New Economic Approaches to Consumer Welfare and Nutrition
A Food & Agricultural Marketing Consortium Conference
Sponsored by the Economic Research Service

January 14-15, 1999

New Economic Approaches to Consumer Welfare and Nutrition

Conference Proceedings

Food and Agricultural Marketing Consortium
Alexandria, Virginia
January 14-15, 1999

Measuring Consumer Demand for Functional Foods and the Impact of Health Labeling Regulation

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Paper presented at the FAMC Conference on New Approaches to Consumer Welfare, Alexandria, VA, January 14-15, 1999

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New scientific understanding of the role of diet in preventing disease is rapidly emerging. Scientists are beginning to understand how some components of food could promote health and reduce the risk of illness, such as phytochemicals that might prevent cancer. These so-called Afunctional@ components of food differ from more widely understood Anutritional@ components of food, such as calories and protein. This emerging knowledge potentially increases consumer welfare by broadening the range of health-promoting activities. As consumers live longer, become more affluent, and hence more interested in preventing chronic disease, their demand for this information and associated food products should grow. This potential raises important public policy issues regarding the appropriate provision of emerging information and the incentives for product innovation to widen consumer choice. This paper discusses these policy issues and their economic implications, and then presents a model of demand for health, followed by the results of original research to measure consumer demand for a functional food product alternative.

Policy regarding provision of health information in food has been evolving and changing during the 1990s. Current policies differ for provision of information in advertising versus food labels and for dietary supplements versus whole foods. There is considerable debate and new legislation to alter the regulation of health claims on food labels. Below, we discuss the current state of health labeling policy and its economic implications. We then turn to evaluating the demand for a particular functional food component, soy protein, that is currently under review by the FDA for a product specific health claim.

There has been relatively little research on how consumers use information about diet-health links in making decisions about food consumption. Will they demand or pay more for food products that promote health? Past research shows that consumer demand shifts in response to new information about the health benefits of existing foods (Ippolito and Mathios; Varyam and Smallwood; Putler and Frazao; Brown and Schrader). These studies used secondary or survey data to infer the effects of information on behavior, and looked at consumption rather than willingness to pay for health characteristics. Willingness to pay is a crucial determinant of the incentives for product innovation using emerging health information.

We develop a model of consumer decisions to pursue activities that promote health and derive hypotheses regarding the resulting demand for functional foods and value of enhanced market information. Next, we report results from experimental auctions to test for the effect of health information on consumer willingness to pay for a new food product with health promoting characteristics. Among the valuation techniques in settings that are not naturally occurring, experimental auctions are relatively inexpensive to implement, and can provide data relatively quickly. Specific hypotheses regarding how consumers value health information or specific products can be tested in a controlled environment (Davis and Holt). Shogren et al and Hayes et al used experimental auctions to elicit the value of reducing risk from food borne microbial pathogens. Our research is the first to use experimental auction techniques to elicit values for food attributes that promote health.

The paper begins with a discussion of the potential health benefits from functional foods and the evolving policy for health claims in the marketplace. In the second section, we present a model of consumer demand for health promoting characteristics of food and the experimental methodology for testing hypotheses from that model, followed by the preliminary experimental results. Finally, we discuss conclusions and implications for future work.

The Potential for Functional Foods to Improve Consumer Well-Being

What are functional foods? The Institute of Medicine of the U.S. National Academy of Sciences has defined functional foods as those that Aencompass potentially healthful products,@ including Aany modified food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains.@ In other words, functional foods are those which may prevent disease or otherwise enhance health. Other terms frequently used for these kinds of food components or products include Anutraceuticals@ or Adesigner@ foods. Scientists are identifying functional components of foods that could reduce risks from the two leading causes of death in the U.S.: cancer and cardiovascular disease.

Phytochemicals, for example, have recently been the focus of intense research efforts because of their cancer preventive properties. Phytochemicals are non-nutrient, physiologically active plant components present in relatively small amounts compared to the macronutrients (fats, carbohydrates, and proteins). Epidemiological studies have demonstrated that populations consuming phytochemicals through a plant-based diet high in grains, legumes, fruits, and vegetables have a markedly reduced incidence of cancer. Only recently have biological scientists begun to identify the mechanisms through which phytochemicals reduce cancer risk. Some phytochemicals, like the organosulfur compounds in allium vegetables such as garlic and onion, Adetoxify@ carcinogens and thus help the body to eliminate them. Others, such as carotenoids in yellow, red, and green vegetables, function as antioxidants by scavenging free radicals that can attack and damage cellular membranes and DNA. Lycopene in tomatoes is another example of a phytochemical that acts as an antioxidant, and has been shown to be especially effective in preventing prostate cancer. Phytoestrogens, such as those found in soybeans (e.g. genistein), have a structure similar to the body=s natural forms of estrogen. Thus, phytoestrogens may reduce the effect of the more potent, naturally occurring estrogens which can promote estrogen-dependent cancers, such as those of the breast and prostate.

Research has also identified functional foods that reduce the risk of cardiovascular disease. One study widely reported in the popular press has identified a mechanism by which a component in red wine reduces hardening of the arteries (Renaud et al.). Many studies have shown that soy protein reduces blood cholesterol (Anderson et al.). Yet another example of a functional food is cranberry juice, which reduces the incidence of urinary tract infections (Avorn et al.).

To improve their health and well-being, consumers need information about the implications of new research results and new products that make it easier to consume the functional components of foods. Public policy plays a role in regulating and providing information to consumers, and public policy can influence the incentives to develop new functional food products. Next we consider current public policy regarding food health claims.

Recent Changes in Public Policy Regarding Food Health Claims

Public policy regarding health claims on food has experienced dramatic changes during the past decade, and continues to evolve as this paper is written. In general, these changes have led to greater use of health related information in product marketing, but such use is still very strictly regulated.

Some of the changes in food labeling regulation since 1990 were spurred by the efforts of public interest groups and the food industry to foster greater health awareness. This began in 1984, when the National Cancer Institute (NCI) endorsed messages about the benefits of dietary fiber for Kellogg=s cereal. In 1991, the NCI and the Produce for Better Health Foundation launched the A5 a Day for Better Health@ program to encourage Americans to eat 5 servings a day of fruits and vegetables. In 1992, the American Heart Association (AHA) allowed use of their red Aheart check@ mark on products that meet FDA=s regulatory requirements for making a coronary heart disease health claim.

A watershed development in food labeling policy occurred with the passage in 1990 of the Nutrition Labeling and Education Act (NLEA). It directed the Food and Drug Administration (FDA) to change the way that food labels were regulated, in order to make additional nutritional information available to consumers. As a result, most food products now carry a revised label that provides information about saturated fat, cholesterol, and dietary fiber, in a format designed to help consumers choose a more healthful and nutritious diet. One study estimated that the potential health benefits from these new labels could be as much as 1.2 million life years gained during the next 20 years (Zarkin et al.).

The NLEA confirmed the authority of the FDA to regulate health claims on food labels and in food labeling. Congress mandated that the FDA review 10 diet disease relationships and establish whether and how claims could be made on behalf of certain foods. The final FDA regulations in 1993 established seven allowable health claims:

1. calcium and a reduced risk of osteoporosis
2. sodium and an increased risk of hypertension
3. dietary saturated fat and cholesterol and an increased risk of coronary heart disease

4. dietary fat and an increased risk of cancer
5. fiber-containing grain products, fruits, and vegetables and a reduced risk of cancer
6. fruits, vegetables, and grain products that contain fiber, particularly soluble fiber, and a reduced risk of coronary heart disease
7. fruits and vegetables and a reduced risk of cancer.

Additional health claims were to be allowed only after stringent review of the scientific evidence.

