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Effects of Healthier Choices on Kid's Menu: A Difference-in-Differences Analysis

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Abstract

This study evaluates the effect of a quick-service restaurant (QSR) strategy which changes default calorie-dense menu items to healthier options on children' menu consumption behaviors. A series of difference-in-differences (DID) models are estimated to compare sales between treatment and control group restaurants in the Washington State. The results do not provide evidence that adding healthier options causes consumers to make healthier diet choices. This negative result suggests that more proactive interdiction is needed to make an impact on childhood obesity. Government policies such as those that require additional, possibly highlighted, information and/or education are likely to have a greater effect.

Keywords: quick service restaurants, children's diet, food away from home

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Introduction

Childhood obesity has been a worldwide problem in recent decades. The global proportion of childhood overweight and obesity rose from 4.2% in 1990 to 6.7% in 2010, and is expected to reach 9.1% in 2020 (Onis et al. 2010). With regard to the obesity prevalence among U.S. children, according to the Centers for Disease Control and Prevention (CDC), the obesity rate among children and adolescents had almost tripled in 2008 since 1980 with obesity rates at about 17% (or 12.5 million) of children and adolescents (aged 2 to 19 years) in 2007-08.

The increasing prevalence of childhood obesity coincides with increasing consumption of food away from home (FAFH) in recent decades. According to the USDA, the FAFH share of total food expenditures increased from roughly 34% in 1972 to approximately 50% in 2008 (USDA, 2010). Meanwhile, compared to home-cooked foods, FAFH meals are generally higher in over-consumed nutrients (calories, fat and saturated fat), and lower in under-consumed nutrients (such as calcium, fiber and iron) (Lin et al. 1999). Mancino et al (2010) discuss that energy intake is higher and diet quality is lower among children who eat FAFH than among those who do not.

Within the category of FAFH, quick-service restaurants (QSR) account for a large portion. Based on ConAgra Foodservice estimates (FAFH Monthly Industry Brief 2010), QSR purchases made up 77.7% of the annualized total commercial restaurant patron purchases in 2009-2010. At the same time, many claim that QSRs provide high-calorie, obesity-promoting foods to kids. O'Donnell et al. (2008) studied the nutrient quality of kids' meals provided by QSRs in Houston, Texas, and found that only 3% of kids' meals met all National School Lunch Program (NSLP) criteria. Meals not meeting the NSLP criteria were, on average, more than 1.5 times more energy dense than those satisfying the criteria.

Rydell et al. (2008) investigated factors affecting the popularity of QSR through a survey for patrons. They found the most frequent reasons for consumers to dine at QSRs were the following: "fast food is quick" (92%), the "restaurants are easy to get to," (80%) and the "food tastes good" (69%). There are few alternative quick and convenient restaurants that offer less calorie-dense choices. We ask the question of whether offering better nutritional quality on existing QSR menus will lead consumers to make better choices. Currently, many kids' meals have calorie-dense default items included. How will replacing the default items with a choice that includes a healthy option affect consumption?

Menu Labeling and Change

To improve the nutritional quality of QSR menus, there are two major approaches. The first is to add nutrition-related information to the menus, and the second is to add healthier options into QSR menus, which actually change those menus. Several studies have been undertaken to investigate the effect of menu labeling on promoting a healthier diet, but the results are ambiguous, while the studies for menu change are rather sparse.

Voluntary Menu Labeling

Regarding the comprehensive efforts to label menus, several restaurants voluntarily displayed nutrient information in their menus from time to time. Boon et al. (1998) demonstrated that under the stimulation of calorie information, cognition plays an important part in the regulation of the food intake of restrained eaters, which implies that consumers might be responsive to health-related nutritional information of the menus. Bassett et al. (2008) studied the voluntary menu labeling in Subway and found that the frequent Subway consumers who noticed calorie information bought 52 fewer calories than those who did not see it on average. Pulos and Leng (2010) investigated six full-service restaurants (FSR) in Washington which added nutrition information to their menus, and concluded that each calorie-reducing patron purchased roughly 75 fewer calories than what they ordered before labeling.

However, not all literature demonstrated a significant effect of providing nutrition information on reducing calorie intake. Berning et al. (2011) found that positive nutrition information led to decreased sales at times, and provided a potential explanation that customers recognize a tradeoff between healthiness and taste and prefer taste to healthiness.

Mandatory Menu Labeling

In order to combat obesity, government entities, such as New Your City (NYC), San Francisco, and King County (which includes Seattle, Washington), have passed laws that require posting of nutrition information, especially calories, on menus. Elbel et al. (2009) investigated the impact of the NYC menu-labeling law at 14 QSRs. They found no statistically significant effects on calories purchased after the introduction of this legislation. Finkelstein et al. (2011) studied mandatory menu labeling effect through 2009 on Taco Time Northwest in King County, Washington, and concluded that this policy did not change purchasing behavior.

Menu Change

In terms of adding new healthier menu items to QSR menus, the Subway restaurant chain has taken positive steps. For example, the Subway chain introduced "Fresh Fit for Kids' meals nationwide in 2007. These meals are composed of a mini low-fat sandwich, apple slices, and low fat milk or 100% juice by default. Lundgren (2008) affirmed the effectiveness of Subway's menu campaigns focusing on "healthiness" and studied its advertising strategy.

Study Framework

This study is motivated by the ambiguous results from researching "menu labeling" effects on promoting kids' healthier food consumption and the sparse results relating to "menu change" effects on reducing children's calorie intake. This article complements previous studies by providing evidence of the effect of only "menu change" strategy from one fast-food chain of Mexican QSRs (Taco Time Northwest) in Northwest Washington on kids' meal side item purchases.

Taco Time Northwest's voluntary menu change went into effect on January 1, 2010, and was complemented with voluntary menu labeling on July 1, 2010 until December 2010. The changes to the kids' menu included, the addition of healthier options, consisting of beans and rice relative to the default side item of Mexi-Fries, and apple sauce to the default choice of dessert item consisting of Crustos and a toy.

Such a voluntary menu change provides an opportunity to examine the impact of adding menu choices on kids' purchasing behavior through DID analysis. Both pre-event and post-event data from Taco Time Northwest with restaurants within and without menu change policy were utilized to test the effect of such strategies on order counts of Mexi-Fries and Crustos from these outlets. It is hypothesized that the total monthly orders of Mexi-Fries and Crustos at restaurants implementing the menu change policy decreased after the policy change compared to stores without adoption of the strategy.

Methods

Difference-in-Differences Approach

The difference-in-differences (DID) technique is a quasi-experimental method used to measure the effect of an event at a given period of time. The DID approach generally differentiates the change induced by a specific treatment (e.g. policy or strategy) into a within-subjects treatment effect which measures the difference in the control group after and before treatment, a between-subjects pre-treatment effect which measures the difference between the treatment and control groups before treatment, and a DID estimator which represents the pre-post, within-subjects differences for the treatment group.

Since Ashenfelter and Card (1985) proposed the method to estimate the training effect for participants in the 1976 Comprehensive Employment and Training Act (CETA) programs, DID technique applications have become quite widespread. One main application is to utilize DID to study the effect of labor market related legislation or events on labor force and employment. For example, Card (1990) studied the effect of the Mariel Boatlift in 1980 on the Miami labor market. Card and Krueger (1994) evaluated the impact of New Jersey's mandatory minimum wage increase on employment in the fast-food industry. Meyer et al. (1995) examined the influence of increased maximum weekly benefit amount on time out of work in Kentucky. Michigan, and Eissa and Liebman (1996) investigated the effect of an expansion of the earned income tax credit (TRA86) on the labor force participation of single women with children.

