Food Marketing Policy Center

Eco-Labels for Credence Attributes:
The Case of Shade-Grown Coffee

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Food Marketing Policy Center
Research Report No. 71
October 2002

Research Report Series

http://www.fmpc.uconn.edu

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Acknowledgement

This work was supported by the Food Marketing Policy Center at the University of Connecticut. The author thanks, without implicating, Shinano Hayashi for research assistant during the completion of this analysis, and Ron Cotterill, Jeremy Foltz, Kathy Sergerson, Sara Scatasta, the Editor, and three reviewers for their substantive comments and suggestions during the completion of this analysis.

Affiliation

Bruce A. Larson is assistant professor in the Department of Agricultural and Resource Economics at the University of Connecticut, Storrs, CT 06268 (Bruce.Larson@uconn.edu, 860-486-1923).

Preface

Using the case of shade-grown coffee, this paper examines the market impacts of 'eco-labels' for credence attributes. First, the Mattoo and Singh (1994) test is conducted for the case of shade-grown coffee to investigate the market impacts of a shade label. This analysis in Section II shows that a shade label could "pass" the test, but the market impacts are likely to be minor. Section II also shows how to use estimates of supply, potential demand, and price elasticities of demand and supply to predict eco-label premiums in the post-label equilibrium. And second, given the importance of consumer demands for eco-label impacts, and since the theoretical foundations of demand for eco-labeled items are not well developed in the literature, Section III takes a closer look at the microeconomics of labels and consumer demand. A nested constant-elasticity-of-substitution preference structure is used to derive theoretically consistent Marshallian demands for shade and non-shade coffee. A numerical simulation shows how relative prices and consumer preferences for the credence attribute and variety are both important factors in demand creation of labeled items.

Key words:

1. Introduction

Eco-labels provide information to consumers on credence attributes of products. Some labels are voluntary programs and some are mandatory regulations, and some programs focus on consumption attributes (e.g. food safety issues) and some focus on production process attributes (e.g. sustainably harvested tropical timber). The focus of this paper is on voluntary eco-label programs designed to provide consumers with additional information on production process attributes.[1] By providing such information to consumers, it is hoped that an eco-label will stimulate additional demand for the labeled item and create a price premium for the labeled item in the market. As a result, the label program would help to make production of the eco-labeled product more competitive vis-a-vis conventionally produced items, increase supply of the labeled item, reduce supply of non-labeled items, and reduce negative externalities (or increase positive externalities) (Mattoo and Singh, 1994).

Given the interest in eco-labels, and the rapidly growing descriptive literature on eco-label programs (see, e.g., the various chapters in Zarrilli, Jha, and Vossenaar 1997), there has been limited theoretical analysis of the consumer response to labeled products, the resulting market impacts, and the eventual impact on reducing environmental externalities. Mattoo and Singh (1994) and Swallow and Sedjo (2000) begin to analyze the market impacts from introducing an eco-label program. Mattoo and Singh (1994) is a partial equilibrium analysis focused on voluntary labeling of a credence attribute for an otherwise homogeneous product. In the post-label equilibrium, "eco-consumers" only purchase the labeled item, while "non-eco-consumers" only purchase the item with the lowest price.[2]

Mattoo and Singh (1994) suggest an empirical test based on excess potential demand in the pre-label market to determine if an eco-label scheme would lead to a post-label equilibrium where: (1) larger quantities of the labeled item are sold as compared to the pre-label equilibrium; and (2) the labeled item is sold for a higher price than the conventional item due to higher marginal production costs. Besides the simple examples discussed in Mattoo and Singh (1994), this empirical test has not been directly used to evaluate potential eco-label schemes.

While the preference structure is not developed in detail in Mattoo and Singh (1994), more recent analyses by Bureau, Marette, and Schiavina (2000) and Nimon and Beghin (1999a, b) have adapted a simple preference structure for quality differentiation from Mussa and Rosen (1978). These analyses allow for products to be differentiated on two attributes (i.e. an experience attribute such as taste as well as a credence attribute such as a production externality). Given a underlying linear utility structure for the labeled and non-labeled item and a fixed budget share allocated to the product category, the ratio of constant marginal utilities and relative prices determines which item is purchased (labeled or non-labeled).[3] As a result, some consumers only buy the labeled item, and some consumers only buy the non-labeled item. Although adequate for their purposes, such extreme assumptions on preferences (additively separable and linear) are unlikely to be reasonable for a wide range of items that consumers regularly purchase.

Using the case of shade-grown coffee, the purpose of this paper is provide two contributions to the existing literature. First, the empirical test outlined in Mattoo and Singh (1994) is implemented. While it is likely that a shade label could pass the test, it is also likely that the market impacts of the label would be minor in terms of additional production induced by the label and the creation of any price premium for shade coffee. This analysis also shows how to combine estimates of 'potential' demand (i.e. demand for the labeled item with no price premium) and price elasticities of demand and supply to predict market price premiums for the labeled item. Not surprisingly, large potential demand that is also price inelastic will support higher price premiums in the market, but even some minor positive supply response will substantially diminish the resulting market price premium for the eco-labeled item.

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[1] For reference, eco-label programs were operating in at least 17 countries as of 1995. Such programs covered over 200 categories of products including fresh and processed foods, textiles and apparel, natural resources, and manufactured products (Vossenaar, 1997). Teisl and Roe (1998) provide a concise overview of various types of labeling schemes. Also see Karl and Orwat (1999), Markandya (1997), and Golan, Kuchler, and Mitchell (2000).

[2] Swallow and Sedjo (2000) focus on secondary market impacts ('general equilibrium' impacts) of an eco-label that is a mandatory product standard (only certified products are allowed on the market). As in the Mattoo and Singh (1994) analysis, "eco-consumers" preferences are such that their marginal utility from consuming the labeled product is always higher than their marginal utility from consuming the non-labeled product.

[3] Recall that linear preferences yield linear indifference curves, so that corner solutions where only one item is purchase is common.