In January 1997, the FDA approved the first food specific health claim under the NLEA, in response to a petition from the Quaker Oats Company. The authorized health claim describes the relationship between consumption of whole oat products and coronary heart disease risk reduction. Products containing a certain minimum level of soluble fiber from oat bran per serving may carry one of the following statements: ASoluble fiber from foods such as oat bran, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease.@ or ADiets low in saturated fat and cholesterol that include soluble fiber from oatmeal may reduce the risk of heart disease.@

The FDA spent two years reviewing studies to establish a scientific consensus that consumption of oat products reduces cholesterol levels. To make this connection and establish a product content standard, the scientists first had to identify a specific functional component in oat bran responsible for this biological effect, in this case beta-glucan. Next they had to identify the minimum quantity that should be consumed to benefit health.

The FDA approval process for the oat bran petition set several important precedents for health claim policy. It demonstrated that the standard will be one of scientific consensus and that any health claim must include the appropriate dietary context (low in saturated fat and cholesterol, in the oat example). Furthermore, the health claim can be used on any product, not just those produced by the petitioner. Thus, General Mills can use the claim for its oat cereals, even though Quaker Oats incurred the costs of supporting the petition and review.

Since the oat bran petition was approved in early 1997, the FDA has completed review of three more product specific claims. A health claim linking psyllium seed husk soluble fiber and reduced cholesterol was published in February, 1998. A petition to link calcium with reduced blood pressure and another to link wheat bran fiber and colon cancer were both turned down in 1997. As this is written in November 1998, there is a pending petition to link soy protein with reduced blood cholesterol.

The FDA Modernization and Accountability Act (FDAMA) became law in November 1997. It contains provisions to reduce the bureaucratic hurdles in the health claim approval process. Specifically, it directs the FDA to authorize health claims that are based on the published authoritative statements from U.S. Government agencies with official responsibility in the health area, such as the Centers for Disease Control (CDC), the National Academy of

Sciences (NAS), or the National Institutes of Health (NIH). Thus health claims could be made without going through the lengthy FDA review process, if they have already been published by these agencies. Pre-market notification (120 days) to the FDA would be required, and the FDA could take action against such claims if they are proved misleading. So far, the FDA has shown great resistance to implementing this new policy, as they denied permission to Weider Nutrition to use several proposed "authoritative statements."[1]

In addition to the FDA=s regulation of food labeling, the Federal Trade Commission (FTC) regulates advertising to prevent consumer deception. The FTC coordinates its regulation of health claims in food product advertising with FDA=s labeling policy, but the FTC allows firms more advertising flexibility. For example, the FTC allowed Quaker Oats to mention the cholesterol lowering effects of oats in print advertisements, prior to the FDA approval of a specific claim for the product label.

In addition to these new developments in food health claims policy, there have been even more recent dramatic changes in the way that dietary supplements are regulated. This is important for functional foods, because they have physiological effects similar to some drugs. Functional health components can be the basis of dietary supplements (beta-carotene, for example). The Dietary Supplement Health and Education Act (DSHEA) of 1994 changed how FDA regulates these products. The DSHEA allows manufacturers to make certain claims and market products without obtaining FDA=s pre-approval. They must notify FDA 30 days before marketing a product with a claim. The burden of proof to demonstrate harm from these products rests on the FDA. Since the passage of the DSHEA, many new supplement products have been introduced on the market, many of which use functional components of food.

Current health labeling policies have raised concerns in the food industry, the dietary supplement industry, and among consumer advocacy groups. Some charge, for example, that less stringent regulation of supplements promotes their development instead of food products, and may discourage consumers from eating a more nutritious and balanced diet. Others worry that consumers may be confused by these differences in regulation, and may attach the same credibility to both supplement and food label claims, even though the latter have been subjected to more rigorous scientific review. The FDA is concerned about its inability to prevent the potential harmful effects of supplements. At the same time, many food industry firms would like to see more flexibility in the FDA=s approach to health claims on food products, a concern

1 The growing international trade in processed food products may also influence industry efforts to support petitions. The U.S. has regulated health claims more stringently than many European countries, where functional claims on food products are more common (Heasman and Mellentin). It remains to be seen whether some of the products now marketed in Europe will be introduced into the U.S., and how the FDA will evaluate their health claims.

that the FDAMA Act was designed to address. Some consumer advocates are concerned that specific product health claims will detract from public education messages about the importance of a healthy overall diet. In part, these controversies arise from competing nutritional paradigms, but they also reflect the lack of economic analysis applied to this policy issue. None of the health claim petitions to FDA have provided any social welfare analysis of the impact of the claim.

The most notable economic contributions to this policy issue are from Papalardo and Calfee, who have argued that current health claims policy should follow a cost-benefit standard, rather than the current standard of scientific consensus. That is, a claim should be allowed if the claim has a high probability of providing benefits to consumers and, if it should prove false, would impose only low costs or risks. Much of the emerging information in the diet and health area might fall into this category where likely benefits exceed likely costs. For example, Kinosian and Eisenberg examined the relative costs of cholesterol reduction from drug regimes versus oat bran consumption. They concluded that dietary modification was much cheaper than drug treatments, as would be expected. The cost of alternative treatments is probably the lower bound of the social value of information about diet and health, and the risks of eating the recommended levels of oat bran are negligible. Thus, the oat bran health claim would likely have passed a cost benefit test. Another example might be health claims related to reduced risk of cancer. Scientific consensus may be very difficult to achieve since there are no clearly measurable bio-markers for reduced cancer risk. But consumer benefits from likely cancer risk reductions are potentially large, and some proposed dietary modifications, such as eating five fruits and vegetables a day, carry low risks. In contrast, certain dietary supplements do have health risks, so that some health claims currently allowed under DSHEA might not pass a cost benefit test.

A full welfare analysis of health information policy requires a better understanding of consumer utility and consumer willingness to voluntarily and systematically engage in health promoting activities. Thus we propose a model below to measure consumer demand for foods (or activities) that promote health and the value of new health information. This model allows us to derive hypotheses, which are then tested in experimental auctions.

A Model of Consumer Demand for Activities or Foods that Promote Health

We consider a stationary economy with an infinite time horizon, with many finitely lived consumers and competitive producers. Consumers value two goods, consumption g_t and health h_t, and have a common, risk neutral utility function given by

$$u(g_t,h_t) = g_t + h_t.$$

Each period, producers supply competitively g_t and an input s_t^s that can be used to produce h_t. Consumers are endowed with amount s_t^e of the input each period. Let $s_t = s_t^e + s_t^s$ denote a consumer's total amount of the input, where $s_t^s = s_t - s_t^e$ is the amount purchased from the producer at total cost $p_t^s(s_t - s_t^e)$, and p_t^s is the market price of the input. Consumers choose nonnegative intertemporal plans for the consumption of $\{g_t\}$ and $\{h_t\}$, and for the market input $\{s_t^s\}$ that is used to produce the health benefit.

The health benefit is generated by the following production constraint

$$h_t^s \leq \gamma f(s_t) - p_t^s(s_t - s_t^e) . \quad (1)$$

This constraint indicates that the net health benefit is determined by the difference between the output from the production function $\gamma f(s_t)$ and the cost of the input in excess of the endowment, which is given by $p_t^s(s_t - s_t^e)$. In this paper we focus on how differences in s_t^e and γ affect consumer's decisions and social welfare. Differences in s_t^e correspond to heterogeneity among consumers in underlying health conditions, and we interpret different γ's as different levels of information about the health benefit of the input. The simplest formulation is to think of $\gamma = 1$ as general information that the input has some health benefit $f(s_t)$, and $\gamma = \gamma^*$ as specific scientific information (e.g., transmitted via health labels) that the input has health benefit $\gamma^* > 1.0$.

Each consumer also faces a standard budget constraint each period given by

$$p_t^s s_t^s + p_t^g g_t \leq M. \quad (2)$$

The budget constraint indicates that consumers have a fixed money income M that can be used to purchase the health promoting input s_t^s or the consumption good g_t at their market prices.

Finally, consumers' investment in the health promoting good is voluntary. Thus consumers face the incentive constraint

$$B(s_t) \leq G(s_t). \quad (3)$$

The incentive constraint indicates that a consumer will choose to acquire the input in order to produce the health benefit if and only if the gain from doing so, $G(s_t)$, is at least as great as the benefit from not doing so, $B(s_t)$. That is, the consumer will find it optimal to invest in market purchases of the costly health promoting input each period whenever (3) is satisfied. We believe that this feature of the model is important for assessing the health benefits of functional foods because consumers derive benefits from these foods only if they consistently make dietary modifications. Constraint (3) states that they will do so only if they perceive it to be in their best interest. To our knowledge, this "voluntary compliance" feature of the problem has not been modeled explicitly before.

