used rather than a categorical variable that indicates the number of states a brand is available to capture the number of potential consumers and account for population differences within states.

The final panel data set includes 5840 observations. Each observation corresponds to a specific fluid milk product that was sold in a specified 13-week or 4-week period from 1995 to 1999. Each product is identified by its UPC. Table 1 summarizes the variables included in the data set that define each observation. Summary statistics for these variables are presented in Table 2.<sup>33</sup> In addition, Table 3 provides market share data of the analyzed fluid milk products across fat content and container size.

### Regression Results

The econometric specification provides little guidance on how to account for time trends and seasonal effects in the estimation equations. A series of four different regression models based on the econometric specification described in equation (4.5)

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<sup>32</sup> Four milk processors produce items in more than one category, for example, organic and conventional milk products.

<sup>33</sup> Some of the variables display extreme values (e.g., minimum values for  $unitsales_{mj}$  and  $P_j$ ). Regressions excluding these extreme values resulted in similar coefficient estimates. Thus, these extreme values were included in the regressions for which parameter estimates are reported.

were therefore estimated for each fat content and container size combination separately in STATA version 7.0.<sup>34</sup>

Base regression model:

$$\ln\left(\frac{unitsales_{m_i}}{unitsales_{m_r}}\right) = \alpha_0 + \alpha_1 population + \beta_1 rBGHfreeonlabeled + \beta_2 rBGHfreelabeled + \beta_3 organic + \beta_4 (P_{m_i} - P_{m_r}) + \varepsilon. \quad (4.6)$$

Model with year ( $Y$ ) and month ( $M$ ) dummies:

$$\ln\left(\frac{unitsales_{m_i}}{unitsales_{m_r}}\right) = \alpha_0 + \alpha_1 population + \beta_1 rBGHfreeonlabeled + \beta_2 rBGHfreelabeled + \beta_3 organic + \beta_4 (P_{m_i} - P_{m_r}) + \chi M + \delta Y + \varepsilon. \quad (4.7)$$

Time trend and time interaction model:

$$\ln\left(\frac{unitsales_{m_i}}{unitsales_{m_r}}\right) = \alpha_0 + \alpha_1 population + \beta_1 rBGHfreeonlabeled + \beta_2 rBGHfreelabeled + \beta_3 organic + \beta_4 (P_{m_i} - P_{m_r}) + \phi_1 year + \phi_2 year^2 + \gamma_1 rBGHfreeonlabeled * year + \gamma_2 rBGHfreelabeled * year + \gamma_3 organic * year + \varepsilon. \quad (4.8)$$

Time interaction model:

$$\ln\left(\frac{unitsales_{m_i}}{unitsales_{m_r}}\right) = \alpha_0 + \alpha_1 population + \beta_1 rBGHfreeonlabeled + \beta_2 rBGHfreelabeled + \beta_3 organic + \beta_4 (P_{m_i} - P_{m_r}) + \gamma_1 rBGHfreeonlabeled * year + \gamma_2 rBGHfreelabeled * year + \gamma_3 organic * year + \varepsilon. \quad (4.9)$$

These regression models differ mainly in their treatment of time trends and possible seasonal effects. Regression (4.6) is the base model. The dependent variable is defined as the logarithm of the ratio of unit sales of a given product to unit sales of the

<sup>34</sup> Due to the possibility of measurement errors in the price variables, an instrumental variable approach (2SLS) was also considered. However, no appropriate instruments could be identified for this approach.

reference brand. An intercept term ( $\alpha_0$ ), a market population variable (*population*), dummies for the rBGH-characteristic (*rBGHfreenonlabeled*, *rBGHfreelabeled*, *organic*) and the price difference of the given product and the reference brand ( $P_{mi}-P_{mr}$ ) are included as independent variables. This specification does not account for time trends or seasonal effects. A vector of month dummies ( $M$ ) and year dummies ( $Y$ ) is added to the variables of the base model in model (4.7). The monthly dummies were included to capture possible seasonal effects and year dummies can detect time trends. Time trends are addressed differently in model (4.8). Instead of year dummies, a variable for the year in which the observation was collected (*year*) and a variable that squares these values (*year2*) are included to account for potential linear and nonlinear time trends. In addition, interaction terms between the rBGH-characteristic variables and the year the observation was collected are included to investigate in specific time trends for the different rBGH-characteristics. Finally, model (4.9) is a variation of model (4.8) in that it only includes the interaction terms between the time trend and rBGH-characteristic variables.

The market population variable serves as a market size measure to account for the fact that only some of the products are available nationwide and might display larger unit sales in this aggregated national-level data set.

The dummies for the rBGH-characteristic are structured to identify mutually exclusive categories. Only one of the dummies can be nonzero for a single item. If a dummy equals zero, there are no differences regarding the rBGH-characteristic between a given product and its reference brand. The reference brands are non-organic products that may be produced with the use of rBGH; that is, they are conventional fluid milk products.

If the rBGH-free non-labeled dummy equals one, the given product is produced without the use of rBGH but is not labeled. If the rBGH-free labeled dummy equals one, the given product is rBGH-free and is labeled. If the organic dummy equals one, the given product is certified organic. Finally, if all three dummies equal zero, the given product is produced conventionally.

Several tests for heteroskedasticity were performed on the data set. A general test for heteroskedasticity that does not specify particular variables (Breusch and Pagan 1979) detected heteroskedasticity in all four models for all combinations of fat content and container size. More restricted tests for heteroskedasticity, using specific variables to define the heteroskedasticity problem (White 1980) failed to reject the null hypothesis of homoskedasticity. In applying White's approach, the population variable, month dummies, and year dummies were used. Heteroskedasticity in the data appears to be introduced by a number of factors that cannot be easily separated. Consequently, the regressions were estimated in a Generalized Least Squares (GLS) form and White-corrected standard errors are reported.

Tables 4 to 11 summarize regression results for each of the four alternative model specifications. Each table presents regression results for products with different fat content and container size combinations. Coefficients for month and year dummies are not reported in the tables since they are not significant individually, and combined F-tests indicated that they have no joint explanatory power for any of the fat content and container size combinations. The parameter estimates for the base model are reported to permit comparisons between the results in model (4.6) and (4.7).

Coefficients on the price difference variable are negative and statistically significant in all regression specifications and fat content and container size combinations. Estimated parameter values range from  $-4.44$  to  $-1.18$ , indicating that larger price differences between the product of interest and its reference brand will lead to a decrease in the (logarithm of) quantity ratio (i.e., a decrease in sales relative to the reference brand). Coefficients on the *population* variable are also significant and range from  $.002$  to  $.006$ . These values suggest that as the market size for a product increases, sales of that product will increase.

The estimated parameter for *rBGHfreelabeled* is of central interest for this study. This coefficient is positive and significant in all regressions except for the 1% fat, one gallon milk category and for the whole, half gallon category in specification (4.8) and (4.9).<sup>35</sup> Values of this coefficient range in magnitude from  $.21$  to  $1.23$ . These results indicate that a rBGH-free label will increase the (logarithm of) quantity ratio. A rBGH-free label appears to shift the demand curve up for these differentiated fluid milk products. Estimates for model specifications in (4.8) and (4.9) further suggest that this labeling effect increases slightly over time. Estimated coefficients for the interaction term between the rBGH-characteristic and the *year* variable are positive though not always significant for all regressions, except for the fat free, one gallon milk category.

While the estimated coefficient for *rBGHfreeonlabeled* is generally significant, it varies in sign across half gallon and gallon categories, ranging in magnitude from  $-2.46$  to  $2.21$ . Additional one-tailed F-tests of whether the coefficient for *rBGHfreelabeled* is

greater in magnitude than the coefficient for *rBGHfree* indicate different results across gallon and half gallon categories.<sup>36</sup> In particular, for the fat free and 2%, gallon categories, the test failed to reject the tested null hypothesis at the conventional significance levels. These inconsistent results may stem from the nature of the data set. Only two milk processors in the data set offer products that are rBGH-free but are not labeled in the data set. For one of these processors, only few product entries are available and no sales are reported for several time periods. The estimated coefficients may be dominated by one milk processor and may reflect brand specific trends.