And second, the structure of consumer demands for labeled and non-labeled products are investigated using fairly general assumptions on consumer preferences. This analysis shows how preferences for credence attributes, preferences for other attributes of the product (e.g. taste), and basic preferences for variety combine to generate demands for eco-labeled items. While strong preferences for the credence attribute generate large potential demand, preferences for variety also make demands relatively more inelastic with respect to price. In other words, simply selling the "difference" of the labeled item can be just as important for demand creation as selling the environmental 'goodness' of the product.

The paper is outlined as follows. Section II introduces the topic of "shade-grown" coffee, where the style of coffee production affects habitat services provided by a coffee plantation. The Mattoo and Singh (1994) test is then implemented, and the resulting market impacts in terms of quantities supplied and price premiums are discussed. Section III then develops a general consumer utility framework to derive theoretical consistent demands for eco-labeled items. Coffee, again the reference item, is typical of many processed food products widely purchased by consumers in developed economies: it is purchased regularly, it is purchased in varying quantities and qualities, there are competing suppliers, and each supplier may have several competing brands. Section IV concludes.

2. Shade Coffee and the Mattoo and Singh "Test"

2.1 Background on Shade Coffee

While a few thousand species of the *Coffea* genus exist in the world, the species commonly called *Arabica* accounts for about 75 percent of world production and *Robusta* accounts for most of the rest (Studivant, 1999). *Arabica* coffees grows at higher altitudes, are considered of higher quality and, therefore, commands higher prices per pound that *Robusta* coffees. *Arabica* coffees are essentially the only type of fresh brewed coffee consumed in the United States. Within the category "*Arabica*", there are numerous varieties grown in different countries around the world.[4]

The United States imports about 2.5 billion pounds of green coffee each year, with over 80% coming from 10 producing countries (USDA FAS 1999).[5] Table 1 provides summary information on U.S. coffee prices and quantities of U.S. coffee imports by country of origin for 1998. For 1998, the U.S. imported over $3 billion of green coffee (with another $175 million of roasted coffee). The largest import quantities came from Columbia (18% market share), Brazil (14%), Mexico (13%), Guatemala (8%), and Vietnam (8%). In terms of import values, the largest import values came from Columbia, Mexico, Brazil, Guatemala, and Indonesia, although imports from Vietnam have grown quickly in recent years.[6]

While coffee bushes were traditionally planted under a canopy of shade trees because they could not tolerate direct sun in tropical growing conditions, new "sun-tolerant" varieties were developed this century that can be grown in direct sun. Thus, as a rough approximation, coffee production can be considered along a continuum from traditional-shade methods to "modern" sun-tolerant methods.[7] Shade methods commonly involve relatively small farms, relatively smaller use of chemical inputs, lower densities of coffee bushes per hectare, and a forest canopy for shade. Such forest canopies can include commercially useful trees (fruit trees, fuel, building materials). Sun methods typically involve higher density plantings per hectare, more chemical inputs, and more capital.

In general, yields are higher using sun methods as compared to shade methods (Gobbi, 2000; Rice and Ward, 1996). As one indication of yield differences between sun and shade methods, average yields in El Salvador are around 0.90 MT per hectare and average yields in Costa Rica are around 1.5 MT per hectare, with El Salvador generally using more shade methods and Costa Rica using sun methods (see, e.g., Harner 1997).[8] Yield differences

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[4] Unless otherwise noted, the remainder of this paper focuses only on *Arabica* coffees.

[5] For reference, 1 pound roasted coffee = 1.19 pounds green bean coffee, which is used to convert roasted coffee into green bean equivalent (GBE units).

[6] The coffee import market can also be separated into standard qualities of *Arabica* coffees and higher-valued 'speciality' coffees that are also *Arabicas*. Of total production of *Arabicas*, perhaps 10% grown is of high enough quality to be considered specialty, although speciality coffee imports into the U.S. have grown to about 30% of total coffee imports (Sturdivant, 1998).

[7] *Arabica* coffees are grown using both sun and shade methods. Rice and Ward (1996), CEC(1999), and Gobbi (2000) provide more complete background on shade coffee production.

[8] These data are for green bean equivalent in 1997 and are from the FAOSTAT data set of the Food and Agricultural Organization

are not profit differences, however, and it is likely that for any given farm shade methods could provide lower marginal costs at lower output levels and sun coffee methods could provide lower marginal costs at higher output levels. Given the substantial switch to sun methods during the nineteenth century, it seems logical to conclude that sun methods have been more profitable in such locations.

It has become recognized that shade-coffee plantations can provide on-site environmental benefits in terms of biodiversity conservation (see, e.g. Gobbi, 2000). For example, the CEC (1999) reports that shade coffee plots are the only 'forested' areas in many areas of Mexico. The Smithsonian Migratory Bird Center has recently promoted the benefits of shade-grown coffee areas as habitat for many bird species (see Smithsonian, 2001). [9]

Shade labels have begun to emerge on coffees sold in the United States to market the positive production externalities generated by shade -coffee plantations (see, e.g., Rainforest Alliance, 1997). For example, "Bird Friendly" is a shade-grown seal issued by the Smithsonian Migratory Bird Center. "Café Audubon" is a label for coffees sponsored by the National Audubon Society, with the Smithsonian's Bird Friendly seal, that are distributed by ECO Organic Coffee Company. "Song Bird Coffee" is sponsored by the American Birding Association and distributed by Thanksgiving Coffee Company. While such labels exists, quantities sold under such labels remain a very minor share of the U.S. market.

2.2 The Mattoo and Singh Test

The basic logic behind the Mattoo and Singh (1994) framework and empirical test is outlined in Figure 1 and Figure 2. In the pre-label market outlined in Figure 1, consumers cannot determine whether an otherwise-homogeneous good is produced using two different production methods, shade or sun. Since the consumer cannot identify this credence attribute (which production process is used), there is one aggregate demand labeled D^b in the pre-label market. There is supply of shade-labeled coffee (denoted as S) and supply of unlabeled sun coffee (denoted as S^u) in the market, and aggregate supply is $S^T = S + S^u$. Given this initial situation, the market clears at total quantity Q^T and price P_0. With this market price P_0 , existing quantities are Q_0 for shade and Q_0^u for sun coffee.