At each time t consumers face an intertemporal decision problem, thus they discount the future at rate β with $0 < \beta < 1$. Following Yaari (1965), discount factor β is given by $\beta = \theta/1+r$, where θ is the "survival probability" and $1/1+r$ is the discount rate. Parameter θ is idiosyncratic as a consumer's probability of survival depends on factors that are specific to that consumer (e.g., the predisposition to a particular health problem, investment in health promoting input, etc.). In contrast, $1/1+r$ is the discount rate given by the market interest rate that all agents use to discount the future. In many applications it is common to assume that β is determined solely by

1/1+r. The more general specification of $\beta(\theta, r)$ is a crucial part of the analysis because survival probabilities clearly differ across consumers.2 For example as θ decreases, discount factor β decreases. When β is low, consumers value the future less highly and are less likely to invest in health promoting activities (all else equal). Consideration of $\beta(\theta, r)$ only suggests that consumers with relatively low probabilities of survival (e.g., the elderly) would be *less* concerned with "investing in" health promoting activities. We will show that this is an incomplete analysis of the problem.

We now analyze constraint (3), which ensures that consumers will wish to honor the initial intertemporal market investment plan $\{s_t^s\}$ in all periods. At time 0, consumers choose consumption plans $\{g_t\}$, $\{h_t\}$ and an investment plan $\{s_t^s\}$ for all future time periods. In each subsequent period, agents must choose whether to adhere to the initial plan or deviate from it.3 Intuitively we can think of this as follows: Each period the agent can follow the health promoting investment plan or "cheat on the diet," smoke, etc. The present discounted utility from adhering to the plan in period t is given by

$$G(s_t) = \sum_{s=t}^{\infty} \beta^{s-t} u[g_t + h_t]$$

Because we assumed that the economy is stationary, consumers face the same problem each period and the time subscripts can be dropped. In stationary form, G(s) is:

$$G(s) = (1/1\text{-}\beta)[u(g+h)] = (1/1\text{-}\beta)[M/p^g - (p^s/ p^g)(s - s_t^e) + \gamma f(s) - p^s(s - s^e)]$$

The benefit from deviating from the plan is the present discounted utility from reneging on the plan in period t and never investing in the health promoting market input again:4

$$B(s_t) = u[g_t + h_t] + \sum_{s=t+1}^{\infty} \beta^{s-t} u[g_t + \gamma f(s^e)] = g_t + h_t + (\beta/1\text{-}\beta)[g_t + \gamma f(s^e)]$$

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2 For example, θ decreases with age. Standard life insurance tables for the U.S. population show that θ is .998 at age 20 and .96 at age 70.

3 This is the classic *time inconsistency problem* analyzed by Kydland and Prescott (1977) in intertemporal problems. When no "commitment technology" exists to force agents to adhere to an ex ante optimal intertemporal plan, they may deviate from the plan ex post. It is well known that contracts with full commitment to intertemporal choices Pareto dominate contracts with limited commitment. Researchers usually obviate the time inconsistency problem by assuming costless, ex post enforcement of agreements by an outside agent (e.g., a court). In this paper we study the implications of limited commitment on health decisions when there is no outside enforcement of initial agreements. As a consequence, contracts must be "self-enforcing." That is, at every point in time the agent must wish to adhere to the plan. See Krasa and Villamil (1998) for a general analysis of limited commitment when enforcement is costly and Asiedu and Villamil (1998) for an application of limited commitment to international finance.

4 None of the results depend on the infinite time horizon in an important way. We adopt it solely to simplify the mathematics.

In stationary form, B(s) can be written as:

$$B(s) = (1/1-\beta)[M/p^g – (p^s/ p^g)(s-s_t^e)] + \gamma f(s) + (\beta/1-\beta)[M/p^g + \gamma f(s^e)]$$

B(s) indicates that if the consumer were to renege on the investment plan in any period t then the discounted present value from this action is the sum of:

- the discounted utility from consuming g and the amount of h produced by using inputs s^e+s^s up to the point that the deviation occurs, plus
- the discounted utility from consuming g plus the amount of h that can be produced with s^e only thereafter.

The key insight is that if the consumer reneges on the private market intertemporal investment plan, the supplier of health promoting input s^s "punishes" the consumer for this action by refusing to supply the input at any point in the future.5

Because both the consumer and the producer understand the incentive problem inherent in their intertemporal contracting problem with limited commitment (i.e., agents have rational expectations), in equilibrium either:

(i) The consumer will never renege on the contract when $B(s) \leq G(s)$ because it is not in the consumer's interest given the punishment.

(ii) The consumer would always renege on the contract when $B(s) > G(s)$ but the supplier, anticipating this outcome, never supplies any input.

Thus, all investment plans for the input are either self-enforcing as a consequence of (3) or no market investment occurs at all (i.e., the consumer autarkically uses only s^e to produce $h = f(s^e)$). This result explains the potential for a market failure in the provision of functional food alternatives to consumers.6

We will show that constraint (3) has important implications for consumers, society, and government policy. In order to do so, we consider the problem of a benevolent social planner who wishes to choose Pareto efficient intertemporal plans for consumers. At time 0 the social planner chooses a sequence for investment in the health promoting input $\{s_t\}$ to maximize the representative consumer's utility subject to constraint (3) which insures that the consumer will voluntarily comply with the plan.

Social Planner's Problem: Choose $\{s_t\}$ to maximize

$$\sum_{t=0}^{\infty} \beta^t u^I(g_t,h_t) = \sum_{t=0}\beta^t[M/p_t^g – (p_t^s/ p_t^g)(s_t - s_t^e) + \gamma f(s_t) – p_t^s(s - s_t^e)]$$

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5 This argument also works for "finite punishments." That is, if the consumer reneges the producer refuses to supply the good for a finite number of periods τ.

6 One recent example is the failure of the Campbell company efforts to provide home delivered meals specifically tailored to certain medical conditions.

$$\text{Subject to: } B(s_t^I) \leq G(s_t^I) \text{ for all t} \qquad (3)$$

Production constraint (1) and budget constraint (2) have been substituted into the objective directly. Thus the planner solves for $\{s_t\}$. Plan $\{h_t\}$ is determined from (2) and the initial health endowment, and plan $\{g_t\}$ is determined from (1). The key insight is that when constraint (3) holds the agent's initial plan to invest in the health promoting activity is self-enforcing. However, because (3) is a constraint which arises as a consequence of limited commitment (i.e., no one can force an agent who benefits from the health promoting good to invest in it), when it binds it imposes a cost on the consumer and society. Indeed, we now show that when (3) binds it can lead to under investment in the health promoting input. This can occur even if consumers have full information about the health benefits of the input. However, if consumers are not accurately informed about the health benefits of the input (i.e., γ) this introduces an additional source of distortion.

In order to show that under investment can occur, let λ be the LaGrange multiplier on constraint (3). The planner's stationary problem each period is to choose $\{s\}$ to maximize

$$L = (1/1\text{-}\beta)[\ M/p^g - (p^s/ p^g)(s\text{-}s^e) + \gamma f(s) - p^s(s\text{-} s^e)] + \lambda[G(s) - B(s)]$$

The first order conditions in the stationary solution are

$$(1/1\text{-}\beta)[-(p^s/ p^g) + \gamma f\,'(s) - p^s - \lambda(p^s/ p^g) + \lambda\gamma f\,'(s) - \lambda p^s] + \lambda\gamma f\,'(s) - \lambda p^s = 0 \qquad (4)$$

and $B(s) = G(s)$. Equation (4) simplifies to

$$\gamma f\,'(s) = \frac{p^s}{p^g} \times \frac{[1 + (1/ p^g)(1+\lambda) - (1\text{-}\beta)\lambda]}{1 + \lambda - (1\text{-}\beta)\lambda} \equiv p^s\,\Omega \qquad (5)$$

Claim 1. When $\Omega < 1$ *under investment* occurs relative to the unconstrained optimum.