Estimated coefficients for the *organic* variable are generally positive and significant. These estimates range from .37 to 4.00 and are greater in magnitude than the estimated coefficients for the variable *rBGHfree* in most cases. Only in the 1% fat, one gallon category are the *organic* coefficients in all of the different specifications insignificant. In the whole milk, one gallon category, *organic* coefficients are not significant in every specification. In addition, for the specification in equation (4.8) and (4.9) the partial effects on *organic* become insignificant for the 2% fat, one gallon and 1% fat, half gallon combinations.

For 1% fat and whole, one gallon fluid milk, the interaction variable *organic\*year* could not be included in the regression. Only very few observations for organic products were available for these categories and most occur in the same year. Therefore, the variables *organic* and *organic\*year* are perfectly collinear.

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<sup>35</sup> In addition, Table 12 presents the p-values for one-tailed t-tests of the difference between rBGH-free labeled and conventional fluid milk products.

<sup>36</sup> P-values for these one-tailed F-tests are reported in Table 13.

### Additional Diagnostic Regressions

The results in Tables 4 to 11 indicate some problems inherent in the data set. As noted in the description of the data, organic gallon products do not appear in the data set until April 1998. Even at later dates, few organic gallons entries are included in the database and no sales are reported for several time periods. This inconsistency is particularly a problem for 1% and whole organic milk in gallons. In addition, the data seem to be influenced by market penetration of organic products. More and more supermarket chains have added organic products to their product palette over the time period during which the data were collected. Therefore, a considerable increase of unit sales because of market penetration may be reflected in the data set. Also, as mentioned earlier, the magnitude of the coefficient for *organic* cannot be fully attributed to the rBGH-characteristic. Other differences between conventional and organic products may influence consumer choice. Thus, the estimates for organic milk demand are not directly applicable for the main interest of this study, the effect of rBGH-free labels.

The four regression specifications in equations (4.6) to (4.9) were also estimated excluding the observations for organic products. Due to the fact that organic milk in gallons appears at a later point in the data set, Chow tests (Chow 1960) were conducted to investigate the possibility of structural changes in the market in 1998. The four regression specifications were estimated using two unrestricted models from 1995 to 1997 and 1998 to 1999<sup>37</sup>, as well as a restricted model covering the full time period for

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<sup>37</sup> The variable *year* was recoded for each time period separately starting at one (1995 to 1997 corresponds to 1-3 and 1998 to 1999 corresponds to 1-2).

each category.<sup>38</sup> While the null hypothesis of no structural change could be rejected for some of the categories and regression specifications, structural change does not appear to be a result of the introduction of organic gallon milk. None of the gallon categories indicate structural changes in the tests. The appearance of structural change may have been introduced by the data collecting procedure. The time periods 1995 to 1997 and 1998 to 1999 also coincide with the change from 13-week period to 4-week period tracking by IRI. It was assumed that the change in the data collection procedure does not affect the results, since quantity ratios rather than unit sales themselves are used in the regression. For some of the fat content and container size categories, the introduction of different time trend specifications results in the disappearance of statistical significant evidence of structural change.

Tables 14 to 21 present the parameter estimates when the organic milk data is omitted. Separate regressions for two time periods (1995 to 1997 and 1998 to 1999) are reported for the model specifications and categories if structural change was detected in Chow tests. The regression estimates did not considerably change compared to the results in Tables 4 to 11. When two time periods were estimated, the coefficients for *rBGHfreelabeled* are consistently greater in the second period than in the first. These results further strengthen the argument that market adjustments to changes in labeling policies occur over time.

In addition to these results, the next section provides a comparison of price elasticity estimates for rBGH-free labeled and conventional branded milk.

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<sup>38</sup> The variable *year2* was not included in the regression specification (4.8) for Chow tests. For the period

### Price Elasticity Estimates

Price elasticities were estimated to examine whether consumer response to price changes differs among fluid milk with various rBGH-characteristics. To compute price elasticities for different rBGH-characteristics, regression specification (4.6) was reformulated as:

$$\ln\left(\frac{unitsales_{m_i}}{unitsales_{m_r}}\right) = \alpha_0 + \alpha_1 population + \beta_1 rBGHfreelabeled + \beta_2 (P_i - P_r) rBGHfreelabeled + \beta_3 (P_i - P_r) conventional + \varepsilon. \quad (4.10)$$

Carrying out appropriate transformations the following equation can be derived to compute the price elasticities for different fat content and container size categories of rBGH-free labeled milk from these regression estimates:<sup>39</sup>

$$\eta = unitsales_{m_r} * e^{\beta_2 P_{m_i}} * \beta_2 * \frac{P_{m_i}}{unitsales_{m_i}}. \quad (4.11)$$

These price elasticities are computed at the sample means.<sup>40</sup>

The specification in (4.10) represents the final estimated regression that does not include interaction terms between price differences and organic or rBGH-free non-labeled milk. The market penetration problem for organic milk in the data set yields positive and significant coefficients for the interaction term between price differences and organic milk. Also, the data entries for the two rBGH-free non-labeled brands do not provide a sufficient price variation between brands to investigate price elasticities for that

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1998 to 1999, *year* only consists of two values, making it unfeasible to include both *year* and *year2* in the regression.

<sup>39</sup> For conventional milk, the same equation is used, substituting  $\beta_3$  for  $\beta_2$ .

<sup>40</sup> The mean values for  $P_{m_i}$  and  $unitsales_{m_i}$  are derived using only the corresponding rBGH-free labeled or conventional milk products of the fat content and container size category.

characteristic. The coefficient for the interaction term between price differences and rBGH-free non-labeled milk are positive and significant for three fat content and container size categories. These estimates would translate into positive estimated price elasticities.

Table 22 presents the price elasticity estimates for rBGH-free labeled and conventional milk.<sup>41</sup> Both of these categories only include branded milk products. For the first time period (1995-1997), some elasticity estimates were not computed because the estimated regression coefficients were statistically insignificant. The analysis therefore focuses on the second period (1998-1999). The results as a whole suggest that no distinctive pattern in response to price changes between these two milk types is evident. If gallons and half gallons of milk are considered as separate product groups, the price elasticity estimates for half gallons suggest that consumers are less responsive to price changes in the rBGH-free labeled milk products. With the exception of the estimate for 1%, half gallon milk in the first time period (1995-1997), rBGH-free labeled products are less price elastic than conventional products at their means. In addition, price elasticities for rBGH-free labeled milk have the smallest absolute values, suggesting that demand for rBGH-free labeled milk might be more price inelastic. This trend is almost reversed, however, for the gallons category. In addition, the in this study estimated price elasticities for rBGH-free labeled products contrast Glaser and Thompson's (2000) obtained high own-price elasticity estimates for organic milk. However, the here estimated price elasticities might indicate that higher income households consume rBGH-free labeled

products. This hypothesis is further supported by higher prices of rBGH-free labeled products relative to conventional products observed in the data set.

While milk is often considered to be one of the most price inelastic commodities (Kinoshita et al. 2001) some of the elasticity estimates presented in Table 22 are significantly higher than unity in absolute values. The elasticity estimates reported here are product-specific. In addition, milk is frequently used in sales promotions by supermarkets to bring customers into their stores (Green and Park 1998). Consumer reaction to these advertised sales could account for some of the high price elasticity estimates.<sup>42</sup> There may be substitutions between offered brands and similar fat contents.

Some of the elasticity estimates presented in this study are lower in absolute magnitude than previously reported price elasticities. Yet, in the aggregate, the results do not differ markedly from previous studies. Glaser and Thompson (2000) use national-level scanner data on fluid milk from 1988-1999 to estimate price elasticities for half gallons of fluid milk with different fat contents. For branded milk, Glaser and Thompson's estimates range from -.726 for whole milk to -1.302 for 2% milk. Gould (1996) reports price elasticities of -.583 for 1% milk, -.593 for 2% milk and -.803 for whole milk using nationwide household survey data for 1991 and 1992. Only the price elasticity estimate for 2% milk is significant in Green and Park's study (1998). Green and Park use scanner data from a retail chain in Texas for 1996 and 1997 and arrive at a value of -2.724. In both Gould and Green's, and Park's study, no differentiation is made

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<sup>41</sup> Price elasticity measures were only computed if  $\beta_2$  and/or  $\beta_3$  were statistically significant in regression specification (4.10).