There is also some research focused on the food industry and consumption using the DID approach, such as Jin and Leslie (2003) to study the effect of the hygiene quality grade cards policy in Los Angeles County (1998) on restaurants' choices of product quality, Abadie et al. (2010) to examine the impact of California Proposition 99 (a tobacco control program in 1988) on tobacco consumption in California, Kiesel and Villas-Boas (2010) to evaluate the influence of supermarket nutritional labels which reduce information costs on microwave popcorn purchases, and Finkelstein et al. (2011) to investigate the effect of the King County (WA) mandatory menu labeling regulation in 2009 on total transactions and average calories per transaction of one fast-food chain.

Data

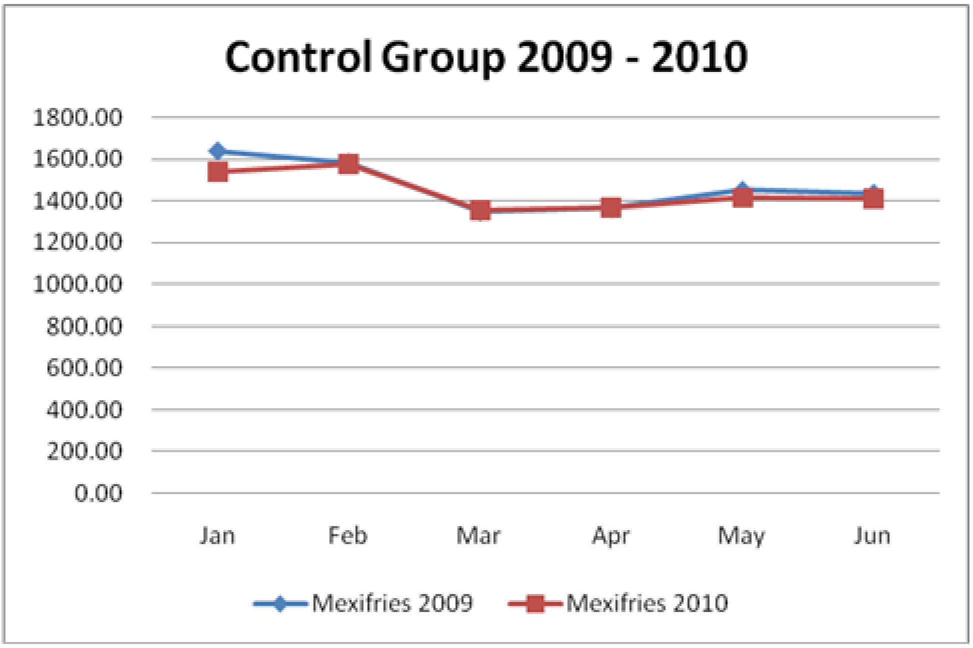
This study is based on transaction data provided by Taco Time Northwest, which is a Mexican-style QSR chain with more than 70 outlets across Washington State. There are a total of thirteen restaurants' monthly sales data throughout two years from January 2009 to December 2010 provided for this analysis. Of the 13 stores, five from King County (which includes Seattle) constitute the *control group*, which did not implement the menu change and labeling strategy during 2010. The *treatment group* is composed of the remaining eight restaurants from adjacent counties, in which the menu change policy was put into practice on January 1, 2010, and the menu labeling strategy was added on July 1, 2010.

For each kids' meal in both control and treatment groups during the *Pre-period*, there was a default energy-dense side item, Mexi-Fries (potato rounds deep-fried and lightly seasoned), and the choice of a high-calorie dessert item, Crustos (deep-fried flour tortilla strips sprinkled with cinnamon and sugar) or a toy. Then in period *POST*, the eight restaurants in the treatment group changed the menu from a default side Mexi-Fries to a side of choices among Mexi-Fries, beans and rice; meanwhile, the original Crustos/toy choice was also expanded to include an apple sauce option for the treatment group. According to the Taco Time Northwest website, within each kids' meal, Mexi-Fries (mini) has 250 calories and Crustos has 316 calories, compared to rice of 133 calories and apple sauce of 90 calories. Therefore, Mexi-Fries (mini) and Crustos are regarded as energy-dense items, while beans, rice and apple sauce are considered to be low-calorie healthier substitutes.

We focus on the monthly purchase counts data of Mexi-Fries and Crustos for each restaurant in both of the control group (five stores) and the treatment group (eight stores) across 12 months (Jan 2009 to June 2009; January 2010 to June 2010). However, due to missing data in January 2009 for the control stores, January is excluded from the DID analysis for Crustos. Therefore, for Crustos, the treatment group only contains seven stores, and the time periods are defined as *Pre-period* (February 2009 to June 2009) and *POST* (February 2010 to June 2010).

Prior to any statistical analysis, a simple comparison of per-store, per-month unit sales between the *Pre-period* (January/ February 2009 to June 2009) and the *POST* (January/ February 2010 to June 2010) on average in the control group and treatment group for Mexi-Fries in Figure 1 and Crustos is presented in Figure 2. Both Figures indicate that the average storewide monthly consumption slightly decreased over time in general within each of the two groups for both food products.

Although the count sales generally fell in the first half of 2010 relative to the corresponding periods of 2009 for both groups, we cannot simply conclude that the new menu with added options led to a reduction in both Mexi-Fries and Crustos. Without adopting the menu change strategy, the restaurants in the control group also have lower sales on both food items in 2010, due to the impact of certain observable and unobservable factors. Since all sampled outlets are close to each other geographically, the treatment group stores could have been affected by the same factors, which compromised the menu change policy impact. Therefore, to examine the pure effect of the menu option-adding strategy on consumption of Mexi-Fries and Crustos, a series of difference-in-differences regressions are defined and estimated. Next, we successively establish a benchmark model and a monthly model and interpret the corresponding estimation results.