After a label exists, as shown in Figure 2, consumers can identify the credence attribute and, as a result, the market is now differentiated into shade-grown and sun-grown products. As drawn in Figure 2, the possibility exists that separate markets can clear with the point (Q_1 , P_1) for shade labeled coffee and the point (Q_1^u , P_0) sun coffee.[10] The outcome drawn in Figure 2, where a label creates a price 'premium' for the labeled item ($P_1 > P_0$) and larger quantities sold ($Q_1 > Q_0$), is the hoped-for outcome of labeling schemes.

For the outcome depicted in Figure 2 to hold, Mattoo and Singh (1994) show that potential demand for shade coffee in the pre-label situation, denoted as Q^p in Figure 2, must be greater than actual supply of shade coffee in the pre-label situation (denoted as Q_0 in Figure 1 and Figure 2). This potential excess demand, $Q^p - Q_0$, provides the logic of the Mattoo and Singh (1994) 'empirical test'. If data can be developed to estimate supply and demand at pre-label prices, excess potential demand can be computed directly. With excess potential demand, the post-label market clears at some point (Q_1 , P_1). The change in land areas needed to provide the additional shade-production from Q_0 to Q_1 could also then be used to evaluate the additional positive environmental externalities created by the label.

2.3 A Shade-Coffee Label Could Pass the Test

Given that the production systems of major coffee exporting countries are fairly well known, it is possible to hazard an estimate of existing quantities of non-labeled shade-grown coffee that is sold in the US. Recent information on consumer preferences for shade coffee also can be used to discuss potential market demands in the near future for this product.

(see, FAO, 2001). For different production methods within El Salvador, Gobbi (2000) reports that sun yields are 180% higher than some shade methods (e.g. commercialized polyculture) but only 20% higher than other shade methods (e.g. 'technified' shade).

[9] The CEC (1999) also suggests that there are shade coffee is somehow more 'healthy' to consumers than sun coffee, although the logic is tenuous at best. Coffee is not consumed for its nutrient value, and the roasting process (burning at high temperatures) eliminates pesticide residues and microbes.

[10] For simplicity, Figure 2 assumes that the post-label price for the unfriendly items remains the same as the pre-label market price P_0. This outcome is likely if the market share of the labeled item is a small portion of the overall market.

Table 3, Part A provides basic information to conduct the 'test' discussed in Mattoo and Singh (1994). Information on current demand in the U.S. and consumer survey data (CEC 1999) can be used to hazard a guess of existing potential demand, Q^p, for shade coffee in the United States. As reported in Table 1, the U.S. imports about 2.5 billion pounds of coffee annually. If 30% of imported quantities are 'specialty' coffees (Sturdivant, 1998), the existing market for specialty coffees (e.g. high quality dark roasts, blends, coffees of specific origins) would be about 750 million pounds annually. The CEC (1999) reports that around 50% of U.S. consumers would buy shade coffee with no price premium assuming that taste is the same as a high quality coffee. If this were the case, and shade-labeled coffee were to competed in the specialty coffee market (CEC, 1999), the potential demand for shade coffee with no price premium could be estimated at about 375 million pounds per year.[11] As a starting point, at least, 375 million pounds annually is used as an initial estimate of potential shade coffee demand (Q^p in Figure 2).

Regarding quantities sold in the pre-label market, current information suggests that most of the coffee imported into the U.S. from El Salvador and Mexico is currently grown under some form of shade methods (CEC 1999; Harner 1997; Rice and Ward 1996). As a starting then, based on the quantities reported from Table 1, shade-grown coffee currently accounts for at least 13% of the total market for all coffee in the United States, which is equivalent to 325 million pounds of shade coffee per year.[12] Thus, 325 million pounds is used as an initial estimate of Q_0 in Figure 2.

With an initial estimate of 325 million pounds of shade coffee sold and potential demand if labeled at 375 million pounds annually, excess demand could be 50 million pounds annually in the United States for shade coffee. In short, according to the Mattoo and Singh (1994) test, there could be a positive outcome–more shade coffee with a higher price.

2.4 What About a Price Premium for Shade-Labeled Coffee?

While a shade-coffee label might pass the Mattoo and Singh (1994) test, excess demand in the pre-label situation says little about the magnitude of the price premium in the post-label equilibrium, where $(P_1 - P_0)/P_0$ is used to define the premium as a percentage above the price of the non-labeled item. As shown in Figure 2, if the quantity of shade coffee supplied was fixed at Q_0 in the post-label market, then the maximum level of the price premium could be $(P_1^m - P_0)/P_0$. If shade coffee supply responds to higher prices, however, then $(P_1 - P_0)/P_0$ would be the market premium associated with the higher production level Q_1. Using existing information regarding price elasticities of demand and supply for coffee, these premiums are calculated and discussed below.

To approximate the maximum premium, first note that $[Q_0 - Q^p]/Q^p = -0.133$. As a result, the maximum price premium $(P_1^m - P_0)/P_0$ would need to be high enough to reduce demand by 13.3 percent. Letting D = D(p) represent a constant elasticity demand function for labeled coffee D in Figure 2, the standard definition of a demand elasticity with respect to price, E_{Dp} = ( ) D/) p)*(p/D), can be rearranged to yield) p/p = ( ) D/D)/E_{Dp}. Evaluating this expression where) D/D = $[Q_0 - Q^p]/Q^p = -0.133$, the maximum premium is $(P_1^m - P_0)/P_0 = -0.133/E_{Dp}$. An estimate of a demand elasticity E_{Dp} is needed to estimate this maximum price premium.

While existing information on actual price elasticities of demand for shade coffee do not exist, the existing literature does suggest that total coffee demand is fairly inelastic with respect to price, but that brand elasticities are substantial. For example, Okunade (1992) estimates a price elasticity of demand in the U.S. equal to -0.34, Akiyama and Variangis (1990) report an estimate of -0.46 for the U.S. and -0.17 for Germany, and Feuerstien (2002) reports an estimate of -0.18 for Germany. While demand for total coffee purchased by a consumer may be fairly inelastic, Krishnamnthi (1991) and Bell, Chiang, and Padmanabhan (1999) provide evidence that price elasticities for brands of coffee are very elastic (e.g., -3, -4, etc.). In other words, prices do not change the total quantity of coffee purchased (e.g. 1 kilogram), but pricing does have a large impact on the brands purchased.