<sup>42</sup> Advertised sales cannot be observed in the in the data set, since the price data is temporally and spatially aggregated and based on list prices.

between container sizes and branded versus private label fluid milk. Furthermore, Heien and Wessells (1988) estimated that demand for milk is generally inelastic (-.62) using nationwide household survey data for 1977 and 1978.

### Summary

This study has investigated the effects of labeling about the use of rBGH in milk production on consumer purchase behavior. Four different estimation models were employed that differ mainly in their treatment of time trends and seasonal effects. Heteroskedasticity was present in all model specifications. As a result the model specifications were estimated in GLS and corrected standard errors are reported.

The positive statistically significant parameter estimates on the variable indicating whether a product is rBGH-free and labeled are consistent with the prediction with respect to the effects of labeling obtained in the theoretical analysis. Milk products that are labeled as rBGH-free are more likely to be consumed, *ceteris paribus*. The demand for rBGH-free labeled fluid milk products is significantly higher than the demand for conventional fluid milk products. Estimates on rBGH-free label-specific time trends further suggest that these effects increase over time. Parameter estimates for the variable indicating whether a product is rBGH-free but not labeled as such were generally statistically significant but varied in sign. Consistent positive demand effects could not be detected for rBGH-free unlabeled products. Additional tests also indicated that estimates for rBGH-free labeled products are significantly different and greater in magnitude than

estimates for rBGH-free non-labeled products for most of the fat content and container size categories. The provision of relevant information on a product label may be necessary for market segmentation between conventional and rBGH-free products. These results suggest that adding a label on the package enables consumers to make an improved product choice and therefore increases consumer surplus, *ceteris paribus*.

Figure 2 illustrates these findings.

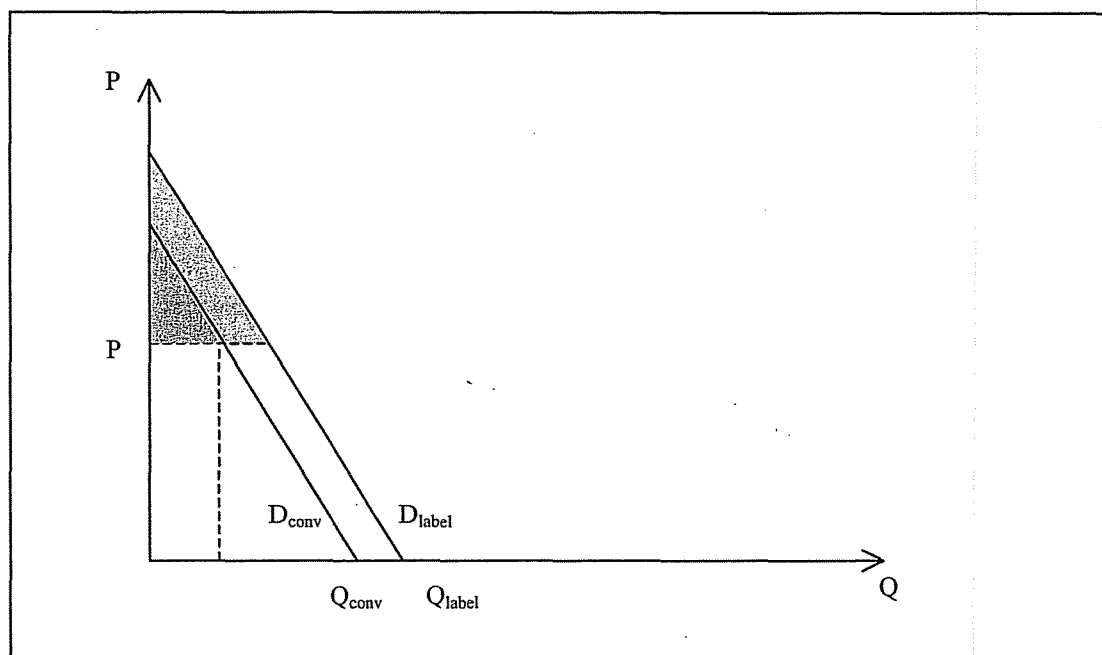


Figure 2. Demand effects and increase in consumer surplus for rBGH-free labeled fluid milk.

Starting from a demand curve for undifferentiated conventional milk products ( $D_{conv}$ ), the provision of labeling information shifts the demand for differentiated rBGH-free milk products ( $D_{label}$ ) to the right. The lighter shaded area illustrates the resulting increase in consumer surplus when both products have the same price,  $P$ .

The demand estimates for organic fluid milk may reflect market penetration of organic products over the time period analyzed. Although the parameter estimates for organic milk are positive and statistically significant and greater in magnitude than the parameter estimates for rBGH-free labeled milk, the estimates may not provide a reliable test to address effects of different levels of labeling information also discussed in the theoretical framework.

In addition, price elasticity estimates for rBGH-free labeled on conventional fluid milk were derived. While some of these elasticity estimates are lower in absolute magnitude than previously reported price elasticities, in the aggregate, the results do not differ markedly from previous studies. The elasticity estimates as a whole suggest no distinctive pattern in response to price changes between rBGH-free labeled and conventional milk. If only the estimated price elasticities for half gallon milk products are considered, consumers appear less responsive to price changes in rBGH-free labeled milk than in conventional milk. More speculatively, lower price elasticity estimates for the demand for rBGH-free labeled products may indicate that higher income households consume rBGH-free labeled products. Higher prices for rBGH-free labeled products relative to conventional products provide some additional support for this hypothesis.

Table 1. Description of variables in final data set.

Variable name	Description
$unitsales_{mi}$	- quantity of investigated fluid milk item sold
$unitsales_{mr}$	- quantity of corresponding (in fat content and container size) reference brand sold
$\ln (unitsales_{mi} / unitsales_{mr})$	- logarithm of ratio of above two quantity measures
$P_{mi}$	- price of single fluid milk item (nominal, in \$)
$P_{mr}$	- price of corresponding reference brand (nominal, in \$)
$P_{mi} - P_{mr}$	- price difference between above two price variables
population	- annual state population estimates for states where a brand is available (in millions)
rBGHfreenonlabeled	- dummy indicating whether a brand is produced without the use of rBGH and not labeled (equals 1 and 0 otherwise)
rBGHfreelabeled	- dummy indicating whether a brand is labeled as rBGH-free (equals 1 and 0 otherwise)
organic	- dummy indicating whether a brand is certified organic (equals 1 and 0 otherwise)
year	- indicates the year the observation was collected in (years 1995-1999 are recoded as 1-5)
year2	- square of <i>year</i>
M	- vector of dummies for the month the observation was collected in (equals 1 for month during which observation was collected, and 0 otherwise)
Y	- vector of dummies for the year the observation was collected in (equals 1 for year during which observation was collected, and 0 otherwise)

Table 2. Summary statistics.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
unitsales <sub>mi</sub>	5840	137490.4	220847.2	1	2030569
unitsales <sub>mr</sub>	312	8351017	1.18*10 <sup>7</sup>	988116	6.56*10 <sup>7</sup>
ln (unitsales/ unitsales <sub>mr</sub> )	5840	-4.90	2.36	-14.91	-1.29
P <sub>mi</sub>	5840	2.22	.75	.95	5.51
P <sub>mr</sub>	312	2.03	.47	1.36	2.87
P <sub>mi</sub> -P <sub>mr</sub>	5840	.31	.53	-.89	3.01
population	5840	130.33	103.61	12.58	272.70
rBGHfreeonlabeled	5840	.08	.28	0	1
rBGHfreelabeled	5840	.28	.45	0	1
organic	5840	.13	.34	0	1

Table 3. Market share of fluid milk products across fat content and container size.