The proof of this claim is obvious. In an unconstrained optimum $\gamma f\,'(s) = p^s/p^g$, given that γ is known. In other words, the marginal product of the health producing input is equal to its real price. When $\Omega < 1$, then $\gamma f\,'(s) > p^s/p^g$. As a result, under investment occurs.

Claim 2. Ω is a measure of the degree of inefficiency caused by the incentive constraint. When γ is known and p^g is given, as $\Omega \rightarrow 1$ the inefficiency is eliminated since $\gamma f\,'(s) = p^s/p^g$ when $\Omega = 1$. Clearly, $\Omega \rightarrow 1$ as:

(i) $\lambda \rightarrow 0$: The constraint is weak.

(ii) $\beta \rightarrow 1$: Agents care more about the future.

We now delineate more precisely when under investment occurs. The stationary solution to the social planner's problem is described by one of three cases:

Case 1. When B(s) > G(s) the constraint set is empty and no investment in the health promoting product occurs.

Case 2. When the constraint binds (i.e., $\lambda > 0$), then $\gamma f'(s) > p^s/p^g$ and the optimal investment plan is constrained: $s = s_c^*$.

Case 3. When the constraint does not bind (i.e., $\lambda = 0$), then $\gamma f'(s) \rightarrow p^s/p^g$ and the optimal investment plan is approximately unconstrained: $s = s_u^*$.

Clearly, $s_c^* < s_u^*$ when $\lambda > 0$ (i.e., the constraint binds). Cases 1, 2, and 3 are illustrated in Figures 1, 2, and 3 in the Appendix.

In Case 1 the benefit from not investing in the healthy product exceeds the gain from the health benefit, thus no investment occurs. We will see that this is the case for agents with high health endowments. Case 2 is an example of Kydland and Prescott's (1977) time inconsistency result: The constrained equilibrium is Pareto inferior relative to the unconstrained equilibrium, but there is no way to force agents to adopt the unconstrained optimal plan. As discussed above, there is a producer that is willing to supply s^s to the market each period at price p^s, but the consumer is free to decline to purchase the input in any period. Constraint (3) is a condition that ensures that the consumer will wish to "stick to the initial intertemporal plan" due to the implicit penalty in B(s). Specifically, if the agent does not buy s^s in a period then the supplier punishes the consumer by refusing to provide s^s in any future period. This potential for market failure in the provision of functional foods indicates the welfare cost of constraint (3). In the remainder of the paper will look at government policy interventions that can weaken constraint (3) and thus allow for Pareto superior outcomes. Finally, Case 3 is the unconstrained optimal investment plan.

It is well known that agents may deviate from an intertemporal plan unless the initial plan was chosen subject to a constraint that ensures that it is optimal in every period (i.e., time consistency constraint (3)). While this constraint ensures that it is in agents' interest to follow the plan each period, when it binds it is costly to agents in terms of utility. The government may thus have an interest in attempting to mitigate the market failure that arises due to agents' inability to commit to the initial plan. One way the government can accomplish this is by providing information about the specific health benefits of products. We will show below that providing this information is beneficial because it weakens constraint (3) (i.e., it effectively lowers λ). In order to show this result we begin by focusing on constraint (3). It follows from evaluating $B(s) \leq G(s)$ that an investment plan s is self-enforcing if the following restriction on β is satisfied:

$$0 \quad < \quad \underline{\quad p^s\,(s-s^e) \quad} \quad \leq \beta \quad < \quad 1$$

$$\gamma[f(s)-f(s^e)]-(p^s/p^g)(s-s^e)$$

We now show that there are two critical thresholds for the discount factor that determine which case of the constraint set the economy is in:

(i) Case 1: No investment in s^s occurs, thus $s^s=0$.

(ii) Case 2: Under investment occurs, s_c^*.

(iii) Case 3: Unconstrained optimal investment occurs, s_u^*.

Define these two critical thresholds on the discount factor interval (0,1) as follows:

$\underline{\beta}$: The minimum discount factor for which in $s_c^* > 0$ is self-enforcing.

β^*: The minimum discount factor for which investment plan s_u^* is self-enforcing.

Proposition 1 below shows that these thresholds segment the unit into three subintervals which correspond to Cases 1, 2, and 3 with $0 \leq \underline{\beta} < \beta^* \leq 1$. Whether or not the producer will be willing to supply s^s (or equivalently, the consumer will be willing to demand s^s) is thus effectively a comparison of the consumer's idiosyncratic $\beta(\theta,r)$ and the relevant subinterval given by Case 1, 2, or 3. The intuition for Proposition 1 is provided in the graph below.

Figure 1

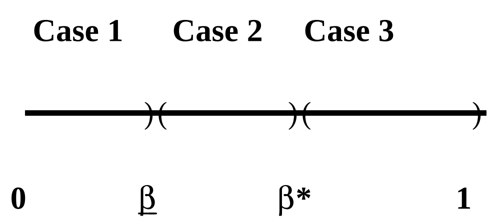

Figure 1 indicates that the thresholds, $\underline{\beta}$ and β^*, segment the unit interval into three subintervals that correspond to Cases 1, 2, and 3, respectively. Case 1 corresponds to $\beta(\theta,r) \in (0, \underline{\beta})$ where no health producing input is demanded or supplied (i.e., autarky). Case 2 corresponds to $\beta(\theta,r) \in (\underline{\beta}, \beta^*)$ where investment in the health producing input is constrained because constraint (3) binds. Case 3 corresponds to $\beta(\theta,r) \in (\beta^*,1)$ where investment in the health producing input is unconstrained optimal because constraint (3) does not bind. Proposition 1 states the result formally. The proof is in the Appendix. In addition, Proposition 1 indicates that as the critical discount factors decline, it is more likely that at least some level of investment in the health promoting input supplied by the market can be sustained.

Proposition 1. The critical discount factors $\underline{\beta}, \beta^* \in (0,1)$ are crucial determinants of the solution with $\underline{\beta} < \beta^*$ such that:

(i) Case 1: For $\beta(\theta,r) \in (0, \underline{\beta})$, $s^s = 0$ is optimal .

(ii) Case 2: For $\beta(\theta,r) \in (\underline{\beta}, \beta^*)$, s_c^* is optimal.

(iii) Case 3: For $\beta(\theta,r) \in (\beta^*,1)$, s_u^* is optimal.

Further, the critical discount factors are given by

$$\underline{\beta}(s^e,p^s,p^g,\gamma) \equiv \frac{p^s}{\gamma f'(s^e)-(p^s/p^g)} \quad (6)$$

$$\beta^*(s^e,s_u,p^s,\gamma) \equiv \frac{p^s(s_u^*-s^e)}{\gamma f(s_u^*)-\gamma f(s^e)-\gamma f'(s_u^*)(s_u^*-s^e)} \quad (7)$$

We now obtain two key comparative static results for the critical discount factors $\underline{\beta}$ and β^*. We determine:

- How a change in a consumer's endowment of s^e changes the critical discount factors.
- How information about γ changes the critical discount factors.

These results are important because the lower $\underline{\beta}$ and β^* are, the more likely investment in the health promoting input is. In particular, if $\underline{\beta} = 0$ then some level of investment is always optimal for any $\beta(\theta,r)$. This case is particularly interesting because it indicates that even if a consumer has a low $\beta(\theta,r)$, perhaps because the agent is old or ill, this consumer would still wish to invest in the health promoting market input when $\underline{\beta} = 0$. This accords with consumer surveys showing that older consumers are more interested in functional foods (IFIC). Thus, this analysis can reconcile two seemingly counter intuitive predictions of the model:

(i) In some cases agents with relatively low discounts factors $\beta(\theta,r)$ will wish to invest in the health promoting input.

(ii) In some cases agents with relatively high discount factors $\beta(\theta,r)$ will not wish to invest in the health promoting input.