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[11] This reported percentage willing to buy with no price premium is consistent with other related empirical literature. For example, the data reported in Govindasamy and Italia (1998) suggest that about 80% of individuals sampled would be willing to purchase fresh produce labeled as grown using integrated pest-management methods. This potential demand figure of 375 million pounds annually may be too high given that the CEC (1999) information is more likely to be described as 'willing to try', rather than will 'only buy' shade for the same price. At the same time, the calculations above assume that shade-labeled coffees would be competing primarily in the market for high quality coffees.

[12] Since shade methods are used in other countries as well, it is likely that this 13% figure is too low.

While there has been little analysis of consumer demands for shade coffee, the CEC (1999) also provides some information that can be used as a starting point. The CEC (1999, Figure 3, p. 14) suggests that 58% of U.S. adults might buy shade coffee if the price was the same as other non-shade alternatives assuming the same taste (a $0 premium). Demand would fall to 22% for a $1 premium. If $7 per pound was an average retail price for specialty coffee, the implied elasticity is $E_{Dp} = -4.4$ (i.e. there is a 62% fall in demand for a shade for a 14% increase in its price from the $7 per pound base for both brands). This implied elasticity of coffee labeled as shade with respect to price is comparable to the estimates of coffee brand elasticities found in the literature.

As reported under Case 1 in Table 3 (Part B), if demand for shade coffee is as elastic as reported in the CEC (1999) with $E_{Dp} = -4.4$, then $(P_1^m - P_0)/P_0 = -0.133/E_{Dp} = -0.133/(-4.4) = 0.03$. In other words, holding supply constant at Q_0 , a 3% price premium would eliminate excess demand if consumer demand for shade coffee is as elastic as implied by the CEC (1999). If, on the other hand, as reported under Case 2 in Table 3 (Part B), demand for shade coffee is inelastic with $E_{Dp} = -0.5$, then $(P_1^m - P_0)/P_0 = -0.133/E_{Dp} = -0.133/(-0.5) = 0.27$. In this case, holding supply constant at Q_0 , a 27% price premium would eliminate excess demand.

Of course the actual premium $(P_1 - P_0)/P_0$ based on new production levels Q_1 in Figure 2 will depend on demand and supply conditions for shade coffee. To compute the actual premium, let S = S(p) represent a constant-elasticity supply schedule for labeled coffee S in Figure 2, and let E_{sp} = ( ) S/) p)*(p/S) represent the supply elasticity with respect to price. Using these definitions of demand and supply elasticities and the fact that excess demand in Figure 2 must be eliminated by some combination of a decrease in demand or an increase in supply (i.e., $Q^p - Q_0 = (Q^p - Q_1) - (Q_1 - Q^p)$), it is possible to solve for the equilibrium premium as $(P_1 - P_0)/P_0 = [Q_0 - Q^p] / [Q_p E_{Dp} - Q_0 E_{Sp}]$.

In sum, four fairly simple pieces of information are needed to develop an estimate of the market premium for the labeled item (shade coffee in this case). Estimates of Q^p , Q_0 , and E_{Dp} have been discussed above, so only an estimate of a supply elasticity E_{sp} is needed to compute the market premium. There is little recent evidence in the literature on coffee supply response to higher prices, in large part due to the perennial crop nature of coffee production. Existing literature suggests that coffee supply is fairly inelastic in the short run (at least increasing supply) because producing area is essentially fixed and supply therefore is essentially a harvesting decision (see, Wickens and Greenfield, 1973; Parikh, 1979; and Arak, 1969). In the longer run, supply could be fairly responsive to sustained price increases.

To show a range of possibilities, Case 3 and Case 4 reported in Table 3 (Part B) use the inelastic demand assumption from Case 2 along with two supply elasticities (an inelastic case with $E_{sp} = 0.5$ and an elastic case with $E_{sp} = 2$) to show how some supply response affects the final price premium. As shown in Case 3, a fairly low supply elasticity (0.5) reduces the price premium from 27% for Case 2 to about 14% for Case 3. If supply is substantially more responsive to price, as considered in Case 4, the premium falls to 6%.

The numbers and calculations provided above are intended to provide a first level analysis of the U.S. market implications of an eco-label for shade coffee production. To date, such analysis has been consistently missing in the eco-label literature. Future research can attempt to provide more precise information on the key needed pieces of information. It is also possible that, because of the presence of a shade label, consumers would become more informed overtime about this topic and, as a result, preferences for the credence attribute would adjust over time. In terms of Figure 2, this would imply that demand for the labeled product D would shift out over time, which could act to sustain and/or increase premiums in the future. Thus, the analysis in Figure 2 and the calculations above are probably best considered the short run implications of an eco-label.[13]

2.5 What about the additional environmental benefits of the label?

While the above analysis suggests that a shade-coffee label might pass the Mattoo and Singh test, passing the test says little about the ability of an eco-label to generate additional environmental benefits. For example, if existing average yields of shade coffee are about 1980 pounds per hectare (using an average of 0.9MT/H for El Salvador), an additional 25,000 hectares of shade coffee would be needed to supply the excess demand of 50 million pounds per year holding prices constant (the no-premium case). Thus, even if supply expanded to meet all the excess demand at current prices, the environmental benefits from 25,000 hectares allocated to shade production would be the maximum

[13] Of course this analysis assumes competitive markets. Given the potential for non-competitive retail markets for processed foods, future research needs to consider if and how much of any retail premium would actually be passed down to producers through the marketing chain.

initial impact possible. While perhaps an important of land for a local growing area, 25,000 hectares represents about 3% of existing coffee hectares just in Mexico (and less than one percent of coffee hectares in Mexico and Central America). Of course with constant prices, there is no reason why producers would increase shade production on 25,000 hectares, and the final increase in shade area would be associated with the production level Q_1 from Figure 2.