	Observations	Mean unit sales	% of total unit sales
½ gallon	3666	119006.31	54.34
fat free	1019	134538.37	17.07
1%	926	90249.84	10.44
2%	902	144884.26	16.28
whole	816	103743.26	10.24
1 gallon	2174	168660.02	45.67
fat free	665	151659.29	12.56
1%	388	142955.44	6.90
2%	572	223691.05	15.94
whole	549	150082.81	10.26

Table 4. Regression results for fat free, 1½ gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-4.38*** (.10)	-4.48*** (.32)	-3.99*** (.42)	-4.39*** (.10)
population	.002*** (.0006)	.002*** (.0006)	.002*** (.0006)	.002*** (.0006)
rBGHfreenonlabeled ( $\beta_1$ )	-1.41*** (.2711)	-1.41*** (.27)	-.62 (.66)	-.26 (.61)
rBGHfreelabeled ( $\beta_2$ )	.67*** (.14)	.68*** (.15)	.17 (.41)	.52 (.34)
organic ( $\beta_3$ )	3.88*** (.32)	3.9*** (.32)	1.90*** (.60)	2.24*** (.56)
$P_{mi}-P_{nr}$	-3.60*** (.26)	-3.61*** (.26)	-3.69*** (.26)	-3.67*** (.26)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			-.21 (.18)	-.31* (.17)
rBGHfreelabeled*year ( $\gamma_2$ )			.15 (.10)	.05 (.08)
organic*year ( $\gamma_3$ )			.52*** (.13)	.42*** (.12)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			-1.25*** (.26)	-1.18*** (.26)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.60*** (.16)	.66*** (.15)
of organic ( $\beta_3+\gamma_3$ *year)			3.46*** (.33)	3.51*** (.33)
<u>Time trend specifications</u>				
year			-.14 (.24)	
year2			.006 (.04)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	1019	1019	1019	1019
Degrees of freedom	1013	998	1008	1010
Sum of squared residuals	2764.63	2752.25	2709.73	2718.53

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 5. Regression results for fat free, 1 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-6.93*** (.15)	-6.80*** (.33)	-6.93*** (.49)	-6.92*** (.15)
population	.005*** (.0007)	.005*** (.0007)	.005*** (.0007)	.005*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	2.11*** (.15)	2.11*** (.15)	2.20*** (.35)	2.59*** (.16)
rBGHfreelabeled ( $\beta_2$ )	1.10 *** (.23)	1.13*** (.23)	1.32*** (.44)	1.74*** (.34)
organic ( $\beta_3$ )	2.57*** (.63)	2.81*** (.64)	3.04* (1.69)	3.91** (1.60)
$P_{mi}-P_{mr}$	-2.74*** (.26)	-2.79*** (.27)	-2.77*** (.27)	-2.71*** (.27)
<b>Interaction terms</b>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			-.02 (.08)	-.13*** (.1764)
rBGHfreelabeled*year ( $\gamma_2$ )			-.05 (.11)	-.17** (.08)
organic*year ( $\gamma_3$ )			-.06*** (.38)	-.29 (.35)
<b>Partial effects<sup>1</sup></b>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			2.13*** (.17)	2.21*** (.15)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			1.17*** (.23)	1.23*** (.22)
of organic ( $\beta_3+\gamma_3$ *year)			2.86*** (.76)	3.02*** (.75)
<b>Time trend specifications</b>				
year			.22 (.3)	
year2			-.05 (.05)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	665	665	665	665
Degrees of freedom	659	644	654	656
Sum of squared residuals	2092.50	2069.74	2071.34	2083.07

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 6. Regression results for 1%, 1/2 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-4.12*** (.21)	-3.77*** (.25)	-3.10*** (.32)	-4.13*** (.08)
population	.003*** (.0006)	.003*** (.0006)	.003*** (.0006)	.003*** (.0006)
rBGHfreenonlabeled ( $\beta_1$ )	-1.84*** (.19)	-1.85*** (.19)	-3.16*** (.52)	-2.02*** (.50)
rBGHfreelabeled ( $\beta_2$ )	.66*** (.13)	.67*** (.13)	-.57* (.32)	.57* (.30)
organic ( $\beta_3$ )	1.41*** (.39)	1.47*** (.39)	-2.06 (1.57)	-.91 (1.55)
$P_{mi}-P_{mr}$	-3.00*** (.19)	-3.00*** (.19)	-3.07*** (.19)	-3.02*** (.19)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			.35** (.14)	.05 (.14)
rBGHfreelabeled*year ( $\gamma_2$ )			.33*** (.08)	.03 (.07)
organic*year ( $\gamma_3$ )			.86** (.35)	.54 (.34)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			-2.11*** (.20)	-1.87*** (.19)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.44*** (.13)	.65*** (.14)
of organic ( $\beta_3+\gamma_3$ *year)			.52 (.62)	.72 (.61)
<u>Time trend specifications</u>				
year			-.22 (.23)	
year2			-.01 (.04)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	929	929	929	929
Degrees of freedom	923	908	918	920
Sum of squared residuals	3066.30	3085.54	2992.83	3053.64

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 7. Regression results for 1%, 1 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-3.85*** (.17)	-3.61*** (.45)	-2.88*** (.68)	-3.85*** (.17)
population	.002*** (.0007)	.002*** (.0007)	.002*** (.0007)	.002*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	-1.07*** (.37)	-1.01*** (.36)	-.77 (1.22)	-.94 (1.21)
rBGHfreelabeled ( $\beta_2$ )	.03 (.21)	.06 (.21)	-.21 (.62)	.08 (.46)
organic ( $\beta_3$ )	.51 (1.13)	.47 (1.14)	.42 (1.17)	.52 (1.14)
$P_{mi}-P_{mr}$	-2.24*** (.35)	-2.30*** (.34)	-2.29*** (.36)	-2.24*** (.36)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			-.06 (.29)	-.04 (.29)
rBGHfreelabeled*year ( $\gamma_2$ )			-.04 (.15)	.01 (.11)
organic*year ( $\gamma_3$ )			<sup>2</sup>	<sup>2</sup>
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			-.96** (.46)	-1.04** (.47)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.09 (.25)	.04 (.23)
of organic ( $\beta_3+\gamma_3$ *year)			<sup>3</sup>	<sup>3</sup>
<u>Time trend specifications</u>				
year			-.82** (.38)	
year2			.13** (.0310)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	388	388	388	388
Degrees of freedom	382	367	378	380
Sum of squared residuals	1267.56	1287.71	1272.08	1287.56

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

<sup>2</sup>Interaction terms could not be included in regression. *Organic* and *organic\*year* are perfectly collinear.

<sup>3</sup>Partial effects could not be computed because of missing value for  $\gamma_3$ .

Table 8. Regression results for 2%, 1/2 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-4.41*** (.13)	-4.48*** (.28)	-3.57*** (.33)	-4.41*** (.0947)
population	.004*** (.0008)	.004*** (.0008)	.004*** (.0008)	.004*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	-2.28*** (.30)	-2.27*** (.30)	-3.13*** (.82)	-2.28*** (.80)
rBGHfreelabeled ( $\beta_2$ )	.61*** (.13)	.62*** (.13)	-.82** (.36)	-.02 (.31)
organic ( $\beta_3$ )	3.71*** (.30)	3.71*** (.31)	.46*** (.70)	1.30* (.68)
$P_{mi}-P_{mr}$	-4.10*** (.20)	-4.10*** (.21)	-4.20*** (.20)	-4.17*** (.20)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			.24 (.22)	.002 (.21)
rBGHfreelabeled*year ( $\gamma_2$ )			.40*** (.09)	.17** (.08)
organic*year ( $\gamma_3$ )			.88*** (.17)	.64*** (.16)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			-2.41*** (.31)	-2.28*** (.31)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.39*** (.14)	.52*** (.14)
of organic ( $\beta_3+\gamma_3$ *year)			3.11*** (.32)	3.23*** (.32)
<u>Time trend specifications</u>				
year			-.24 (.25)	
year2			.0003 (.04)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	902	902	902	902
Degrees of freedom	896	881	891	893
Sum of squared residuals	3420.65	3427.97	3306.61	3348.83

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 9. Regression results for 2%, 1 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-5.21*** (.18)	-4.88*** (.38)	-3.80*** (.58)	-5.20*** (.18)
population	.005*** (.0008)	.006*** (.0008)	.006*** (.0008)	.005*** (.0008)
rBGHfreenonlabeled ( $\beta_1$ )	.54 (.36)	.60* (.35)	.67 (.76)	1.01 (.76)
rBGHfreelabeled ( $\beta_2$ )	.50** (.20)	.51** (.20)	-.21 (.52)	.26 (.37)
organic ( $\beta_3$ )	.38*** (.46)	.37*** (.48)	1.20 (1.69)	.13 (1.52)
$P_{mi}-P_{mr}$	-2.07*** (.21)	-2.09*** (.21)	-2.12*** (.21)	-2.09*** (.21)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			-.02 (.18)	-.14 (.18)
rBGHfreelabeled*year ( $\gamma_2$ )			.20 (.13)	.07 (.08)
organic*year ( $\gamma_3$ )			-.14 (.38)	.06 (.33)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			.62* (.37)	.64* (.38)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.40* (.22)	.46** (.21)
of organic ( $\beta_3+\gamma_3$ *year)			.78 (.66)	.31 (.63)
<u>Time trend specifications</u>				
year			-.89** (.34)	
year2			.12 (.05)**	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	572	572	572	572
Degrees of freedom	566	551	561	563
Sum of squared residuals	2127.69	2156.66	2124.60	2153.73