We will show that either different endowments of s^e or different amounts of information γ can lead to this outcome. Both results are stated as claims below. The proofs are in the Appendix.

Claim 3. The critical discount factors are affected by s^e as follows:

(a) $d\underline{\beta} / ds^e > 0$;

(b) $d\beta^*/ ds^e > 0$.

Result (a) indicates high s^e (i.e., healthy) agents will have high $\underline{\beta}$. This means that the Case 1 interval where no investment occurs is relatively big for these agents. As a consequence, unless the $\beta(\theta,r)$ of these agents is extremely large, no or little investment in the health promoting input will occur. Similarly, the result indicates that low s^e (i.e., unhealthy) agents will have low $\underline{\beta}$. As a consequence, they will wish to invest even when $\beta(\theta,r)$ is relatively low. The intuition for this result is that when the endowment is low the investment good is more essential and this weakens constraint (3). That is, the market supplied input s^s is very important to the consumer and as a consequence the penalty of imposing $s^s =0$ if the consumer were to renege is severe. This high penalty effectively weakens the constraint. Thus we get the somewhat surprising result that the consumer will not renege on the investment contract even when it values the future in only a limited way (i.e., $\beta(\theta,r)$ is small), as long as $\beta(\theta,r) > \underline{\beta}$. Indeed, if $\underline{\beta} = 0$, then the consumer would always invest, even if $\beta(\theta,r)$ is small.

Claim 4. The critical discount factors are affected by γ as follows:
(a) $d\underline{\beta} / \gamma < 0$;
(b) $d\beta^*/ \gamma < 0$.

Claim 4 indicates that more information, γ, drives down both of the critical discount factors. This makes it more likely that some level of investment in the market input will occur by expanding the Case 2 and Case 3 intervals, and reducing the Case 1 interval.

The two claims show that agents with different endowments or different information will make different decisions that can be characterized as follows:

Figure 2a: low s^e or high γ **Figure 2b: high s^e or low γ**

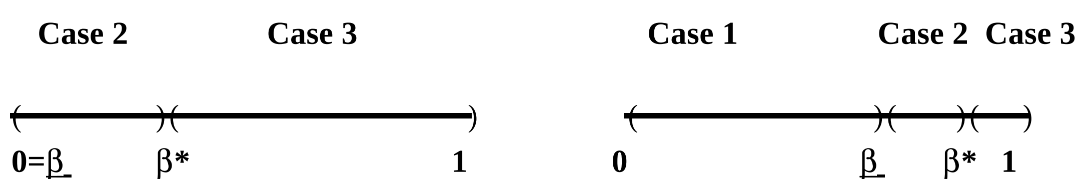

Figure 2a indicates that when the consumer's endowment of the input is sufficiently small or information indicates that the value of investing in the input is sufficiently high, then the Case 1 equilibrium where no market investment in the input occurs is completely eliminated. In this case even if the consumer values the future in only a limited way (i.e., $\beta(\theta,r)$ is relatively low), it is optimal for the agent to demand some amount of the market input. In contrast, Figure 2b indicates that when the consumer's endowment of the input is sufficiently large or information indicates that the value of investing in the input is sufficiently low, then the Case 1 equilibrium where no market investment in the input occurs is completely is large. In this case even if the consumer values the future strongly (i.e., $\beta(\theta,r)$ is relatively high), it is not optimal for the agent to demand the market input in Case 1.

These results suggest the following testable hypotheses:

1. Consumers should be willing to demand, and hence pay more for, the health promoting market input when they learn that it has substantial health benefits (i.e., γ is large).
2. Consumers with low health endowments should be willing to pay more for the health

promoting input.

3. Consumers with high health endowments should not be willing to pay more for the health promoting input.

Measuring Consumer Willingness to Pay for Functional Foods: Experimental

Methodology

We use experimental auctions to elicit what subjects in controlled laboratory experiments would pay for a product with health benefits. We elicited consumer valuations of conventional and soy baked goods, both before and after presenting information regarding product content and health benefits. Thus our elicited bids reveal the value of a change in γ. Subjects were drawn from two population categories: Students and Senior Citizens. These auctions allow us to measure the value of health information to consumers with different health conditions.

Regular consumption of soy has been demonstrated to reduce blood cholesterol levels (Anderson, Johnstone, and Cook-Newell). Consumption of at least 25 grams per day of soy protein has been shown to have a clinically significant effect in reducing blood cholesterol. This effect occurs within two to four weeks of adding soy to the diet; it disappears within a similar time period if the diet is discontinued. As soy is not a part of the traditional American diet, food scientists have been working on ways to incorporate soy into various conventional food products, including baked goods. Food scientists at the University of Illinois Foods Research Laboratory have developed a peanut butter cookie that contains soy. Our experiments were conducted to find out what Senior Citizens and Students would pay for a (soy) cookie with specific health benefits. Participants made bids both before and after receiving information about soy health benefits and cookie ingredients.

The experiment had three stages (complete experiment protocols are available on request from the authors). In each stage, a Vickrey second-price auction is carried out and subjects are given funds for use in bidding. They may use only the funds provided by the experimenter (i.e., they may not supplement these funds with their own money). Trials are repeated and one is selected randomly for payment. Their compensation for participation in the experiment is any good that they purchase plus the unspent funds.

- In stage 1, subjects are given $2 to use in bidding for a candy bar. This auction is conducted with 5 trials to familiarize subjects with auction rules, and the candy bar is awarded to the second highest bidder in the randomly selected trial.
- In stage 2, subjects taste two kinds of cookies, cookie "A" and cookie "B", and are given no information about cookie ingredients. Subjects receive $6, and then make separate bids for the two kinds of cookies over 8 trials. A container of six cookies is awarded to the second highest bid for each type of cookie in a randomly selected round. At the end of stage 2, information is collected about personal characteristics, nutrition knowledge and attitudes, and

sensory evaluation of cookies.

- In stage 3 subjects receive information about the benefits of soy protein isolate in reducing blood cholesterol and risk of heart disease. The information relates risk reduction to specific levels of intake, and tells participants how much soy protein isolate is contained in the soy cookies. In addition, they are told which cookie is made with soy and which is a "conventional cookie." Subjects again receive $6, and both kinds of cookies are auctioned over 8 trials.

Our specific hypotheses are as follows:

1. Bids for soy cookies by Senior Citizens are higher after they learn about health benefits.
2. Bids for soy cookies by Students do not increase after they learn about health benefits.
3. Candy bar bids do not exceed the market price plus transactions costs (i.e., subjects pass a baseline test of payoff maximization).

To evaluate hypotheses 1 and 2, we use the t-test for matched samples (Anderson, Sweeney, and Williams, p. 386). Our experiments follow a matched sample design, because each sampled item (subject) provides a pair of data values (before and after information). The difference between these matched values can be evaluated using the following t-statistic: Where, d is the average difference between bids before and after information, s_d is the standard deviation of d, and n is the number of matched observations. If the t statistic is in the rejection region for n, then the hypothesis that the difference between the bids is zero is rejected. The bid data are evaluated for each experiment group (n = number subjects in the group), for the two

$$t = \frac{\bar{d}}{s_d / \sqrt{n}}$$

subject populations (students and senior citizens), and for individuals (n = 7 trials).7 Complete experimental data were obtained from a total of 67 students in 6 groups and from a total of 51 senior citizens in 5 groups.

Experiment Results

In order to understand the bid outcomes, it is useful to examine the responses of subjects to our questionnaire about personal characteristics and diet-health knowledge. Answers on the questionnaires confirm our assumptions about health endowments, diet health knowledge, and food tastes. Students were drawn from undergraduate and graduate programs, and their ages varied from 18 to 44. Senior Citizens were identified through Elderhostel or Senior Center programs and their ages varied from 55 to 84. Senior Citizens were predominantly female, in contrast to Students, who were predominantly male (Table 1). Senior Citizens were somewhat less educated than Students on average; less likely to smoke; and more likely to be the primary food shopper.

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7 Following Shogren et al, we drop the first trial because it is a learning trial.