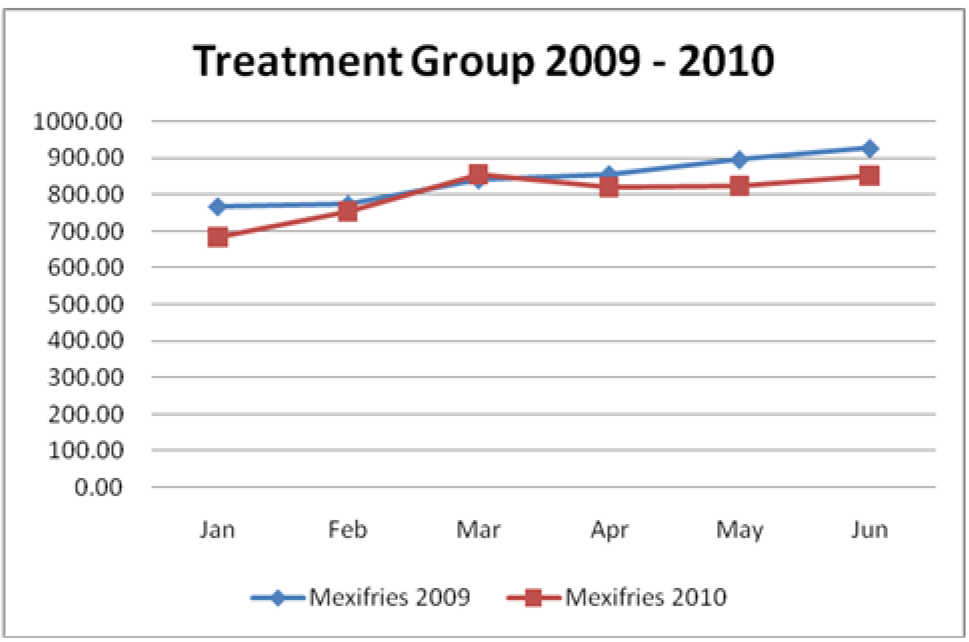


Figure 1. Monthly Comparisons of Average Values for Mexi-Fries

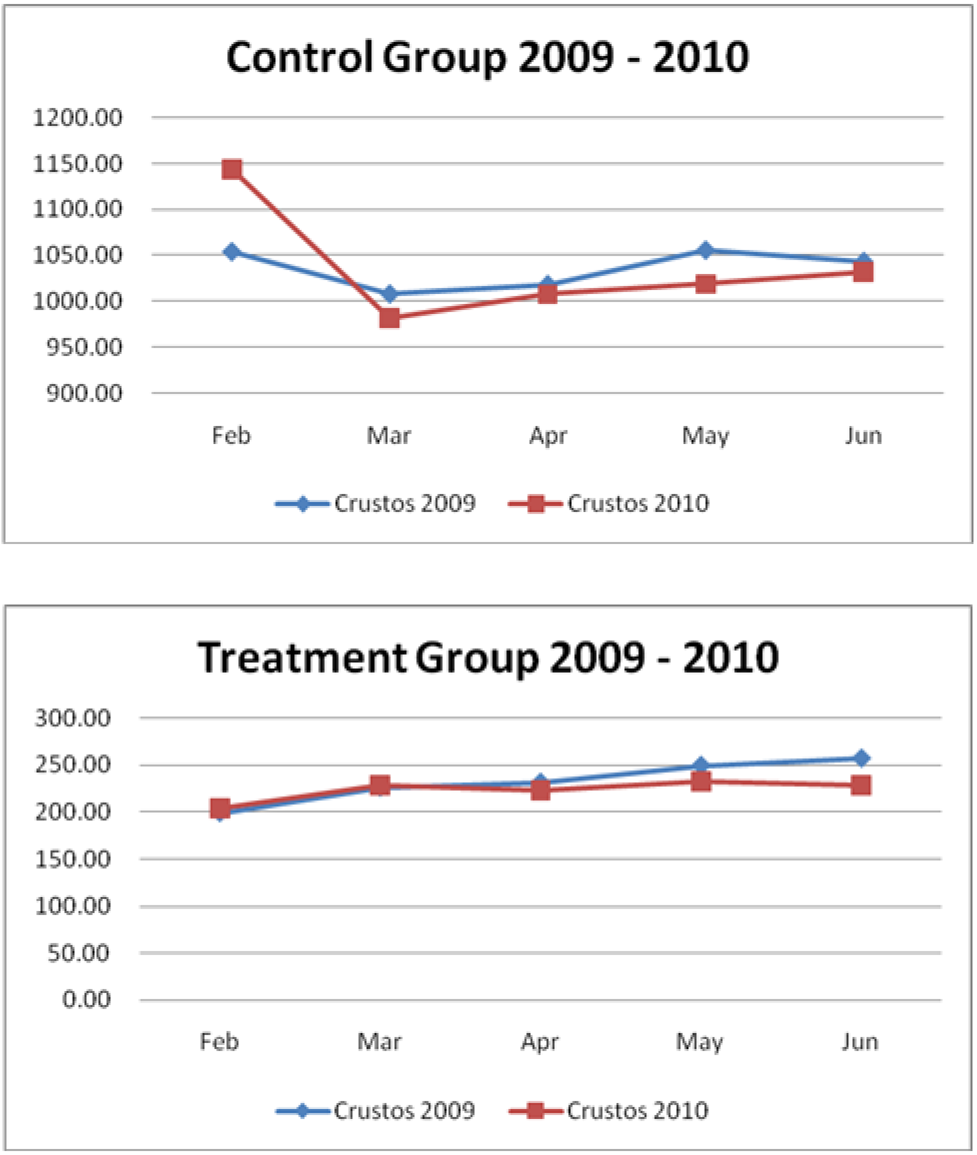


Figure 2. Monthly Comparisons of Average Values for Crustos

Benchmark Model

The standard DID regression for the benchmark model is the following:

(1) $Q_{it} = \beta_0 + \beta_1 TG_i + \beta_2 POST_t + \beta_3 (TG_i \times POST_t) + \varepsilon_{it}$

where Q_{it} is the response variable, representing unit sales of Mexi-Fries for each restaurant i (i = 1,...,13) in each month t (t = 1,…,6; 13,…,18). TG_i is a dummy variable for membership in the treatment group, which equals 1 if restaurant *i* belongs to the treatment group (i = 6,...,13); TG_i is the only variable that controls for the general *geographic variation* of the treatment group against the control group. $POST_t$ is a dummy variable for period *POST* when the menu change policy enacted, which equals one when month t falls between Jan 2010 and Jun 2010 (t = 13,…,18); $POST_t$ is also the only variable to control for the general *temporal variation* of period *POST* against *Pre-period*. The interaction term $TG_i \times POST_t$ represents the pure menu change policy effect excluded from the above two exogenous variations (geographic and temporal variations). Therefore it tests the key hypothesis that Pre-Post changes in average monthly sales measured in counts for Mexi-Fries are different in treatment stores than in control stores due to the added menu choices without menu labeling. $\beta_0, \beta_1, \beta_2, \beta_3$ are corresponding parameters, and negative parameter estimates $\hat{\beta}_3$ for $TG_i \times POST_t$ are capable of verifying the main hypotheses of a negative effect of the menu change strategy on Mexi-Fries consumption. The variables are defined basically the same for Crustos. However, since there were only seven treatment stores for Crustos, TG_i = 1 if i = 6,…,12, due to the elimination of January, $POST_t$ = 0 under t = 2,…,6; $POST_t$ = 1 under t = 14,…,18.

Monthly Model

Recall that we observe a prominent monthly difference on the Pre-Post average sales variations for both Mexi-Fries and Crustos. Although the benchmark model is able to examine the overall impact of the menu change policy, the monthly temporal effect has been concealed. To investigate such policy effects on an individual monthly basis, we propose a monthly model composed of six regressions (five for Crustos), each having the same structure as the benchmark model, but only utilizing the observations of one month in 2009 and the same month in 2010. Specifically, the general form of the monthly regressions is exactly the same as Equation (1), shown as below:

$$(2)\quad Q_{it} = \beta_0 + \beta_1 TG_i + \beta_2 POST_t + \beta_3 (TG_i \times POST_t) + \varepsilon_{it}$$

where the variables and coefficients are defined the same as the benchmark model, but each DID regression is exclusively for the comparison during January when t = (1,13) (only for Mexi-Fries), February when t = (2,14), March when t = (3,15), April when t = (4,16), May when t = (5,17), and June when t = (6,18). We still focus on the parameter estimates $\hat{\beta}_3$ for all six regressions (five for Crustos) to determine the amount of menu change strategy effect on sales of both products for each month. Summary statistics of response variables for both benchmark model and monthly model are presented in Table 1.