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 10. Regression results for whole, 1/2 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-4.46*** (.11)	-5.04*** (.33)	-5.05*** (.49)	-4.47*** (.11)
population	.002*** (.0007)	.002*** (.0007)	.002*** (.0007)	.002*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	-2.44*** (.34)	-2.46*** (.35)	-1.22 (.83)	-1.35* (.78)
rBGHfreelabeled ( $\beta_2$ )	.27* (.15)	.26* (.15)	-.04 (.50)	-.16 (.41)
organic ( $\beta_3$ )	3.98*** (.31)	4.00*** (.31)	1.07 (.84)	.96 (.80)
$P_{mi}-P_{mr}$	-4.41*** (.19)	-4.44*** (.20)	-4.51*** (.19)	-4.51*** (.19)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			-.33 (.23)	-.30 (.22)
rBGHfreelabeled*year ( $\gamma_2$ )			.09 (.12)	.13 (.10)
organic*year ( $\gamma_3$ )			.76*** (.20)	.79*** (.18)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			-2.22*** (.33)	-2.24*** (.33)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.23 (.18)	.21 (.17)
of organic ( $\beta_3+\gamma_3$ *year)			3.35*** (.36)	3.32*** (.35)
<u>Time trend specifications</u>				
year			.40 (.30)	
year2			-.06 (.04)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	816	816	816	816
Degrees of freedom	810	795	805	807
Sum of squared residuals	3204.62	3237.00	3114.59	3122.27

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 11. Regression results for whole, 1 gallon milk (whole sample).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-4.82*** (.16)	-4.83*** (.35)	-5.66*** (.52)	-4.82*** (.16)
population	.002*** (.0006)	.002*** (.0006)	.002*** (.0005)	.002*** (.0006)
rBGHfreenonlabeled ( $\beta_1$ )	-.91*** (.30)	-.92*** (.31)	.67 (.71)	.87 (.61)
rBGHfreelabeled ( $\beta_2$ )	.91*** (.18)	.95*** (.18)	.70 (.45)	.80** (.31)
organic ( $\beta_3$ )	.86 (.58)	1.29** (.61)	1.18* (.62)	.87 (.59)
$P_{mi}-P_{mr}$	-1.18*** (.25)	-1.26*** (.25)	-1.24*** (.25)	-1.18*** (.25)
<u>Interaction terms</u>				
rBGHfreenonlabeled*year ( $\gamma_1$ )			-.40** (.20)	-.45*** (.1764)
rBGHfreelabeled*year ( $\gamma_2$ )			.06 (.12)	.03 (.07)
organic*year ( $\gamma_3$ )			<sup>2</sup>	<sup>2</sup>
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1+\gamma_1$ *year)			-.54* (.29)	-.49* (.28)
of rBGHfreelabeled ( $\beta_2+\gamma_2$ *year)			.88*** (.19)	.89*** (.19)
of organic ( $\beta_3+\gamma_3$ *year)			<sup>3</sup>	<sup>3</sup>
<u>Time trend specifications</u>				
year			.71** (.33)	
year2			-.12** (.05)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	549	549	549	549
Degrees of freedom	543	528	539	541
Sum of squared residuals	2034.34	2034.34	1999.61	2017.09

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

<sup>2</sup>Interaction terms could not be included in regression. *Organic* and *organic\*year* are perfectly collinear.

<sup>3</sup>Partial effects could not be computed because of missing value for  $\gamma_3$ .

Table 12. P-values for tests of difference between rBGH-free labeled and conventional fluid milk.

	(4.6)	(4.7)	(4.8)	(4.9)
½ gallon				
fat	$2.03 \times 10^{-6}$	$1.76 \times 10^{-6}$	.0001	$9.59 \times 10^{-6}$
free				
1%	$1.30 \times 10^{-7}$	$1.35 \times 10^{-7}$	.0006	$1.24 \times 10^{-6}$
2%	$3.09 \times 10^{-6}$	$2.48 \times 10^{-6}$	.003	.0002
whole	.04	.04	.10	.11
1 gallon				
fat	$4.48 \times 10^{-7}$	$7.96 \times 10^{-7}$	$2.69 \times 10^{-7}$	$2.56 \times 10^{-8}$
free				
1%	.39	.44	.36	.42
2%	.006	.007	.03	.01
whole	$1.11 \times 10^{-7}$	$2.98 \times 10^{-7}$	$2.15 \times 10^{-6}$	$1.41 \times 10^{-6}$

Note: The null hypothesis that  $\beta_2 > 0$  was tested in a one-tailed t-test.

Table 13. P-values for tests of difference between rBGH-free labeled and non-labeled fluid milk.

	(4.6)	(4.7)	(4.8)	(4.9)
½ gallon				
fat free	$1.48 \times 10^{-11}$	$1.28 \times 10^{-11}$	$3.49 \times 10^{-9}$	$5.13 \times 10^{-10}$
1%	$2.31 \times 10^{-25}$	$1.66 \times 10^{-25}$	$2.44 \times 10^{-25}$	$1.01 \times 10^{-24}$
2%	$4.10 \times 10^{-17}$	$2.02 \times 10^{-17}$	$2.83 \times 10^{-15}$	$7.04 \times 10^{-15}$
whole	$1.79 \times 10^{-12}$	$1.44 \times 10^{-12}$	$3.04 \times 10^{-10}$	$5.62 \times 10^{-11}$
1 gallon				
fat free	.99	.99	.99	.99
1%	.005	.005	.026	.019
2%	.59	.54	.70	.65
whole	$3.36 \times 10^{-7}$	$5.04 \times 10^{-7}$	.00005	.00005

Note: The null hypothesis that  $\beta_2 > \beta_1$  was tested in a one-tailed F-test.

Table 14. Regression results for fat free, 1/2 gallon milk (organics not included in regression and separate time periods).

	1995-1997	1998-1999	1995-1999	1995-1999	1995-1999	1995-1999
<b>Independent variable</b>	<b>(4.6)</b>	<b>(4.6)</b>	<b>(4.6)</b>	<b>(4.7)</b>	<b>(4.8)</b>	<b>(4.9)</b>
constant	-4.45*** (.23)	-4.46*** (.10)	-4.44*** (.10)	-4.42*** (.34)	-3.88*** (.44)	-4.45*** (.10)
population	.004** (.002)	.001** (.0007)	.002*** (.0006)	.002*** (.0006)	.002*** (.0006)	.002*** (.0006)
rBGHfreenonlabeled ( $\beta_1$ )	-.86** (.42)	-1.65*** (.34)	-1.41*** (.27)	-1.41*** (.27)	-.641 (.67)	-.27 (.62)
rBGHfreelabeled ( $\beta_2$ )	.52* (.31)	.94*** (.17)	.80*** (.15)	.80*** (.14)	.20 (.41)	.57* (.33)
$P_{mi}-P_{mr}$	-3.99*** (.98)	-3.93*** (.25)	-3.91*** (.25)	-3.92*** (.25)	-3.97*** (.25)	-3.93*** (.25)
<u>Interaction terms</u>						
rbghfreenonlabeled*year ( $\gamma_1$ )					-.20 (.18)	-.31* (.17)
rBGHfreelabeled*year ( $\gamma_2$ )					.17 (.10)	-.06 (.08)
<u>Partial effects<sup>1</sup></u>						
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1 * year$ )					-1.25*** (.27)	-1.19*** (.26)
of rBGHfreelabeled ( $\beta_2 +$ $\gamma_2 * year$ )					.70*** (.16)	.76*** (.15)
<u>Time trend specifications</u>						
year					-.27 (.26)	
year2					.026 (.04)	
Month dummies included	no	no	no	yes	no	no
Year dummies included	no	no	no	yes	no	no
Sample size	279	614	893	893	893	893
Degrees of freedom	274	609	888	873	884	886
Sum of squared residuals	948.21	1483.56	2463.32	2444.13	2437.90	2448.87