Given the minor adjustments in aggregate production of shade coffee implied by these calculations, it is likely at least in the shorter run that there would be relatively few additional environmental benefits generated by a shade label. Looking at this issue from another perspective, however, a main benefit of a label might be to slow conversion of coffee plantations in the future from shade to sun methods. Slowing this conversion could clearly be important, and future research needs to farmer decisions regarding production methods and the relative returns to different coffee production systems in different climates and elevations.

3. A Closer Look At Preferences and Demands For Credence Attributes

The Mattoo and Singh (1994) model and the discussion provided in Section II emphasize the importance of consumer demands for the impacts of eco-labels in competitive markets. Clearly, an eco-label will create higher price premiums when there is substantial excess demand (Q^p - Q_0) in the pre-label market and if consumer demands for the labeled item are very inelastic. Since the existing eco-label literature does not provide explicit utility-maximizing frameworks, it is not clear what preference structures would generate such demands. Strong ‘preferences’ for the credence attribute are usually discussed, which might explain strong demands without a premium, but such preferences do not necessarily imply inelastic demands.

To begin to fill this gap in the literature, this section develops an explicit utility maximizing framework to investigate the structure of demand for eco-labeled items. To develop this analysis, a nested constant-elasticity-of-substitution (CES) utility structure is used to model demand for labeled and non-labeled products. As is well known, a CES utility structure allows for a range of utility structures as special cases (linear, Leontief, Cobb-Douglas, etc.) based on the magnitude of the elasticity of substitution parameter. For example, the utility framework used in the previous quality differentiation models (Nimon and Beghin, 1999a,b; and Bureau, Marette and Schiavina 1998) is a special case of a CES utility framework with an infinite elasticity of substitution between labeled and non-labeled goods.

The ‘pre-label’ problem is considered first, followed by the ‘post-label’ situation. Example numerical simulations of post-label consumer demands for the labeled and non-labeled item shows clearly how preference structures interact to affect final consumer demands.

3.1 The ‘Pre-Label’ Consumer Problem

For notation in the pre-label situation, let C represent coffee purchased at price p_c , let D represent all other beverages purchased at price p_d , and let I represent income allocated to beverages. Let U(C,D) represent a constant-elasticity-of-substitution (CES) function for beverages, where:

$$U(C,D) = (C^{-\alpha} + D^{-\alpha})^{-\frac{1}{\alpha}}. \tag{1}$$

In the utility function (1), the parameter " determines the elasticity of substitution F" , where F" = 1/(1+") (see Varian, p. 129 and Intrilligator, p. 187). The parameter " can be between -1 to +4 for (1) to be a utility function. The utility function in (1) is linear as " approaches -1, is Cobb-Douglas as " approaches 0, and is Leontief as " approaches +4. Thus, by varying the parameter ", a range of preferences can be explored.

Given the above utility function, the dual expenditure function for the CES utility function in (1) can be written as:

$$e(p_c, p_d, U) = [p_c^{\kappa} + p_d^{\kappa}]^{1/\kappa} U, \tag{2}$$

where 6 = "/(1+") (e.g., see Varian, p. 130 and page 31-32).[14]

[14] The expression of the expenditure function looks slightly different than that in Varian. I use the convention in Intrilligator that

Equating the expenditure function to total income I and inverting provides the indirect utility function:

$$V(p_c, p_d, I) = [p_c^{\kappa} + p_d^{\kappa})^{-1/\kappa} I. \tag{3}$$

Using Roy's identity, the Marshallian demand for coffee and total coffee expenditures can be written as:

$$C(p_c, p_d, I) = [p_c^{\kappa} + p_d^{\kappa})^{-1} p_c^{\kappa-1}$$

and

$$M = p_c C = I[p_c^{\kappa} + p_d^{\kappa})^{-1} p_c^{\kappa}. \tag{4}$$

This pre-label demand situation in (4) is equivalent to the pre-label demand D^b in Figure 1.

3.2 The 'Post-Label' Consumer Problem

After a labeling program exists, consumers can now identify in advance the type of coffee they are purchasing. In effect, the coffee market is now separated into two commodities, and the household can allocate it's income to three goods (labeled coffee, non-labeled coffee, and other drinks). For notation in the post-label situation, let G represent the quantity of labeled coffee (e.g., "environmentally-friendly", "good") purchased at price p_G , and let B represent other coffee ("bad") purchased at price p_b . Let M continue to represent income allocated to all coffee purchases.

In the pre-label equilibrium, total coffee consumed C was a composite commodity of the form C = G + B by default because consumers were only able to observe C and not G or B individually. As a result, utility was a simple function of total coffee purchases in (1). In the post-label situation, individuals can now express demands directly for G and B. While total coffee purchases in pounds or kilograms remain G+B, each item can provide utility directly to the consumer, so that the general utility structure is now U = U(G,B,D).

As an example, consider the following nested CES structure, where a sub-utility function for coffee consumption is:

$$\chi(B,G) = [(\theta\gamma G)^{-\beta} + B^{-\beta}]^{-\frac{1}{\beta}}, \tag{5}$$

where the parameter β determines the elasticity of substitution (σ_β) between labeled and non-labeled coffee, with $\sigma_\beta = 1/(1+\beta)$. The parameter θ in (5) is related to product attributes such as taste, and the parameter γ is related to credence attributes identified by the label (e.g., shade grown). The overall utility function is U = U[χ(B,G), D], with the function U = U[χ, D] defined in (1) above.

By labeling coffee, consumers can now distinguish production methods used for coffee growing, <u>and</u> they can also evaluate its taste relative to the non-labeled coffee. Intuitively, $\theta > 1$ in (5) implies that a consumer prefers the taste of labeled coffee type G as compared to coffee type B, and $\gamma > 1$ implies a consumer prefers the credence attributes of the labeled product relative to the non-labeled item. In combination, when $\theta\gamma > 1$, a unit of labeled coffee provides more utility than a unit of non-labeled coffee.[15]

Besides preferences for taste and credence attributes, consumers may also have preferences for variety, where preferences for variety can be related to the parameter β . Recall that as β becomes negative and close to -1, the sub-utility function $\chi = \chi$(B,G) becomes linear in B and G. In this case, consumers have no preference for variety, and they consume at a corner solution of only one type of coffee. However, as β becomes positive and large, the sub-utility function $\chi = \chi$(B,G) begins to approach a fixed proportions function (Leontief). Fixed proportions implies that

---

the parameter α is between -1 and positive infinity, while Varian uses the convention that $\rho = -\alpha$, with ρ between 1 and negative infinity.