Table 1. Summary Statistics of Dependent Variables

Variable		Obs	Mean	Std.Dev.	Min	Max
	Q of Mexi-Fries	156	1065.270	453.921	398	2430
	Q of Crustos	119	560.807	442.776	78	1705
JAN	*Q of Mexi-Fries*	26	1057.730	592.219	398	2430
FEB	*Q of Mexi-Fries*	26	1077.880	570.759	405	2392
	Q of Crustos	23	554.696	527.385	78	1705
MAR	*Q of Mexi-Fries*	26	1041.230	371.742	485	1862
	Q of Crustos	24	547.167	420.263	115	1285
APR	*Q of Mexi-Fries*	26	1040.120	381.958	421	1814
	Q of Crustos	24	554.833	434.197	100	1367
MAY	*Q of Mexi-Fries*	26	1080.000	405.134	452	2000
	Q of Crustos	24	572.917	435.063	104	1414
JUN	*Q of Mexi-Fries*	26	1094.650	387.502	458	1944
	Q of Crustos	24	574.167	429.822	109	1335

Results

Benchmark Model

Here we utilize ordinary least squares (OLS) to estimate the benchmark model regressions for Mexi-Fries and Crustos, and obtain the estimation results in Table 2. The benchmark model fits the data better for Crustos than Mexi-Fries, since the coefficient of determination R^2 is only 46.81% for Mexi-Fries regression but 81.35% for Crustos regression. Both significantly negative parameter estimates for the treatment group dummy variables indicate that treatment stores generally have much lower monthly sales of both Mexi-Fries and Crustos compared to control stores in the *Pre-period*. Both insignificant coefficient estimates for the *POST* period dummies suggest that there are no remarkable Pre-Post temporal effects on the consumptions of both products in general.

The difference-in-differences parameter estimates for the interaction terms in Table 2 test the key hypotheses. Since both estimates are not significantly different from zero, we could not reject the hypotheses that the new menu with added options had no effect on the consumptions of both Mexi-Fries and Crustos. Although not statistically significant, the DID estimates both have a negative sign.

Table 2. Summary Statistics of Dependent Variables

	Mexi-Fries			Crustos		
	Parameter	*Std*	*P-value*	*Parameter*	*Std*	*P-value*
Constant	1469.93***	61.04	<.0001	1035.08***	39.54	<.0001
TG	-626.18***	77.81	<.0001	-802.40***	51.33	<.0001
POST	-27.80	86.32	0.7478	2.00	55.35	0.9713
$TG \times POST$	-17.62	110.03	0.8730	-11.17	72.16	0.8773
R^2		46.81%			81.35%	

***, **, * denotes significance at .01, .05, .1 level, respectively.

Monthly Model

We apply OLS to estimate the monthly model and obtain the corresponding estimation results for each month in Table 3 for Mexi-Fries and in Table 4 for Crustos. Similar to the benchmark model, the monthly model fits the Crustos sales better than the Mexi-Fries sales. The R^2 statistics is about 50% for Mexi-Fries regressions on average and about 80% for Crustos regressions in general. All significantly negative coefficient estimates for the treatment group dummies illustrate constantly lower consumptions of both products in treatment stores than in control stores among each month before the menu change policy. All insignificant parameter estimates for the *POST* dummy variables imply that the general Pre-Post temporal impact on Mexi-Fries and Crustos sales are not prominent.

Table 3. Estimation Results for Mexi-Fries (Monthly Model)

Mexi-Fries	Jan			Feb		
	Parameter	*Std*	*P-value*	*Parameter*	*Std*	*P-value*
Constant	1640.20 ***	193.82	<.0001	1584.80 ***	191.74	<.0001
TG	-872.58 ***	247.08	0.0019	-811.30 ***	244.42	0.0031
POST	-103.00	274.11	0.7107	-9.40	271.16	0.9727
$TG \times POST$	19.50	349.42	0.9560	-9.60	345.66	0.9781
R^2	52.87%			50.35%		
	Mar			**Apr**		
	Parameter	*Std*	*P-value*	*Parameter*	*Std*	*P-value*
Constant	1346.60 ***	131.66	<.0001	1362.40 ***	132.83	<.0001
TG	-504.85 ***	167.83	0.0065	-506.65 ***	169.32	0.0067
POST	6.40	186.19	0.9729	2.60	187.84	0.9891
$TG \times POST$	6.85	237.35	0.9772	-38.35	239.45	0.8742
R^2	44.81%			46.79%		
	May			**Jun**		
	Parameter	*Std*	*P-value*	*Parameter*	*Std*	*P-value*
Constant	1450.00 ***	137.34	<.0001	1435.60 ***	134.19	<.0001
TG	-553.50 ***	175.07	0.0045	-508.23 ***	171.06	0.0071
POST	-37.60	194.22	0.8483	-25.80	189.77	0.8931
$TG \times POST$	-34.40	247.59	0.8908	-49.70	241.91	0.8391
R^2	49.44%			47.24%		

All of the DID coefficient estimates for interaction terms are not significantly different from zero. Therefore, the hypotheses of no effect of the menu change policy on both product consumptions are not rejected from each month (January to June for Mexi-Fries and February to June for Crustos). Although not statistically different from zero, most DID estimates are negative valued for Mexi-Fries (except for January and March). As for Crustos, the DID estimates are negative only among February and June, compared to positive among the months March, April and May. This may imply that the menu change policy effect on reducing Crustos sales is compromised during Spring (March, April. and May).

Table 4. Estimation Results for Crustos (Monthly Model)

Crustos	Feb			Mar		
	Parameter	*Std*	*P-value*	*Parameter*	*Std*	*P-value*
Constant	1053.75***	146.70	<.0001	1008.40***	78.89	<.0001
TG	-854.75***	183.90	0.0002	-782.26***	103.29	<.0001
$POST$	90.85	196.82	0.6496	-26.80	111.57	0.8126
$TG \times POST$	-85.99	251.66	0.7363	29.09	146.08	0.8442
R^2	73.27%			84.68%		
	Apr			**May**		
	Parameter	*Std*	*P-value*	*Parameter*	*Std*	*P-value*
Constant	1018.40***	85.67	<.0001	1055.40***	80.96	<.0001
TG	-786.97***	112.17	<.0001	-805.83***	106.00	<.0001
$POST$	-10.40	121.15	0.9324	-36.60	114.49	0.7525
$TG \times POST$	2.40	158.63	0.9881	20.17	149.91	0.8943
R^2	83.07%			84.94%		
	Jun					
	Parameter	*Std*	*P-value*			
Constant	1043.20***	74.90	<.0001			
TG	-785.91***	98.07	<.0001			
$POST$	-10.80	105.93	0.9198			
$TG \times POST$	-17.77	138.70	0.8993			
R^2	86.80%					

***, **, * denotes significance at .01, .05, .1 level, respectively.

Conclusions

This study examined the effect of a menu change strategy which alters default energy-dense menu items to choices including healthier products on kids' menu purchase behaviors. Two difference-in-differences models (benchmark model and monthly model) are used to compare monthly unit sales between eight treatment QSR stores and five control QSR stores focusing on

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one time period immediately following the menu change policy until the appearance of promotional phrases (Jan 2010 to Jun 2010).
The estimation results of two DID models do not provide strong evidence that adding healthier options into a menu with calorie-dense default items could significantly promote consumers to make healthier diet choices. Further related studies should be taken to identify the conditions under which menu change policy is most likely to be effective and efficient. The results in this study provide directions for future research. In the monthly model estimation, the spring season offsets the decreasing effect of the menu change strategy on Crustos consumptions. Future studies could be undertaken to investigate the seasonal patterns of the impact of such option-adding new menus. Also, further explorations can be taken to examine the effect of menu change combined with menu labeling on consumptions of both food items.