The soy cookies were not rated highly for taste, so consumption of this health producing input entails some loss of utility. Forty percent of Students and 35 percent of Senior Citizens did not like the soy cookie. Senior Citizens liked the regular cookie more than the soy cookie, while most Students did not like either cookie (Table 1). Participants answered this question before they knew about the ingredient content of the soy cookies.

As expected, Senior Citizens were more likely than Students to know their blood cholesterol levels and to have a high cholesterol level (Table 2), confirming our assumptions regarding initial health conditions. In general, the Senior Citizens were more likely than the Students to know about connections between diet and health and to use that knowledge in food purchasing. Senior Citizens were more likely than Students to strongly agree that diet is linked to health and the risk of chronic disease; to agree that nutrition is very important when purchasing food; to know that cholesterol is linked to heart disease risk; and that soy can reduce cholesterol (Table 2). Senior Citizens were also more likely than Students to use food labels for all kinds of information, including ingredients, the nutrition panel with calories, protein and fat, phrases such as low-fat or light, and statements about the health benefits of foods.

In order to understand how representative our experimental results might be for the larger population, we asked many of the same questions included in the USDA 1994 national Diet Health Knowledge Survey. Where applicable, the answers to the DHKS for all respondents and for Senior Citizens (those 55 or older) are included in Tables 1 and 2. These national survey data show that our experiment subject populations were better educated than the U.S. average. However, they were not very different in their attitudes regarding diet health relationships and the importance of nutrition. The experiment populations were much more likely to use food labels and to know that the government regulates these labels, which accords with prior expectations regarding the impacts of education (see Putler and Frazao for empirical evidence). The Senior Citizens in our experiments were also somewhat more likely than the average to know that they had high blood cholesterol. Thus, our subjects may be more motivated than the average Senior Citizen to respond to information about the health characteristics of food.

Table 3 reports the average bids by population and experiment group. Groups 1 through 6 were made up of Student subjects; groups 7 through 11 were made up of Senior Citizens. The average candy bar bid for all subjects is very close to the supermarket price of 50 cents (65 cents from the vending machine), but there were large differences in bids across groups and subjects. Clearly subjects differed in their willingness to bid for this good or to retain compensation.

We examined how many subjects made bids of 70 cents or less, which would be a baseline test for payoff maximization. A bid of 70 cents would be roughly equal to the vending machine price, plus a small additional value for transaction costs or delayed gratification (waiting until the end of the experiment to go to the machine or store). Almost all of the Students, 57 out of 67, made bids of 70 cents or less for the candy bar. Thus we have confidence that most Students were maximizing their payoffs, rather than trying to "win a prize" or prevent others from doing so. Only about half of the Senior Citizens, 27 out of 51, made bids of 70 cents or less on the candy bar. This may reflect their lack of familiarity with campus vending machines, a desire to win the bid, higher subjective transaction costs among Senior Citizens, or an asymmetric bidding bias in the second price auction in our experiments.8

The cookie bids were for a container of six cookies. Subjects received $6 for each cookie auction and one round was randomly selected for payment. Subjects could use the $6 to bid for either or both kinds of cookie, or retain the money (to purchase "other goods'' after leaving the experiment). Average bids were in the range of 53 to 65 cents for these containers, but like the candy bar bids, showed large variation (Table 3). These average bids are slightly below the full cost of making the cookies in the Food Research Laboratory (about 78 cents including labor and overhead) or the cost of peanut butter cookies purchased in a store (about 75 cents).

Average bids by population group show that Students bid less than Senior Citizens (Table 3), which may reflect their lower sensory evaluations of the cookies and/or a higher marginal utility of retained compensation (i.e., "other goods" g). Student bids did not change significantly after receiving information about cookie ingredients and soy health benefits, as the model predicts. The average Senior Citizen bids were higher for soy cookies after information and lower for regular cookies. Bids varied widely across experiment groups and individuals.

The t-test for matched samples tests whether the difference between cookie bids before and after information is significantly different from zero (Anderson, Sweeney, and Williams, p. 386). Table 4 shows the difference in soy cookie bids before and after information for population categories and experiment groups. Soy cookie bids do not change significantly for Students, but the average increase of 19 cents for Senior Citizens is significant. Thus, on average the population categories behaved according to our hypotheses. Students were not interested in forgoing the value of other goods to consume more soy, presumably because they have a large initial endowment of health. Senior Citizens bid more for the soy cookies after learning of their health benefits. Because they are likely to have a lower endowment of health, Senior Citizens consequently value the soy product more highly when they learn of its higher marginal product in producing health.

At the experiment group level, the results show more variation. Of the six Student experiment groups (1 through 6), three groups show a significant decrease in average cookie bids after information, two groups show no significant change, and one group shows a significant increase. Of the five Senior Citizen groups, 7 through 11, three groups show positive and

8 Average prices are well known to be higher in second price auctions than in the theoretically equivalent English auction (see Davis and Holt). We would expect any such bias to be consistent across information treatments, but this remains a topic for future research.

significant increases in average soy cookie bids, and two groups showed no significant change. These results confirm the general pattern that Senior Citizens were more likely than Students to bid more for soy cookies after information about health benefits.

Table 5 reports the number of individual subjects in each population subcategory who made significant changes in either cookie bid, or in retained compensation. These results show more detail regarding the influence of individual subjects on group and population category outcomes. Significant positive increases in soy cookie bids were observed for 18 out of 51 Senior Citizens and 7 out of 67 Students. Thus, over one-third of the Senior Citizen subjects increased their bid for soy cookies, while only about one-tenth of Students did so. To offset increases in soy cookie bids, Senior Citizens tended to reduce their bids for regular cookies or the compensation retained. Students, on the other hand, tended to reduce their bids for both cookies (significant negative change), and to increase retained compensation. Thus, Students showed a clear preference for retaining the money compensation, while Senior Citizens were willing to forego other goods to increase soy bids.

Our experiment results give us a measure of willingness to pay for health characteristics of food among Senior Citizens. These six cookies contained one-third of the daily soy intake needed to reduce blood cholesterol by 9%. If you have a blood cholesterol level of 250 mg/dl (the cut-off for high), a 9% reduction would reduce your mortality risk from coronary heart disease roughly by half. On average, Senior Citizens were willing to pay 19 cents more for soy cookies after learning about their health benefits. The average bid increase implies that these Senior Citizens would be willing to pay about 57 cents a day for consuming the quantity of soy protein recommended in the petition to FDA for a health claim linking soy to reduced the risk of coronary heart disease. In the three Senior Citizen groups with increased bids, the winning bids increased by $0.50 to $1.00, implying $1.50 to $3.00 per day for a diet that reduces blood cholesterol by 9%. Of course, food sellers could capture prices at the level of these winning bids only if they were able to price discriminate among consumers. Given the low sensory evaluations of the soy cookie, the average price premium in these experiments is likely to be a lower bound for willingness to pay for cholesterol reduction among Senior Citizens.

Conclusions

The new scientific findings regarding diet and health offer the opportunity to improve health. In order for consumers to use and benefit from this knowledge, choices in the marketplace must expand and methods of conveying this information must be found. Public policy must foster more complete information and more consumer choice, while still safe-guarding consumers from unnecessary risks. Health claims for dietary supplements appear in the market place without scientific review while health claims for specific food products must meet a standard of scientific consensus. Consumers therefore receive inconsistent market information regarding the value of whole foods in maintaining and promoting health. Food producers are unsure how to respond to consumer demand within an uncertain regulatory environment. As suggested by Calfee and Papalardo, cost benefit analysis could provide a way of ensuring that health information policy promotes net gains in social welfare. Such analysis requires more understanding of the consumer welfare gains from functional foods.

To better understand the emerging demand for functional foods, we presented a model of consumer demand for health promoting foods. The model captures several key features of this market, including: the need for consistent dietary change over time, the potential for market failure, the value of information, and the influence of personal discount rates on incentives to invest in health. We demonstrated why market failure can occur in the provision of functional food alternatives and why consumers may fail to invest in consistent dietary change over time. We show that information increases functional food demand and provide a measure of the value of health information in improving incentives to invest in health. A key feature of the model is how consumer health conditions or endowments interact with personal discount rates to influence decisions to invest in health. These features allow us to explain why consumers with low health endowments are more willing to invest in health promoting goods than consumers with high health endowments.