[15] Allowing for product and process attributes to be included directly in the utility function is important for coffee decisions and probably the case for a variety of food products. As reported by CEC (1999), while consumer surveys may document potential demand for labeled coffee (e.g. shade), taste considerations could slow the growth in demand.

a consumer strongly prefers variety; in other words, even as relative prices change, the consumer continues to buy both products. In sum, preferences related to taste, credence attributes, and variety will influence the post-label outcome.

To analyze this post-label situation, it is again convenient to begin with the expenditure minimization problem for the coffee sub-utility problem, where:

$$e_c(p_g, p_b, \chi) = \min_{g,B}(p_g g + p_b B \;\; s.t. \;\; [g^{-\beta} + B^{-\beta}]^{-\frac{1}{\beta}} = \chi)$$

where (6)

$$g \equiv \theta\gamma G \;\; and \;\; p_g \equiv p_G /(\theta\gamma)$$

This coffee expenditure function just shows the minimum amount of money that is needed to produce χ units of the composite coffee commodity when a label exists. For reference, $g = \theta\gamma G$ can be considered the 'effective' units of labeled coffee consumed, and $p_g = p_G /(\theta\gamma)$ is the effective price of labeled coffee, with p_G being the actual market price facing consumers.

As with the previous expenditure function for the pre-label case, the expenditure function in (6) can be written as:

$$e_c(p_g, p_b, \chi) = p_\chi(p_g, p_b, 1)\chi$$

where

$$p_\chi(p_g, p_b, 1) = [p_g{}^{\delta} + p_b{}^{\delta}]^{\frac{1}{\delta}} \tag{7}$$

and

$$\delta = \frac{\beta}{1+\beta}.$$

In this post-label situation, the 'composite' price $p_\chi = p_\chi(p_g, p_b, 1)$ in (7) shows the cost to the consumer of "creating" one unit of the composite commodity coffee given prices for the labeled and non-labeled items.

Using Shephard's lemma, the Hicksian demand for labeled coffee is:

$$G(p_g, p_b, \chi) = \frac{g(p_g, p_b, \chi)}{\theta\gamma} = \frac{\partial p_\chi(p_g, p_b, 1)}{\partial p_g}\frac{\chi}{\theta\gamma}, \tag{8}$$

and the Hicksian demand for non-labeled coffee is:

$$B(p_G, p_b, \chi) = \frac{\partial p_c(p_g, p_b, 1)}{\partial p_b}\chi. \tag{9}$$

In this post-label situation, the 'composite' price $p_\chi = p_\chi(p_g, p_b, 1)$ can be substituted into equation (4) to determine the total Marshallian demand for the coffee composite χ and total expenditures on coffee M as:

$$\chi(p_\chi(p_g, p_b, 1), p_d, I) = I[p_\chi(p_g, p_b, 1)^{\kappa} + p_d{}^{\kappa}]^{-1} p_\chi(p_g, p_b, \delta)^{\kappa-1}$$

and

$$M = p_\chi \chi. \tag{10}$$

As a last step, the Marshallian demand for the coffee composite (10) can be substituted back into the Hicksian demand for labeled-coffee (8) and non-labeled demand in (9) to determine the Marshallian demands for labeled and non-labeled coffee.

3.3 Numerical Examples of the Nested CES Consumer Model

Rather than presenting somewhat tedious comparative static derivations of how demands change as prices and other parameters of the model change, numerical simulations of the model outlined in (1) - (10) are used here to discuss how the combination of consumer preferences for credence attributes, variety, and relative prices combine to create consumer demands for the eco-labeled item. Four types of consumers are analyzed: Type I consumers do not care about the credence attribute or variety; Type II consumers care strongly about the credence attribute but not about variety; Type III consumers do not care about the credence attribute but Type III consumers have stronger preferences for variety; and Type IV consumers have strong preferences for both the credence attribute and variety. The basic parameters for the simulation model based on equations (1) - (10) for these four types of consumers can be found in Table 4 (under the appropriate column headings).

For these four types of Consumers, Figure 3 shows how demands for the labeled item adjusts to higher prices, where price is expressed as relative prices, p_G/p_b, representing a price premium for the labeled product. Consider first the results for the Type I consumer. In short, while this consumer is indifferent between the labeled and non-labeled coffees if there is no price premium, $p_G/p_b = 1$, in which case even at Type I consumer could buy a relatively high share of labeled coffee, any premium for the labeled item would lead to a large reduction in labeled purchases. In Figure 3, for example, a 30% price premium for labeled coffee would reduce demand for labeled coffee by 87%, with an implied price elasticity of demand of -2.9.

If the US market contains a large number of Type I consumers, eco-label programs will not be able to depend on retail price premiums to help make shade coffee more profitable vis-a-vis sun methods. Groups developing eco-labels for shade-grown coffee would need to focus on reducing production costs so that shade can simply out-compete sun methods. At the same time, the logic of the ‘fair-trade’ movement could make sense, where new marketing channels are created, through reductions in profits elsewhere in marketing channels, so that farmers can receive higher farm-gate prices while retail prices can remain constant or fall.

Second, consider the results for the Type II consumer presented in Figure 3. For these consumers, with no price premium, they would consume essentially only the labeled item. As the premium increases, however, these consumers still respond in a normal fashion by reducing purchases of the labeled item and increasing purchases of the non-labeled item (even though they have “strong” environmental preferences). In this case, a 30% premium would reduce demand for the labeled item by about 19%, with an average price elasticity of demand of -0.63.