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 15. Regression results for fat free, 1 gallon milk (organics not included in regression).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-6.92*** (.15)	-6.78*** (.33)	-6.90*** (.49)	-6.91*** (.15)
population	.005*** (.0007)	.005*** (.0007)	.005*** (.0007)	.005*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	2.08*** (.15)	2.07*** (.16)	2.19*** (.35)	2.61*** (.17)
rBGHfreelabeled ( $\beta_2$ )	1.24*** (.23)	1.27*** (.23)	1.38*** (.44)	1.83*** (.34)
$P_{mr}-P_{mr}$	-3.05*** (.26)	-3.09*** (.27)	-3.01*** (.27)	-3.01*** (.27)
<u>Interaction terms</u>				
rbghfreenonlabeled*year ( $\gamma_1$ )			-.03 (.08)	-.14*** (.03)
rBGHfreelabeled*year ( $\gamma_2$ )			-.03 (.11)	-.15* (.08)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1$ *year)			2.09*** (.17)	2.18*** (.19)
of rBGHfreelabeled ( $\beta_2 +$ $\gamma_2$ *year)			1.29*** (.23)	1.36*** (.22)
<u>Time trend specifications</u>				
year			.22 (.30)	
year2			0.05 (.04)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	629	629	629	629
Degrees of freedom	624	609	620	622
Sum of squared residuals	1999.85	1976.47	1978.88	1991.90

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 16. Regression results for 1%, 1/2 gallon milk (organics not included in regression and separate time periods).

	1995-1997	1998-1999	1995-1999	1995-1997	1998-1999	1995-1999	1995-1999	1995-1997	1998-1999	1995-1999
<b>Independent variable</b>	(4.6)	(4.6)	(4.6)	(4.7)	(4.7)	(4.7)	(4.8)	(4.9)	(4.9)	(4.9)
constant	-3.68*** (.17)	-4.42*** (.09)	-4.18*** (.08)	-3.72*** (.39)	-4.14*** (.42)	-3.89*** (.23)	-3.01*** (.29)	-3.68*** (.17)	-4.41*** (.09)	-4.19*** (.08)
population	.004*** (.001)	.003*** (.0007)	.003*** (.0006)	.004*** (.001)	.003*** (.0007)	.003*** (.0006)	.003*** (.0006)	.004*** (.001)	.003*** (.0007)	.003*** (.0006)
rBGHfreeonlabeled ( $\beta_1$ )	-2.37*** (.31)	-1.58*** (.25)	-1.85*** (.19)	-2.37*** (.32)	-1.59*** (.31)	-1.87*** (.20)	-3.19*** (.53)	-2.57*** (.76)	-1.25* (.70)	-2.01*** (.51)
rBGHfreelabeled ( $\beta_2$ )	-.06 (.23)	1.18*** (.15)	.79*** (.13)	-.07 (.23)	1.19*** (.15)	.79*** (.13)	-.58* (.31)	-.11 (.54)	1.21*** (.38)	.59** (.30)
$P_{mi}-P_{mr}$	-2.59*** (.67)	-3.47*** (.17)	-3.27*** (.18)	-2.58*** (.66)	-3.47*** (.17)	-3.26*** (.17)	-3.35*** (.18)	-2.59*** (.66)	-3.47*** (.17)	-3.29*** (.18)
<b>Interaction terms</b>							.36** (.15)	.10 (.33)	-.23 (.50)	-.05 (.14)
rbghfreeonlabeled*year ( $\gamma_1$ )							.37*** (.08)	.02 (.25)	-.02 (.23)	.06 (.07)
rBGHfreelabeled*year ( $\gamma_2$ )										
<b>Partial effects<sup>1</sup></b>										
of rBGHfreeonlabeled ( $\beta_1 + \gamma_1 * year$ )							-2.12*** (.20)	-2.37*** (.31)	-1.48*** (.29)	-1.88*** (.20)
of rBGHfreelabeled ( $\beta_2 + \gamma_2 * year$ )							.53*** (.13)	-.06 (.23)	1.19*** (.19)	.75*** (.14)
<b>Time trend specifications</b>										
year							-.32 (.21)			
year2							.001 (.032)			
Month dummies included	no	no	no	yes	yes	yes	no	no	no	no
Year dummies included	no	no	no	yes	yes	yes	no	no	no	no
Sample size	236	563	799	236	563	799	799	236	549	799
Degrees of freedom	231	558	794	223	545	779	790	229	541	792
Sum of squared residuals	421.69	1082.66	1576.81	416.19	1077.15	1551.25	1510.96	421.42	1081.74	1575.01

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1996 (2) was used to compute the partial effects for the time period 1995-1997, 1998 (1) was used to compute the partial effects for the time period 1998-1999 and 1997(3) was used for the whole time period.

Table 17. Regression results for 1%, 1 gallon milk (organics not included in regression).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-3.77*** (.16)	-3.55*** (.46)	-2.70*** (.68)	-3.77*** (.16)
population	.002*** (.0008)	.002*** (.0008)	.002*** (.0008)	.002*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	-1.14*** (.35)	-1.08*** (.34)	-.77 (1.21)	-.89 (1.20)
rBGHfreelabeled ( $\beta_2$ )	.21 (.21)	.24 (.21)	.30 (.63)	.22 (.47)
$P_{mi} - P_{mr}$	-2.81*** (.34)	-2.88*** (.33)	-2.87*** (.34)	-2.82*** (.34)
<u>Interaction terms</u>				
rbghfreenonlabeled*year ( $\gamma_1$ )			-.08 (.28)	-.07 (.28)
rBGHfreelabeled*year ( $\gamma_2$ )			-.01 (.15)	-.0006 (.11)
<u>Partial effects<sup>1</sup></u>				
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1$ *year)			-1.01** (.45)	-1.09** (.45)
of rBGHfreelabeled ( $\beta_2 +$ $\gamma_2$ *year)			.26 (.24)	.21 (.22)
<u>Time trend specifications</u>				
year			-.87** (.38)	
year2			.14** (.06)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	372	372	372	372
Degrees of freedom	376	352	363	365
Sum of squared residuals	1145.05	1123.99	1127.65	1144.73

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 18. Regression results for 2%, 1/2 gallon milk (organics not included in regression and separate time periods).

	1995-1997	1998-1999	1995-1999	1995-1997	1998-1999	1995-1999
<b>Independent variable</b>	<b>(4.6)</b>	<b>(4.6)</b>	<b>(4.6)</b>	<b>(4.7)</b>	<b>(4.7)</b>	<b>(4.7)</b>
constant	-3.86*** (.20)	-4.81*** (.17)	-4.47*** (.13)	-4.02*** (.40)	-4.85*** (.72)	-4.41*** (.29)
population	.004** (.002)	.005*** (.0008)	.004*** (.0008)	.004** (.002)	.005*** (.0008)	.004*** (.0008)
rBGHfreenonlabeled ( $\beta_1$ )	-2.85*** (.44)	-1.93*** (.38)	-2.25*** (.29)	-2.84*** (.47)	-1.93*** (.39)	-2.24*** (.30)
rBGHfreelabeled ( $\beta_2$ )	.36* (.21)	1.06*** (.17)	.76*** (.13)	.36 (.22)	1.06*** (.18)	.77*** (.13)
$P_{mi}-P_{mr}$	-5.62*** (.46)	-4.27*** (.22)	-4.46*** (.19)	-5.63*** (.48)	-4.28*** (.22)	-4.46*** (.20)
<u>Interaction terms</u>						
rbghfreenonlabeled*year ( $\gamma_1$ )						
rBGHfreelabeled*year ( $\gamma_2$ )						
<u>Partial effects</u>						
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1 * year$ )						
of rBGHfreelabeled ( $\beta_2 +$ $\gamma_2 * year$ )						
<u>Time trend specifications</u>						
year						
year2						
Month dummies included	no	no	no	yes	yes	yes
Year dummies included	no	no	no	yes	yes	yes
Sample size	274	536	810	274	536	810
Degrees of freedom	269	531	805	261	518	790
Sum of squared residuals	829.36	2067.63	2999.18	821.51	2062.71	2983.75

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

Table 18. Regression results for 2%, 1/2 gallon milk (organics not included in regression and separate time periods) (continued).