The lack of statistical significance of the menu change on consumption of the calorie dense menu items suggests that more proactive interdiction is needed to make an impact on childhood obesity. Government policies such as those that require additional, possibly highlighted, information and/or education are likely to have a greater effect. There might be gains in health from mandating a standardized format, such as the British traffic light system (TLS). Calorie-dense items could have a red traffic light next to them. Since the QSRs' objective is to maximize profits, their incentives are to highlight only the healthy items (green light items). Consequently identifying red lights would need to be mandated by government policy and may result in QSRs changing their menus to offer fewer of these items.

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A Pilot Study of the Market for Energy Drinks

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Abstract

The energy drink market is one of the fastest growing markets in the non-alcoholic beverage industry. Yet, relatively little is known about this set of "new age" beverages. To fill this research void, we provide a historical perspective on this market and gather information from a local retailer located close to the campus of Texas A&M University to estimate the demand interrelationships for major energy drink brands (Full Throttle, Monster, Red Bull, and Rockstar). We employ the Barten synthetic demand system in this regard and obtain estimates of own-price, cross-price, and expenditure elasticities for the respective brands.

Keywords: energy drinks, Barten synthetic demand system, pilot study

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Background

The energy drink market is one of the fastest growing markets in the non-alcoholic beverage industry. Sales of energy drinks in the United States were expected to grow to $10 billion by the close of 2011 (The Beverage Network 2011). Designed to combat physical and mental fatigue, energy drinks contain a variety of vitamins, herbal supplements, and stimulants. Main ingredients include caffeine, taurine, sucrose, glucose, and B-group vitamins. Japan is viewed as the pioneer of the energy drink phenomenon, starting in 1962 where Taisho Pharmaceuticals manufactured a beverage called Lipovitan-D (Penalty 2006). In 1987, an Austrian, Dietrich Mateschitz, formulated Red Bull which surged in popularity in Europe. In 1997, Red Bull was introduced to the U.S. market, paving the way for other brands of energy drinks. As exhibited by Figure 1, four brands: Red Bull, Monster, Rockstar, and Full Throttle currently comprise roughly 75 percent of the market for energy drinks in the United States.

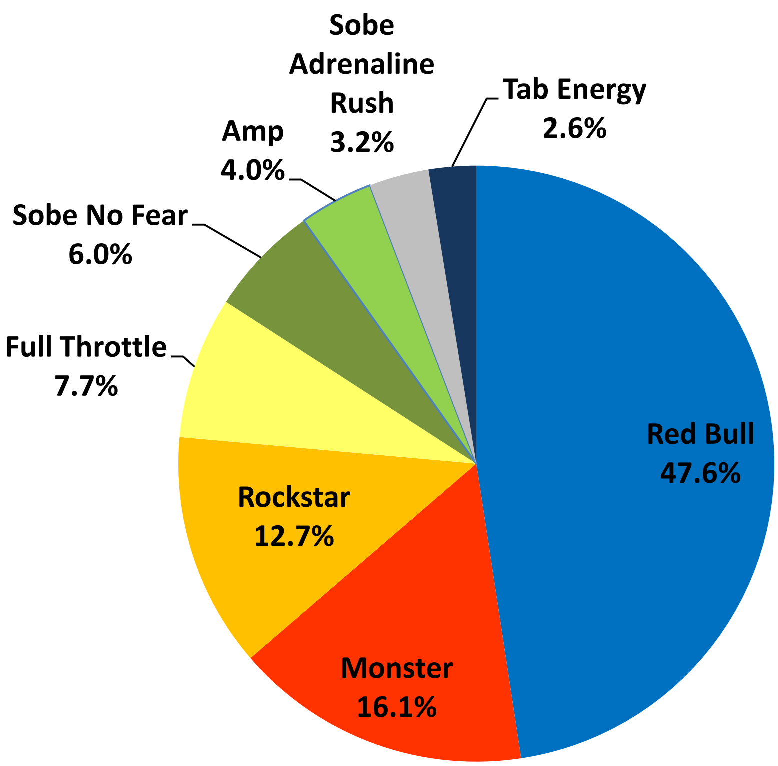

Figure 1. Share of the Energy Drink Market in the United States, 2010 (based on dollar sales)
Source: BevNET.com – The Beverage Network, 2010

Energy drinks are the "new soft drinks of the world" according to Chairman and Chief Executive Officer of Hansen, Rodney C. Sacks, the manufacturer of Monster (Palmeri 2005). Yet relatively little is known about this set of "new age" beverages. The motivation of this research is to shed light on the energy drink market and to examine the demand relationships of the major energy drink brands.

The objectives are threefold: (1) to provide a historical perspective on the nature of the market for energy drinks; (2) to gather information from a local retailer (H-E-B) in the Bryan-College Station area in order to investigate factors associated with the demands for the Red Bull, Monster, Rockstar, and Full Throttle brands; and (3) to provide strategic information to the local retailer principally via own-price elasticities and cross-price elasticities of the major energy drink brands. In essence, this work is a pilot study concerning the nature of demand interrelationships in the domestic energy drink market.

According to the Beverage Network (2011), the primary consumers of energy drinks are those under 35 years of age. In particular, college students are major consumers of energy drinks. Malinauskas et al. (2007) found that slightly more than 50 percent of college students consumed more than one energy drink per month. Given that the Bryan-College Station community encompasses Texas A&M University, this pilot study allows us to focus on purchases of energy drinks largely, although not exclusively, by college students.

Historical Perspective on the Energy Drink Market

To fulfill the first objective, we provide a historical perspective on the market for energy drinks. To that end, we describe the current manufacturers of energy drinks in the U.S. market, and we provide background information on each of the respective major brands (e.g. the date in which the product was introduced, characteristics of the product, distribution of the product, and market share). Also, we discuss various aspects of advertising/promotion for energy drinks.

Energy drinks provide attractive margins to distributors and to retailers. Additionally, these beverages do not require much shelf space. Energy drinks are distributed in convenience and gas stores, supermarkets, and other outlets. A near-majority of sales takes place in convenience and gas stores; immediate gratification destinations. Over the period 2004 to 2009, roughly 46 percent to 53 percent of the volume sold of energy drinks took place in convenience and gas stores, about 10 percent of the volume sold took place in supermarkets, and approximately 13 percent of the volume sold took place in food service outlets (The Beverage Network, 2011). The marketing of energy drinks typically rests on the use of nontraditional outlets, for example, extreme sports, NASCAR, and celebrity endorsements. Not much is done through the use of television, radio, and print advertising (The Beverage Network 2011).

Roughly two-thirds of the consumers of energy drinks are male. The majority of consumers are under 35—primarily ages 12 to 30, and heavy consumers are 20 to 30 years of age. In Figure 2, we present the various reasons to consume energy drinks according to college students: (1) insufficient sleep; (2) need energy; (3) mix with alcohol; (4) studying; (5) driving long distances; and (6) treat a hangover (Malnauskas et al. 2007).

The energy drink market is characterized in economic parlance as monopolistically competitive, where the chief characteristics are a large number of sellers, ease of entry and exit from the industry, and product differentiation. We provide information on the market share for the leading brands of energy drinks: Red Bull, Monster, Rockstar, and Full Throttle. As well, we place emphasis on product differentiation in light of the monopolistic competitive market.