If the US market contained a relatively large share of Type II consumers, developing an eco-label for US sales could lead to large demands when relative prices $p_G/p_b = 1$. Demand could stay relatively strong with substantial premiums if supply remains constant in this case. As noted in Case 3 of Table 3 (Part B), however, inelastic demands for the labeled item combined with some positive supply response creates fairly modest price premiums.

Next, consider the case of the Type III consumer presented in Figure 3. Type III consumers have no environmental preferences (same as Type I consumers) but they like variety. As shown in Figure 3, with no price premium, Type III consumers purchase less of the labeled item as compared to Type II consumers. As the premium increases, however, Type III consumers also have fairly inelastic demands. For these Type III consumers, a 30% premium only reduces demand by about 16%, with an implied price elasticity of demand equal to -0.53. Thus, while Type III consumers tend to buy less of the labeled item as compared to Type II consumers (strong environmental preferences), Type III consumer demands are also fairly price inelastic.

And last, the results for the Type IV consumer (likes the credence attribute and variety) are also presented in Figure 3. Type IV consumers are simple a combination of Type II and Type III preferences. Because Type IV consumers have strong environmental preferences, they buy more of the labeled item than Type III consumers when there is no premium. Because they also like variety, however, they buy less of the labeled item as compared to the

Type II consumer. The demand functions for these Type IV consumers remain less responsive to price than Type II consumers, however. For example, a 30% premium reduces demand by about 15%, with an average elasticity of -0.5.

For each of these examples, as noted in Table 4, it was assumed that other attributes of the commodity were identical (i.e. no taste differences). Any taste differences between the labeled and non-labeled coffees (e.g. if the parameter 2 = 0.8), would imply that the demand schedules for the labeled coffee would fall. As experience with the organic produce market shows, environmental and potential food safety attributes of products do not easily substitute for taste and appearance attributes.

4. Conclusion

While numerous types of eco-labels for credence attributes of products (i.e. non-product related production and process method attributes) exist in the U.S. and elsewhere, there is surprisingly little analysis of their usefulness as a policy instrument to affect market prices, increase supplies of the labeled item, and manage production externalities. Using the topic of 'shade-grown' coffee, this paper discusses and analyzes the implications of a label for shade-grown coffee in the US. While shade-grown coffee might pass the Mattoo and Singh (1994) test, the resulting market implications are likely to be modest.

Given the importance of how consumers adjust to eco-labels, and given the lack of research on the theoretical foundations of demand for eco-labeled items, Section III develops a representative consumer model based on a nested CES utility structure. This frameworks allows of a relatively easy comparison of utility maximizing outcomes across a rather wide range of preference structures. As shown in Section III , preferences for the credence attribute and variety are both important and supporting motives to purchase labeled items. Strong preferences for the credence attribute help to generate large demands in the absence of any price premium for the labeled item, while preferences for variety help to make such demands less responsive to higher prices. Future research should investigate the implications of variety for marketing the "differentness" of eco-labeled products as opposed to (or in tandem with) the "environmental-ness" of the items.

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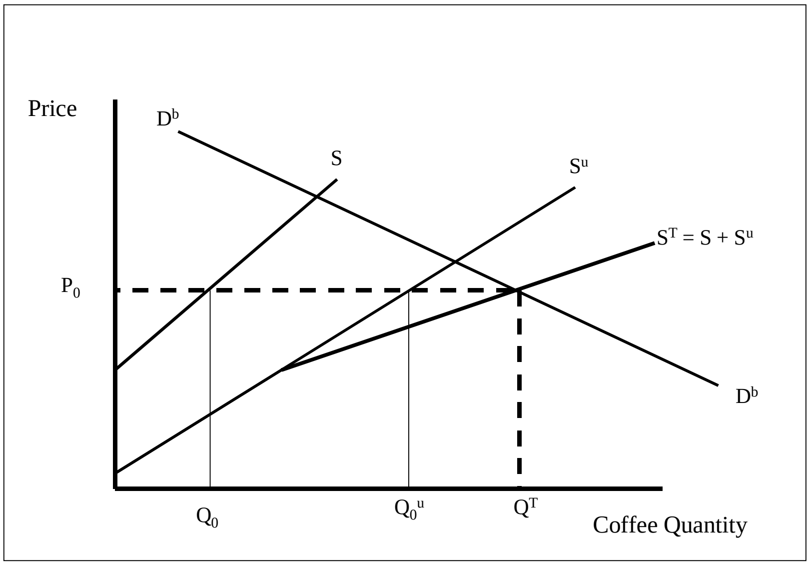

Figure 1. The "Pre-Label" Market

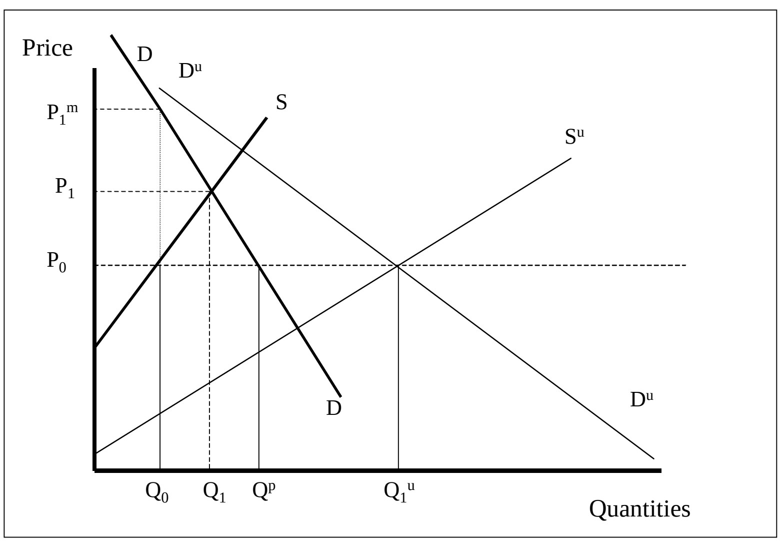

Figure 2. The Post-Label Market with Premium $(P_1 - P_0)/P_0$

Table 1. U.S. Coffee Imports for 1998 (Green Bean)