	1995-1997	1998-1999	1995-1999	1995-1997	1998-1999	1995-1999
Independent variable	(4.8)	(4.8)	(4.8)	(4.9)	(4.9)	(4.9)
constant	-3.57*** (.71)	-5.13*** (.40)	-3.55*** (.34)	-3.86*** (.20)	-4.81*** (.17)	-4.48*** (.13)
population	.004** (.002)	.005*** (.0008)	.004*** (.0008)	.004** (.002)	.005*** (.0008)	.004*** (.0008)
rBGHfreenonlabeled ( $\beta_1$ )	-3.46*** (1.23)	-1.76 (1.11)	-3.10*** (.82)	-2.96** (1.18)	-2.08** (1.06)	-2.23*** (.80)
rBGHfreelabeled ( $\beta_2$ )	-1.08* (.55)	1.46*** (.52)	-.76** (.35)	-.57 (.45)	1.14*** (.35)	.11 (.30)
$P_{mi}-P_{mr}$	-5.71*** (.45)	-4.27*** (.22)	-4.55*** (.20)	-5.73*** (.45)	-4.27*** (.22)	-4.51*** (.19)
<u>Interaction terms</u>						
rbghfreenonlabeled*year ( $\gamma_1$ )	.31 (.54)	-.11 (.75)	.24 (.22)	.06 (.51)	.11 (.71)	-.004 (.21)
rBGHfreelabeled*year ( $\gamma_2$ )	.73*** (.27)	-.27 (.33)	.42*** (.10)	.48** (.20)	-.06 (.21)	.18** (.07)
<u>Partial effects</u> <sup>1</sup>						
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1$ *year)	-2.84*** (.45)	-1.87*** (.48)	-2.25*** (.31)	-2.85*** (.44)	-1.98*** (.47)	-2.25*** (.31)
of rBGHfreelabeled ( $\beta_2 + \gamma_2$ *year)	.38* (.22)	1.19*** (.23)	.64*** (.14)	.38* (.21)	1.08*** (.20)	.64*** (.14)
<u>Time trend specifications</u>						
year	-.25 (.18)	.21 (.26)	-.30 (.26)			
year <sup>2</sup>			.008 (.04)			
Month dummies included	no	no	no	no	no	no
Year dummies included	no	no	no	no	no	no
Sample size	274	549	810	274	549	810
Degrees of freedom	265	539	801	267	541	803
Sum of squared residuals	809.04	2064.43	2938.04	815.37	2067.27	2982.67

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1996 (2) was used to compute the partial effects for the time period 1995-1997, 1998 (1) was used to compute the partial effects for the time period 1998-1999 and 1997 (3) was used for the whole time period.

<sup>2</sup>Year<sup>2</sup> was not included in the unrestricted regression, because for the second time period (1998-1999), year only displays two values.

Table 19. Regression results for 2%, 1 gallon milk (organics not included in regression).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-5.12*** (.18)	-4.77*** (.39)	-3.66*** (.57)	-5.10*** (.19)
population	.006*** (.0008)	.006*** (.0008)	.006*** (.0008)	.006*** (.0008)
rbGHfreeonlabeled ( $\beta_1$ )	.49 (.35)	.55* (.33)	.66 (.74)	1.04 (.74)
rbGHfreelabeled ( $\beta_2$ )	.61*** (.21)	.63*** (.21)	-.17 (.52)	.30 (.38)
$P_{mi}-P_{mr}$	-2.38*** (.23)	-2.42*** (.22)	-2.45*** (.22)	-2.42*** (.23)
<u>Interaction terms</u>				
rbghfreeonlabeled*year ( $\gamma_1$ )			-.03 (.18)	-.15 (.17)
rbGHfreelabeled*year ( $\gamma_2$ )			.22* (.13)	.09 (.09)
<u>Partial effects<sup>1</sup></u>				
of rbGHfreeonlabeled ( $\beta_1 + \gamma_1 * \text{year}$ )			.58 (.35)	.59 (.37)
of rbGHfreelabeled ( $\beta_2 +$ $\gamma_2 * \text{year}$ )			.50** (.22)	.56*** (.21)
<u>Time trend specifications</u>				
year			-.91*** (.34)	
year2			.12** (.05)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	536	536	536	536
Degrees of freedom	531	516	527	529
Sum of squared residuals	2073.21	2042.17	2038.16	2069.00

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects.

Table 20. Regression results for whole, 1/2 gallon milk (organics not included in regression and separate time periods).

	1995- 1997	1998- 1999	1995- 1999	1995- 1999	1995- 1999	1995- 1997	1998- 1999	1995- 1999
<b>Independent variable</b>	<b>(4.6)</b>	<b>(4.6)</b>	<b>(4.6)</b>	<b>(4.7)</b>	<b>(4.8)</b>	<b>(4.9)</b>	<b>(4.9)</b>	<b>(4.9)</b>
constant	-4.61*** (.22)	-4.45*** (.11)	-4.50*** (.11)	-4.86*** (.34)	-5.09*** (.51)	-4.61*** (.23)	-4.45*** (.11)	-4.50*** (.11)
population	.005*** (.001)	.002** (.0009)	.003** (.0007)	.003*** (.0007)	.003*** (.0007)	.005*** (.001)	.002*** (.0009)	.003*** (.0007)
rBGHfreenonlabeled ( $\beta_1$ )	-2.07*** (.53)	-2.71*** (.44)	-2.45*** (.35)	-2.46*** (.35)	-1.26 (.83)	-1.30 (1.23)	-2.55* (1.31)	-1.38* (.79)
rBGHfreelabeled ( $\beta_2$ )	.59** (.28)	.38** (.18)	.42*** (.15)	.42*** (.15)	-.005 (.49)	-.09 (.61)	.35 (.48)	-.11 (.40)
$P_{mi}-P_{mr}$	-6.37*** (.44)	-4.45*** (.20)	-4.79*** (.18)	-4.81*** (.19)	-4.84*** (.19)	-6.46*** (.42)	-4.45*** (.20)	-4.84*** (.19)
<u>Interaction terms</u>								
rbghfreenonlabeled*year ( $\gamma_1$ )						-.32 (.23)	-.39 (.60)	-.29 (.22)
rBGHfreelabeled*year ( $\gamma_2$ )						.11 (.12)	.35 (.27)	.14 (.10)
<u>Partial effects<sup>1</sup></u>								
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1$ *year)						-2.24*** (.34)	-2.08*** (.53)	-2.25*** (.33)
of rBGHfreelabeled ( $\beta_2 + \gamma_2$ *year)						.34* (.18)	.61** (.28)	.32* (.17)
<u>Time trend specifications</u>								
year						.41 (.31)		
year2						-.06 (.05)		
Month dummies included	no	no	no	yes	no	no	no	no
Year dummies included	no	no	no	yes	no	no	no	no
Sample size	227	487	714	714	714	227	487	714
Degrees of freedom	222	482	709	694	705	220	480	707
Sum of squared residuals	856.64	1819.67	2742.41	2726.46	1510.96	846.88	1819.51	2720.71

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1996 (2) was used to compute the partial effects for the time period 1995-1997, 1998 (4) was used to compute the partial effects for the time period 1998-1999 and 1997 (3) was used for the whole time period.

Table 21. Regression results for whole, 1 gallon milk (organics not included in regression).

Independent variable	(4.6)	(4.7)	(4.8)	(4.9)
constant	-4.82*** (.16)	-4.84*** (.36)	-5.66*** (.52)	-4.82*** (.16)
population	.002*** (.0006)	.002*** (.0005)	.002*** (.0005)	.002*** (.0006)
rBGHfreenonlabeled ( $\beta_1$ )	-.91*** (.30)	-.92*** (.31)	.67 (.71)	.87 (.61)
rBGHfreelabeled ( $\beta_2$ )	.91*** (.18)	.95*** (.18)	.70 (.45)	.80** (.31)
$P_{mi}-P_{mr}$	-1.17*** (.25)	-1.26*** (.25)	-1.24*** (.25)	-1.18*** (.25)
<b>Interaction terms</b>				
rbghfreenonlabeled*year ( $\gamma_1$ )			-.40** (.52)	-.45*** (.17)
rBGHfreelabeled*year ( $\gamma_2$ )			.06 (.12)	.03 (.07)
<b>Partial effects<sup>1</sup></b>				
of rBGHfreenonlabeled ( $\beta_1 + \gamma_1$ *year)			-.54* (.29)	-.49* (.28)
of rBGHfreelabeled ( $\beta_2 +$ $\gamma_2$ *year)			.89*** (.19)	.89*** (.19)
<b>Time trend specifications</b>				
year			.71** (.33)	
year2			-.12** (.05)	
Month dummies included	no	yes	no	no
Year dummies included	no	yes	no	no
Sample size	540	540	540	540
Degrees of freedom	535	520	531	533
Sum of squared residuals	2033.24	2005.28	1998.58	217.09

Note: Standard errors are corrected for heteroskedasticity and reported in parentheses. Also, \*, \*\* and \*\*\* denote coefficients that are statistically different from 0 at the 10%, 5% and 1% level.