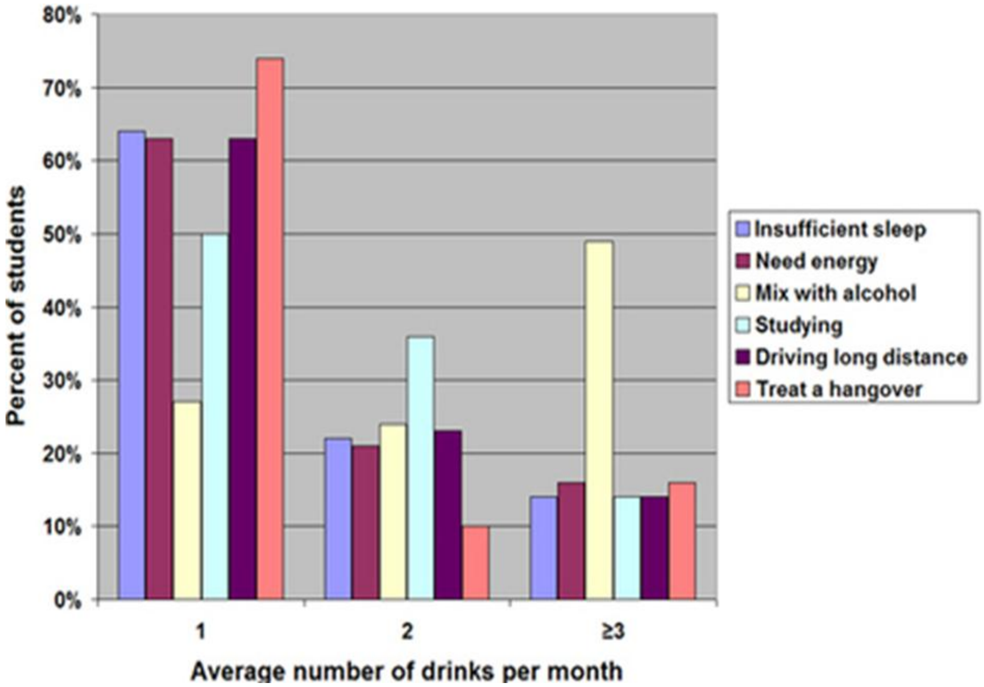

Figure 2. Percentage of College Students Reporting the Frequency of Energy Drink Consumption by Situation within a Month.
Source: Malinauskas et al. (2007)

Red Bull

Red Bull is the best known and most widely consumed energy drink in the world. Red Bull was adapted from a Thai beverage called "Krating Daeng," a popular drink with rickshaw drivers in Thailand. Established in 1984, the co-founders of this brand were Dietrich Mateschitz, an Austrian entrepreneur, and Chaleo Yoovidhya, owner of Krating Daeng. Red Bull is currently manufactured by Red Bull GmbH, an Austrian company. Its main ingredients include taurine (an amino acid) and glucuronolactone (a carbohydrate). Proclamations made by the manufacturers of Red Bull include increased performance, increased concentration, increased reaction speed, improved vigilance, improved emotional status, and stimulated metabolism (Penalty 2006). Its slogan is "Red Bull gives you wings." As with the majority of energy drinks, Red Bull is mainly advertised through sporting event sponsorships and celebrity endorsements. Currently, Red Bull occupies a market share of between 40 percent and 45 percent among energy drinks (The Beverage Market 2011).

Monster is manufactured by the Hansen Natural Corporation in Corona, California. Introduced initially in 2002, this brand was one of the first energy drinks marketed in a 16-ounce can, nearly twice the size of the typical "bullet" size. The slogan for Monster energy drinks is "unleash the beast." The drink typically comes in a black can with a green "M" logo. Monster pull tabs are unique from standard pull tabs in that they are punched with an "M" instead of a large hole (Penalty 2006). Monster contains ingredients of l-carnitine, taurine, ginseng, and B vitamins. The manufacturer's advertising methods include the sponsorship of extreme sporting events such as Supercross, Nascar, snowboarding, and drag racing. At present, the market share for Monster is around 15 percent (The Beverage Market 2011).

Rockstar was created in 2001 by Russell Weiner, son of the renowned herbalist, Michael Weiner. The slogan for this brand is "party like a rockstar." The official website is black and red and bursting with photographs of celebrities drinking or holding the beverage. Manufactured by Rockstar, Inc. based in Las Vegas, Nevada, Rockstar was the first energy drink to be available in 16 and 24 ounce cans. Weiner sought to differentiate Rockstar from the industry leader Red Bull, claiming that the drink was "twice the size of Red Bull for the same price." Rockstar also differentiates its product by featuring ingredients that are "scientifically" formulated to speed the recovery time of those who lead active and exhausting lifestyles (Penalty 2006). Rockstar is also available in many different flavors. At present, the market share for Rockstar is between 10 percent and 12 percent among energy drinks (The Beverage Network 2011).

Full Throttle is made with 100 percent premium Arabic coffee. Its slogan is "no choke mixture…full flavor you don't have to force down…No mystery ingredients. No bull." (Penalty 2006). Full Throttle is available in several different flavors. Currently, the market share for Full Throttle is between 5 percent and 10 percent (The Beverage Network 2011).

Data from a Local Retailer Concerning Major Energy Drink Brands

To satisfy the second objective, we solicited data related to weekly sales, volume, and price information as well as weekly customer counts for Red Bull, Monster, Rockstar, and Full Throttle energy drinks from a local H-E-B supermarket in close proximity to the campus of

Texas A&M University. This information spanned a period of 153 weeks, beginning with the week of October 29, 2007 to November 4, 2007 and ending with the week of September 27, 2010 to October 3, 2010. With this information we provide descriptive information concerning weekly brand sales in dollars, weekly volume in ounces, and weekly prices in dollars/ounce. Additionally, for this supermarket, we provide weekly market share information over the 153-week period.

As depicted in Figure 3, weekly customer counts ranged from 24,000 to 36,000 over the three-year period. The median weekly customer count was roughly 29,700 patrons. In Figure 4 (see Appendix 1), we exhibit the dollar sales associated with the four major brands over the period October 29, 2007 to October 3, 2010. For this local retailer, weekly nominal dollar sales for Monster and Red Bull exhibited an upward trend, while dollar sales of Full Throttle exhibited a downward trend. Weekly dollar sales for Rockstar declined initially then rose, before leveling off at the end of the three-year period. Weekly median nominal dollar sales were $112.72 for Full Throttle, $286.22 for Rockstar, $610.64 for Monster, and $1,007.28 for Red Bull.