Country	Quantity (60 kg. bags)	Share of Total Imports	Values	Price per kilogram	Price per Pound	% Average Retail Price
El Salvador	500,700	0.03	88,113,346	2.93	1.33	0.35
Honduras	633,871	0.03	123,602,646	3.25	1.48	0.39
Peru	770,614	0.04	122,518,253	2.65	1.20	0.32
Costa Rica	770,983	0.04	154,118,238	3.33	1.51	0.40
Indonesia	1,272,991	0.07	150,957,815	1.98	0.90	0.24
Vietnam	1,508,202	0.08	142,228,022	1.57	0.71	0.19
Guatemala	1,563,363	0.08	299,838,252	3.20	1.45	0.39
Mexico	2,470,628	0.13	466,643,933	3.15	1.43	0.38
Brazil	2,687,770	0.14	371,546,261	2.30	1.05	0.28
Columbia	3,410,206	0.18	655,293,072	3.20	1.46	0.39
Total	18,997,935	0.82	3,062,636,560	2.69	1.22	0.32

Sources: All data from FAO (2001) except the average retail price of $3.756 per pound in 1998 is from the (USDA FAS 1999).

Table 2. Coffee Consumption Per Capita (kg.) in the U.S. and Europe

	1992	1998
United States	4.33	4.09
Europe	5.78	5.4

Source: USDA FAS 1999

Table 3. The Mattoo and Singh Test

Part A: Does Excess Demand Exist?	Notation	Numbers
Speciality Coffee Imports (pounds per year)		750,000,000
% Consumer Willing to Buy with no price premium relative to speciality coffee		0.5
Potential Demand for Shade Coffee	Q_p	375,000,000
Existing Supply of Shade Coffee	Q_0	325,000,000
Pre-Label Excess Demand	$Q_p - Q_0$	50,000,000

Part B: What About Price Premiums for Shade Coffee?	Notation	Numbers			
Potential Demand for Shade Coffee	Q_p	375000000			
Existing Supply of Shade	Q_0	325000000			
Excess Demand	$Q_p - Q_0$	-50000000			
		Case 1	Case 2	Case 3	Case 4
Elasticity of Demand = EDp	E_{Dp}	-4.4	-0.5	-0.5	-0.5
Elasticity of Supply = ESp	E_{Sp}	0	0	0.5	2
Price Premium	$(P_1 - P_0)/ P_0$	0.03	0.27	0.14	0.06

where $(P_1 - P_0)/ P_0 = [Q_0 - Q_p] / [Q_p E_{Dp} - Q_0 E_{Sp}]$

Table 4. CES Initial Parameters and Information for Type I - IV Consumers

	Notation	All Consumers
General Parameters		
CES Basic Utility Parameter	"	1.00
Income Allocated to All Beverages	I	100
Pre-Label Market Prices		
Coffee Price	p_c	1.00
Other Beverages Price	p_d	1.00
Post-Label Information		
Taste Preference Parameter	2	1.00
Labeled Coffee Price	p_G	1.00-1.90
Non-labeled Coffee	p_b	1.00

		Type I	Type II	Type III	Type IV
Parameters That Change Across Consumer Types					
CES Coffee Sub-Utility Parameter	$	-0.90	-0.9	1.00	1.00
Credence Preference Parameter	(	1.00	2.00	1.00	2.00

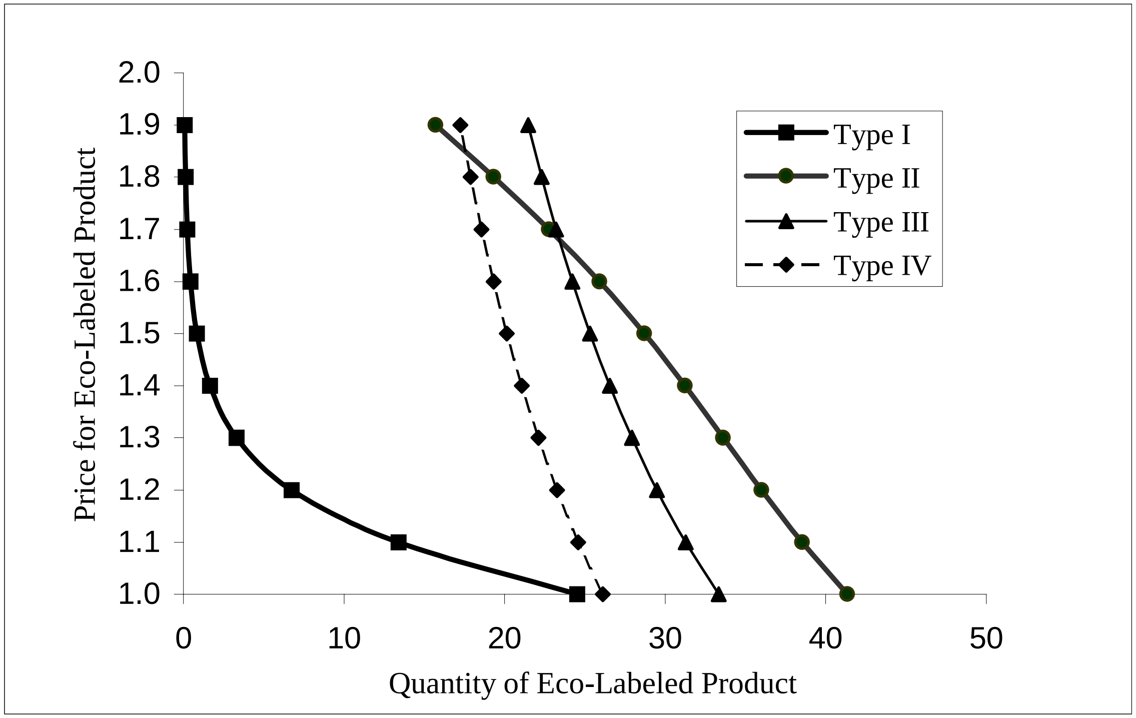

Figure 3. The Effect of Preferences on Consumer Demands (Type I - IV Consumers)

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1376 Storrs Road, Unit 4021
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