We then turn to a preliminary empirical test of the model through experimental auctions. This method provides a means of testing demand for a hypothetical product currently under review for a product specific health claim. Our experiment results show that average market behavior bears out the hypotheses regarding the market for health promoting foods. There was a marked difference in bidding behavior between the two population groups before and after information. On average, Senior Citizens made significant changes in soy product bids after receiving information about product ingredients and their benefits. Far fewer Students were willing to make higher bids for soy products, and most preferred to retain a greater portion of their compensation. This outcome is consistent with our hypothesis that the two groups have fundamentally different endowments of health. Thus, functional food alternatives, such as baked goods containing soy, will likely have niche markets with consumers whose health endowments lead them to value health benefits more highly. The largely negative sensory evaluations of the soy cookie indicate that our experiments were a very strong test of the demand for health benefits from new food products. Price premiums could well be higher for products that are better substitutes for the conventional product in terms of flavor.

In future work, we will explore the implications of the model and further test the demand for functional foods. The model of consumer demand for health promoting activities can be extended to consider the potential impact of product or information subsidies, or the scope for product differentiation. Empirical work will examine alternative products, different information treatments, and the influence of health endowments and prior information by sampling from a larger population. In particular, it would be useful to understand the demand for functional foods among middle-aged individuals, who may well have the greatest potential gain from dietary change.

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Table 1: Personal Characteristics and Tastes of Experiment Subjects and of USDA/DHKS Respondents (percent of group)

	Experiment Subjects		DHKS Survey	
	Students (n=67)	Seniors (n=51)	All Respon dents (n =1,879)	Senior Re spondents (n= 725)
Gender				
-- Male	62.7	21.6	48.00	46.34
--Female	37.3	78.4	52.00	53.67
Highest Education				
-- high school	0	19.6	34.43	33.24
-- some college	44.8	33.3	20.44	15.17
-- college degree	0	19.6	10.32	6.07
-- grad study	55.2	27.5	10.70	8.14
Smoker	14.9	3.9	48.58	32.51
Non-U.S. origin	38.8	0	na	na
Primary food shopper in household	64.2	82.0	75.15	77.79
Lives where meals provided	20.9	6.0	na	na
Liked soy cookie				
-- very much	16.5	19.6		
-- somewhat	43.2	45.1	na	na
-- not at all	40.3	35.3		
Liked regular cookie				
-- very much	20.9	41.2		
-- somewhat	59.7	39.2	na	na
-- not at all	19.4	19.6		

Table 2: Nutrition Knowledge and Attitudes of Experiment Subjects and of USDA/DHKS Respondents (percent of group)

	Experiment Subjects		DHKS Survey	
	Students (n=67)	Seniors (n=51)	All Respondents (n =1,879)	Senior Respondents (n= 725)
Diet linked to health and disease				
--- Strongly agree	47.8	52.9	59.34	56.00
--- Somewhat agree	44.8	39.2	29.80	30.21
--- Not too or not at all important	7.4	7.9	10.86	13.79
Nutrition important in food purchases				
--- Very important	43.3	60.8	63.44	68.00
--- Somewhat important	37.3	39.2	29.16	22.76
--- Not too or not at all important	19.4	0	7.7	9.24
Often use food labels for:				
-- nutrition panel w/ calorie, protein	59.7	68.6	32.73	29.66
-- list of ingredients	22.4	68.6	30.49	32.41
-- Alow-fat@ or Alight@ phrases	47.8	54.9	28.47	29.66
-- health benefit statements	23.9	31.4	17.03	16.69
Know that government defines Alow cholesterol@ on labels	56.7	55.1	32.11	30.98
Cholesterol level				
-- don=t know	67.2	12.0	na	na
-- know it=s normal	31.3	50.0	na	na
-- know it=s high	1.5	38.0	15.81	25.79
Know that cholesterol linked to heart disease risk	85.1	100.0	na	na
Know that soy reduces cholesterol	35.8	70.6	na	na

Table 3: Average Bids for Candy Bar, Regular Cookies, and Soy Cookies (dollars)

		Before Information		After Information	
Population	Candy Bar	Regular Cookie	Soy Cookie	Regular Cookie	Soy Cookie
All Subjects n = 118	0.53 (0.36)	0.65 (0.73)	0.53 (0.65)	0.56 (0.64)	0.60 (0.64)
Students n = 67	0.40 (0.29)	0.29 (0.29)	0.27 (0.30)	0.27 (0.30)	0.25 (0.25)
Seniors n = 51	0.70 (0.36)	1.11 (0.87)	0.87 (0.81)	0.95 (0.77)	1.06 (0.70)
Group 1 n = 9	0.53 (0.29)	0.50 (0.33)	0.39 (0.34)	0.33 (0.20)	0.31 (0.18)
Group 2 n = 6	0.21 (0.18)	0.36 (0.30)	0.17 (0.17)	0.14 (0.08)	0.11 (0.13)
Group 3 n = 12	0.59 (0.21)	0.45 (0.26)	0.54 (0.26)	0.67 (0.25)	0.61 (0.24)
Group 4 n = 10	0.42 (0.23)	0.14 (0.16)	0.18 (0.16)	0.12 (0.13)	0.24 (0.14)
Group 5 n = 15	0.51 (0.33)	0.31 (0.30)	0.31 (0.36)	0.22 (0.30)	0.20 (0.19)
Group 6 n = 15	0.11 (0.13)	0.11 (0.18)	0.04 (0.05)	0.13 (0.24)	0.03 (0.04)
Group 7 n = 9	0.50 (0.28)	0.81 (0.57)	0.61 (0.80)	0.66 (0.28)	0.59 (0.42)
Group 8 n = 4	0.48 (0.33)	1.01 (0.48)	0.37 (0.31)	0.87 (0.39)	1.12 (0.37)
Group 9 n = 12	1.05 (0.32)	1.79 (0.75)	1.32 (0.81)	1.46 (0.77)	1.69 (0.60)
Group 10 n = 13	0.56 (0.30)	0.51 (0.36)	0.52 (0.50)	0.52 (0.45)	0.80 (0.73)
Group 11 n = 13	0.74 (0.32)	1.34 (1.12)	1.12 (0.95)	1.11 (1.03)	1.03 (0.63)

Average of trials 2-5 for candy bars and trials 2-8 for cookies. Standard deviation in parentheses.

Table 4: Tests for Significant Increase in Soy Cookie Bids after Information

Population	Difference between Soy cookie bids (standard deviation)	T-test (5% level of significance)
Students n = 67	-0.02 (0.28)	-0.70 (2.00)
Seniors n = 51	0.19 (0.67)	2.33 (2.02)
Group 1 n = 9	-0.08 (0.24)	-2.79 (2.31)
Group 2 n = 6	-0.06 (0.090)	-5.05 (2.57)
Group 3 n = 12	0.07 (0.30)	1.96 (2.20)
Group 4 n = 10	0.06 (0.18)	2.63 (2.26)
Group 5 n = 15	-0.11 (0.34)	-2.63 (2.15)
Group 6 n = 15	-0.01 (0.03)	-1.84 (2.145)
Group 7 n = 9	-0.02 (0.614)	-0.20 (2.306)
Group 8 n = 4	0.76 (0.13)	48.63 (3.18)
Group 9 n = 12	0.36 (0.75)	3.98 (2.20)
Group 10 n = 13	0.28 (0.68)	3.38 (2.18)
Group 11 n = 13	-0.09 (0.61)	-1.25 (2.18)

Table 5: Significant Changes in Individual Bids Before and After Information (number subjects)

	Positive	Negative	No significant change
Seniors			
-Soy cookie	18	7	26
- Regular cookie	4	12	35
- Retained compensation	10	12	29
Students			
- Soy cookie	7	19	41
- Regular cookie	5	20	42
- Retained compensation	18	6	43

Appendix

Proof of Proposition 1. Consider each case:

Case 1: Figure 1 shows that B(s) cuts G(s) at s^e from below. As a consequence, B'(s) > G'(s). This implies that $\beta[\gamma f'(s^e) - (p^s/p^g)] < p^s$. Define

$$\underline{\beta}(s^e,p^s,p^g,\gamma) \equiv \frac{p^s}{\gamma f'(s^e)-(p^s/p^g)}$$

Then $\underline{\beta}$ is the minimum discount factor in order for investment to occur. For any $\beta \in (0,\underline{\beta})$, no investment occurs.