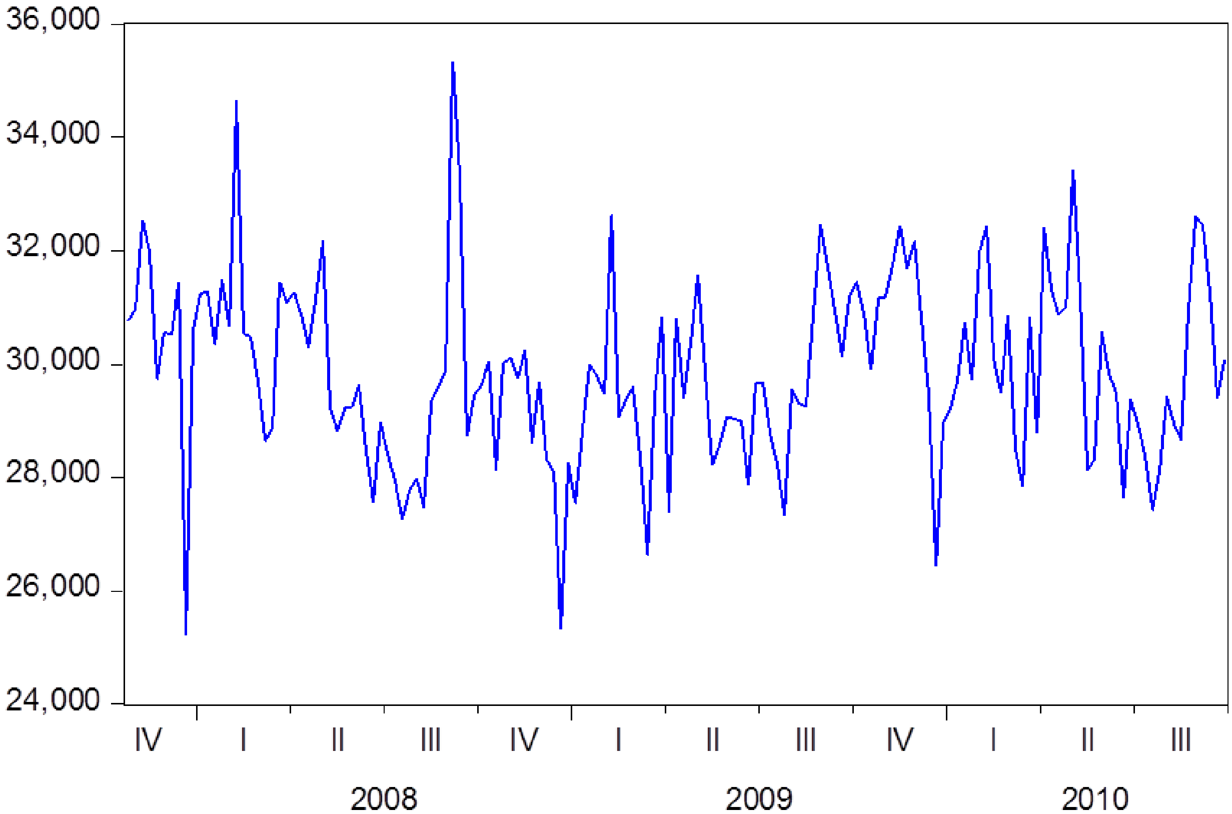

Figure 3. Weekly Customer Count of the Local H-E-B Supermarket in the Bryan-College Station Area*
*Period: Week beginning 10/29/2007 to 11/4/2007 through week ending 9/27/2010 to 10/3/2010.
Source: H-E-B.

As presented in Figure 5 (see Appendix 2), ounces sold for energy drinks from October 29, 2007 to October 3, 2010 exemplified the same types of patterns as for dollar sales. Median ounces sold were 944 for Full Throttle, 2,615 for Rockstar, 4,918 for Red Bull, and 5,569 for Monster. Market shares for the four energy drink brands are given in Figure 6. On average, the market share was about 49 percent for Red Bull, 31 percent for Monster, 14 percent for Rockstar, and six percent for Full Throttle. The market share information for this local retailer is consistent with the national situation for energy drinks. Clearly the industry leaders are Red Bull and Monster.

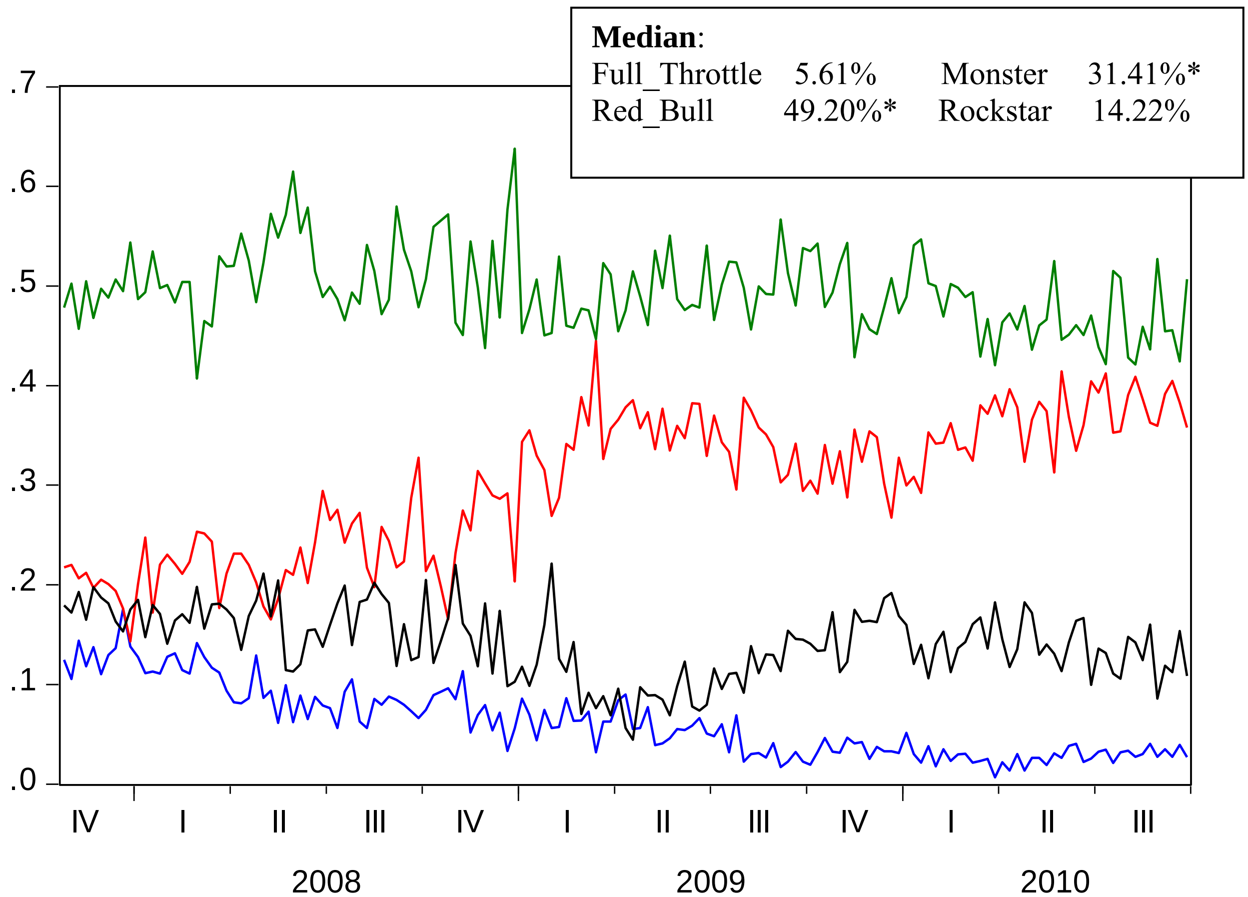

Figure 6. Market Shares for the Local H-E-B Supermarket in the Bryan/College Station Area*
*Period: Week Beginning 10/29/2007 to 11/4/2007 through Week Ending 9/27/2010 to 10/3/2010.
Source: H-E-B.