<sup>1</sup>The year 1997 (3) was used to compute the partial effects

Table 22. Price elasticities computed at the sample means.

	1995-1997		1998-1999	
	rBGH-free labeled	conventional	rBGH-free labeled	conventional
½ gallon				
fat free	-.06	—	-.05	-2.05
1%	-1.58	-.46	-.0005	-.47
2%	-.02	—	-.03	—
whole	-.002	-.01	-.02	-2.55
1 gallon				
fat free	-1.23	-.005	-1.83	-.02
1%	—	—	-.028	-.21
2%	—	-.012	-.62	-.07
whole	-.31	—	-.21	—

Note: Estimated price elasticities reported in the table are significant at the 1% significance level, with the exception of the estimate for 1% half gallon milk in the period 1995-1997 that is significant only at the 10% level.

## CHAPTER 5

## CONCLUSIONS

The objective of this thesis has been to investigate the effects of voluntary labeling for genetically modified organisms (GMO) in food products at the market level. The use of the genetically modified Bovine Growth Hormone (rBGH) in fluid milk production is an appealing case for evaluating labeling effects for several reasons. One of the first genetically modified products approved in the market, rBGH was widely introduced in 1994. It therefore offers the potential for studying relatively long-term data sets. Fluid beverage milk also represents a fairly homogenous product, and voluntary rBGH-free labels are somewhat uniform because they must follow guidelines set by the Food and Drug Administration (FDA). In addition, the analysis of fluid milk markets allows for differentiation between rBGH-free labeled and unlabeled products and permits comparisons with conventional and organic brands.

Theoretical and empirical literature that addresses product labeling and labeling of GMO, non-GMO, and organic commodities has been reviewed in this study. Labeling can be viewed as one possible form of quality signaling by firms that establishes markets for different product qualities. Consumer search models examine the acquisition and use of information by consumers and the effects on market structure but mainly focus on price dispersion. Household production models are useful extensions of consumer search models because they take account of different product qualities and the allocation of time.

Hedonic price models and random utility models also offer insights in how to incorporate product attributes and consumer uncertainty about these attributes into a utility maximization framework. The theoretical model developed in this thesis has extended these approaches to specifically address the relationship between consumer knowledge, information search, and product choice. Theoretical predictions, in particular the hypothesis that a milk product is more likely to be chosen if it is labeled as rBGH-free, were derived in this framework.

Previous empirical studies of health and environmental related acquisition and disclosure of information were mainly based on survey responses. This research is still in its infancy, especially with regard to regulations on the use of GMO in food production. More detailed market-based research that allows cross-brand comparisons and separating labeling effects is needed to provide significant insights for policy makers and researchers. A new data set was obtained in this study to empirically investigate the effects of rBGH-free labels on consumer product choice of fluid milk and addresses these shortcomings. A cooperative agreement with the U.S. Department of Agriculture (USDA) and Economic Research Service (ERS) provided access to national-level supermarket scanner data (1995 to 1999) on fluid milk demand. Additional information on the rBGH-characteristic at the product level was obtained through a telephone survey of relevant milk processors.

The empirical specification of the estimation equations utilized conditional logit models. The regression specifications estimated in this study represent linear transformations of these models. The parameter estimates obtained in the empirical

analysis provide evidence that the demand for fluid milk products labeled rBGH-free is significantly higher than the demand for conventional milk products and has increased slightly over time. This result suggests that consumer beliefs previously measured in surveys have led to an observable and statistically significant change in market behavior. The results presented in this thesis show a consistent positive demand effect only for rBGH-free labeled products but not for unlabeled products. Thus, the empirical results of this study suggest that the provision of relevant information on a product label may be necessary for market segmentation between conventional and rBGH-free products. In addition, price elasticity estimates for half gallons of milk suggest that consumers are less responsive to price changes for rBGH-free labeled milk products than for conventional milk products.<sup>43</sup> These elasticity estimates contrast with the higher own-price elasticity estimates for organic milk reported by Glaser and Thompson (2000). The more price inelastic estimates for the demand of rBGH-free labeled products derived in this study could indicate that higher income households consume rBGH-free labeled products. This hypothesis is further supported by higher prices for rBGH-free labeled products relative to conventional products observed in the data set. Overall, adding a label on the package appears to enable consumers to make an improved product choice and increases consumer surplus, *ceteris paribus*.

Previous studies have reported that consumer attitude and market behavior towards GMO and non- GMO products will be most likely influenced by quality and safety benefits. In contrast, consumers may not perceive lower prices for GMO products,

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<sup>43</sup> The derived elasticity estimates for gallons of milk do not show the same trend.

a result of higher yields or lower input prices, as a direct benefit to them (FDA 2000, Baker and Burnham 2001). For producers and marketers, the results of this thesis further imply that product labels with regard to the use of GMO are an important consideration in marketing strategies.

The results of this thesis also have implications for policy makers. To date, there is no scientific evidence about differences between GMO and non-GMO products. Previous labeling regulations in the U.S. have been based primarily on the scientific value of the information provided, such as nutritional labeling. The findings of this study indicate that labeling with regard to the use of GMO provides information that has economic value to consumers and, therefore, that either labeling by private firms or labeling regulations may increase economic welfare. More stringent labeling regulations with regard to GMO in the U.S. may increase the effects on market behavior. Institutions such as the FDA, Environment Protection Agency (EPA) and USDA possess a high level public confidence relative to comparable public institutions in Europe (Baker and Burnham 2001).

This thesis provides new insights in a field that is just beginning to be understood. Limitations of this study mainly arise from shortcomings in the data set and may be addressed in future research. Due to market penetration of organic products during the time period analyzed, demand estimates with regard to organic certification of products<sup>44</sup> are not reliable for the focus of this study. Additional research should investigate

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<sup>44</sup> A necessary condition for a product to be certified organic is that it has to be produced without the use of GMO.

consumer reaction to and consumer value of different levels of labeling regulation. This additional research could, for instance, provide insights into understanding different policy paths chosen by various countries. Data problems with respect to organic fluid milk further suggest that market-based research for organic product demand has to consider carefully the developing market for these products. Another limitation arises from the use of national-level scanner data, while fluid milk is often supplied regionally and locally. The analysis involves comparison of prices and unit sales of milk brands that may not compete directly in each local or regional market. Furthermore, the prices used are temporally and spatially aggregated and do not reflect advertised sales.<sup>45</sup> Therefore, results may differ for specific geographic markets with only a subset of the investigated brands available. Research that focuses on regional or local data and allows to control for advertised sales will be especially helpful in establishing more reliable price elasticity estimates. An ideal data set to address these limitations would, for instance, consist of point of purchase observations at a particular supermarket. The relevant product choices and relevant prices could be directly identified in this data set. In addition, socio-demographic information on consumers could be collected at the point of purchase and their effects on product choice could be investigated. Finally, potentially significant substitution effects between other beverage products, such as soy-based products, are not accounted for in this study and could be addressed in future research.

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<sup>45</sup> Advertised sales are especially important for fluid milk products since they are often used as loss leaders by supermarkets (Green and Park, 1998).

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aspects of consumer search models, household production theory and random utility models are combined to develop a theoretical framework for an individual's choice between different brands of milk. Testable predictions about the effects of labeling are derived using this framework. The econometric specification to test these predictions, the data set used, and the empirical results are presented in Chapter 4. Chapter 5 summarizes major findings and discusses them with regard to the scope and focus of future research.