Case 2: Substitute $s = s_u^*$ and $p^s/p^g = \gamma f'(s^e)$ into (3) and define β^* as:

$$\beta^*(s^e,s_u,p^s,\gamma) \equiv \frac{p^s(s_u^*-s^e)}{\gamma f(s_u^*)-\gamma f(s^e)-\gamma f'(s_u^*)(s_u^*-s^e)}$$

Case 3: Asiedu and Villamil (1998) show that there exists an $\bar{s} > s^e$ such that the interval $[s^e, \bar{s}]$ is self-enforcing. They prove that $s_u^* \notin [s^e, \bar{s}]$ for $\beta\in(\underline{\beta},\beta^*)$, that $0 < \underline{\beta} < \beta^* < 1$, and $f'(s^e) > p^s/p^g$.

Proof of Claim 3: The proof of (a) follows immediately from differentiation of (6):

(a) $$d\underline{\beta} / ds^e = - \frac{p^s \gamma f''(s^e)}{[\gamma f'(s^e)-(p^s/p^g)]^2}$$

This expression is positive since $f''(s^e) < 0$ because the production function is concave.

(b) $$d\beta^*/ ds^e = \frac{-1 + f'(s^e) + f'(s_u^*)}{[\gamma f(s_u^*)-\gamma f(s^e)-\gamma f'(s_u^*)(s_u^*-s^e)]^2}$$

This expression is positive if $f'(s^e) + f'(s_u^*) > 1$, which follows from concavity of the production function.

Proof of Claim 4. The proof of (a) and (b) follows immediately from differentiation of (6) and (7) respectively:

(a) $$d\underline{\beta} / \gamma = - \frac{p^s f'(s^e)}{[\gamma f'(s^e)-(p^s/p^g)]^2}$$

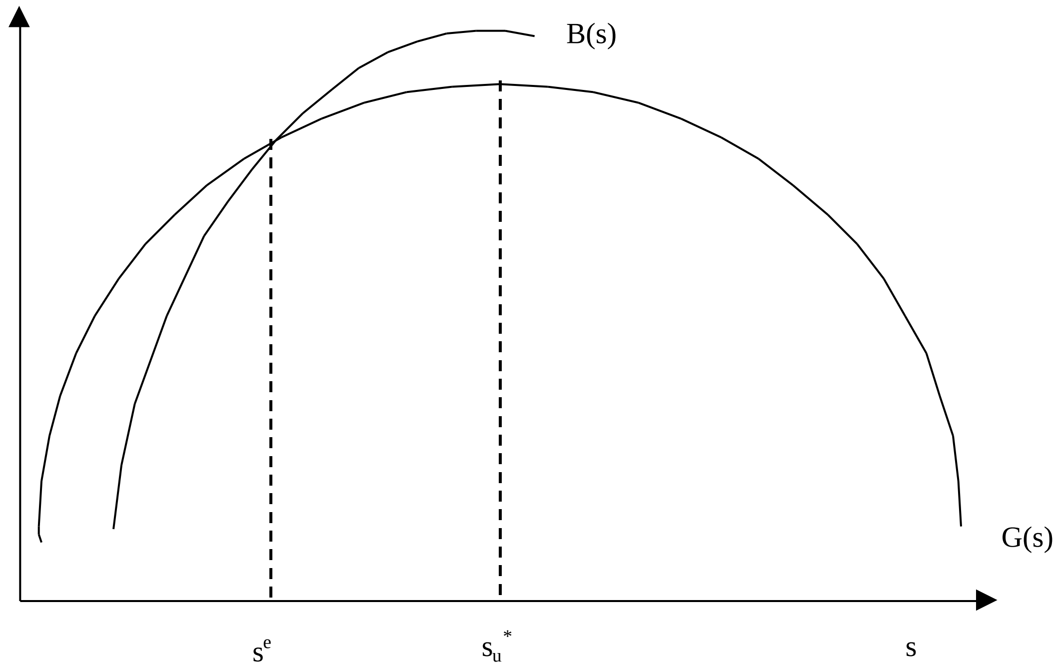
This expression is negative since $f'(s^e) > 0$.

(b) $$d\beta^*/ \gamma = - \frac{p^s(s_u^*-s^e) [f(s_u^*)-f(s^e)-f'(s_u^*)(s_u^*-s^e)]}{[\gamma f(s_u^*)-\gamma f(s^e)-\gamma f'(s_u^*)(s_u^*-s^e)]^2} = - \frac{p^s(s_u^*-s^e)}{\gamma f(s_u^*)-\gamma f(s^e)-\gamma f'(s_u^*)(s_u^*-s^e)}$$

This expression is also negative since it equals $-\beta^*$.

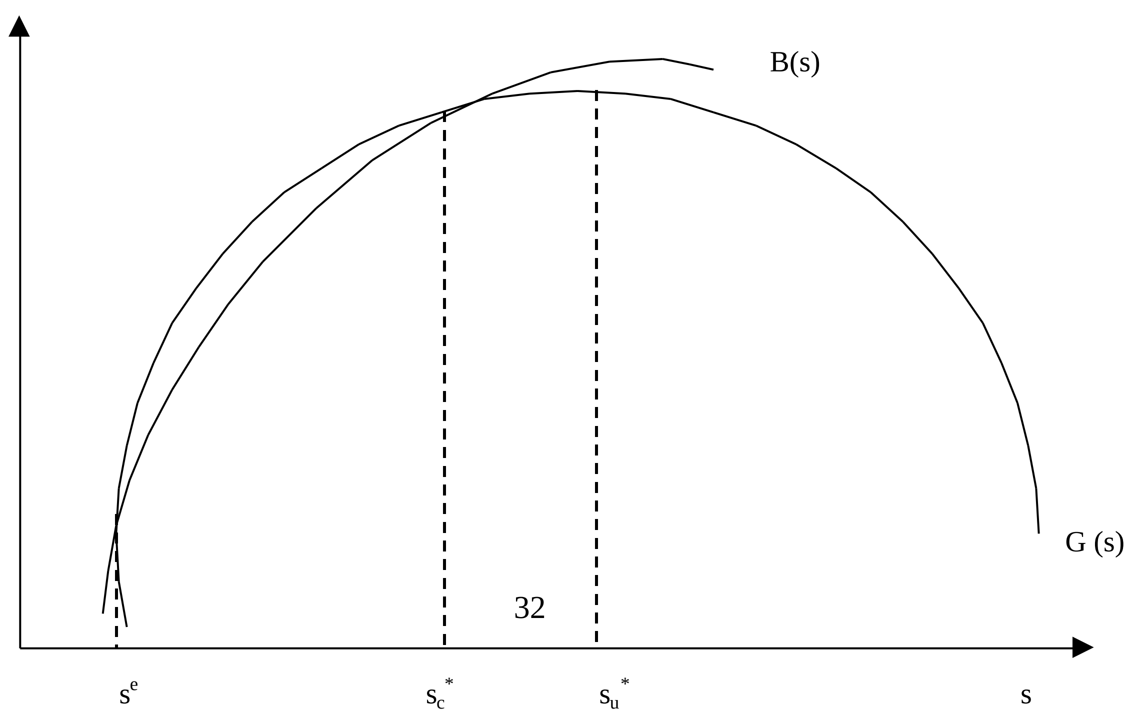
Appendix Figure 1

Case 1: Autarky Equilibrium



Appendix Figure 2

Case 2: Constrained Equilibrium



Appendix Figure 3

Case 3: Unconstrained Optimal Equilibrium