Understanding Interdependencies of Demand among Major Energy Drink Brands

To accomplish the third objective, we use a formal demand systems approach to estimate own-price and cross-price elasticities for the four brands. With the estimated own-price elasticities, we are in position to determine the degree of price sensitivity for local customers of Red Bull, Monster, Rockstar, and Full Throttle. With the estimated cross-price elasticities, we are in position to identify major substitutes among brands.

One of the compelling features of demand system models is that they maintain flexibility while simultaneously satisfying the adding-up, homogeneity, and symmetry restrictions in accordance with demand theory. However, there is little to guide researchers when attempting to choose a particular functional form among various alternatives. In this light, Barten (1993) developed a synthetic system which nests four popular differential demand systems including the Rotterdam, LA/AIDS, CBS (Central Bureau of Statistics), and NBR (National Bureau Research). Maynard and Veeramani (2003) also demonstrate that synthetic models help avoid specification bias through the use of generalized functional forms.

The Barten model is specified as follows:

$$(1)\quad w_i d\ln q_i = (b_i + \delta w_i) d\ln Q + \sum_j \left[c_{ij} - \gamma w_i(\delta_{ij} - w_j)\right]\ d\ln p_j + e_i$$

where $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$. $d\ln Q$ represents a Divisia Volume Index; w_i and q_i denote expenditure share and sales quantity of i^{th} energy drink brand, respectively and p_j denotes the price of j^{th} energy drink brand. $b_i, c_{ij}, \delta,$ and γ are the parameters to be estimated in the demand system. When $\delta = \gamma = 0$, this specification statistically is equivalent to the Rotterdam model. When $\delta = \gamma = 1$, the specification is tantamount to LA/AIDS; when $\delta = 1$ and $\gamma = 0$, the Barten model is equivalent to the CBS model and when $\delta = 0$ and $\gamma = 1$, the Barten model and the NBR model are indistinguishable. Theoretical demand restrictions are homogeneity, symmetry and adding-up, which are given by

(2a) $\sum_j c_{ij} = 0$ for all i (homogenity),

(2b) $c_{ij} = c_{ji}$ for all i and j (symmetry),

(2c) $\sum_i c_{ij} = 0$ for all j (adding-up), and

(2d) $\sum_i b_i = 1 - \delta$ (adding-up).

In our demand system *i* and *j* run from 1 to 4; e_i represents the disturbance term for the *i*th brand. To account for potential seasonality, we add dummy variables pertaining to 13-week periods to the demand system specification. To avoid the dummy variable trap, the reference quarter is the fourth quarter of the year. We also account for variations in weekly customer count by appending this variable to each equation of the demand system. Dynamics are formally incorporated in the use of this demand system because the respective quantity, price, and total expenditure terms are expressed in terms of logarithmic changes.

Weekly nominal median prices of the energy drink brands over the three-year period were \$0.1152/ounce for Full Throttle, \$0.1107/ounce for Monster, \$0.2023/ounce for Red Bull, and \$0.1121/ounce for Rockstar. The median prices of Full Throttle, Monster, and Rockstar were very similar. The median price of Red Bull was nearly double the median prices of the remaining major brands for this local retailer. The range of the nominal prices was \$0.0999/ounce to \$0.1431/ounce for Full Throttle, \$0.1013/ounce to \$0.1231/ounce for Monster, \$0.1900/ounce to \$0.2283/ounce for Red Bull, and \$0.0928 to \$0.1328/ounce for Rockstar. Pairwise correlations among the respective prices were not high by any means, ranging from -0.1937 to 0.3324.

In estimating the Barten synthetic demand system, one equation was dropped to avoid estimation problems due to the singularity of the variance-covariance matrix of disturbance terms. The equation pertaining to the Rockstar brand was chosen arbitrarily to be omitted from the system. The parameter estimates associated with this omitted equation are recovered through the use of the aforementioned theoretical restrictions given by equations (2a) to (2d).

An Iterated Seemingly Unrelated Regression (ITSUR) technique is applied, taking into account the contemporaneous correlation of the disturbance terms among the equations. As well, we allow for the presence of first-order serial correlation [AR(1)] in the disturbance terms in each of the equations. The "mechanical" correction accounts for other systematic factors (e.g. advertising and promotion, the prices of other non-alcoholic beverages, etc.) that do not explicitly appear in the demand system due primarily to the lack of available data. These other systematic factors may affect the dependent variables in the system. Because of adding-up, a common AR(1) coefficient was estimated for the system of equations.

The estimated coefficients, standard errors, p-values, and goodness-of-fit statistics associated with the Barten synthetic demand system are presented in Tables 1a and 1b. The estimated coefficients with the c_{ij}'s are all statistically different from zero except for c_{14}. The estimated coefficients associated with the b_i's are not statistically different from zero. Neither the coefficients pertaining to seasonality nor customer counts were statistically different from zero. The goodness-of-fit statistics indicate that the individual equations of the demand system explain a notable amount of variability in each of the dependent variables. The range of the goodness-of-fit statistics was from 0.427 to 0.812. Importantly, based on the estimates of δ and γ, the Barten model was statistically superior to the Rotterdam model, the LA/AIDS model, and the NBR model. The empirical analysis, however, was consistent with the CBS model.

Table 1A. Parameter Estimates, Standard Errors, p-values, and Goodness-of-Fit Statistics for the Synthetic Barten Model

Equation	**Durbin-Watson**	**R-Squared**	
Full Throttle	2.2662	0.4270	
Monster	2.0513	0.7244	
Red Bull	2.1806	0.8124	
Rockstar (omitted equation)	--	--	
	Coefficient	**Standard Error**	**p-value**
b_1	-0.0016	0.0120	0.8922
c_{11}	-0.0646	0.0213	0.0026
c_{12}	0.0224	0.0280	0.3848
c_{13}	0.0426	0.0323	0.1884
b_2	0.0331	0.0471	0.4831
c_{22}	-0.4295	0.0656	0.0000
c_{23}	0.3005	0.0669	0.0000
b_3	0.0594	0.0740	0.4226
c_{33}	-0.4599	0.0950	0.0000
delta	0.9134	0.1446	0.0000
gamma	0.1283	0.1328	0.3344
rho	-0.4414	0.0431	0.0000
We recover the coefficients associated with the Rockstar brand (c_{14}, c_{24}, c_{44}, and b_4) as theoretical::	**Coefficient**	**Standard Error**	**p-value**
$c_{14} = -c_{11}-c_{12}-c_{13}$	-0.0004	0.0189	0.9812
$c_{24} = -c_{12}-c_{22}-c_{23}$	0.1066	0.0355	0.0027
$c_{34} = -c_{13}-c_{23}-c_{33}$	0.1168	0.0471	0.0131
$c_{44} = -c_{14}-c_{24}-c_{34}$	-0.2229	0.0376	0.0000
$b_4 = 1-b_1-b_2-b_3$-delta	-0.0043	0.0249	0.8628

Notes:

1. EVIEWS 7.1 was used to estimate the synthetic Barten model.
2. Rho refers to the common autocorrelation coefficient in the disturbance terms [AR(1)].
3. The estimated coefficient b_i's and c_{ij}'s correspond to equation (1). Subscript 1 represents Full Throttle, 2 represents Monster, 3 represents Red Bull, and 4 represents Rockstar.

	$\chi2$	p-value
4. Test of H_0: delta = 0 and gamma = 0 (Rotterdam Model)	40.95	0.0000
Test of H_0: delta = 1 and gamma = 1 (LA/AIDS model)	43.51	0.0000
Test of H_0: delta = 1 and gamma = 0 (CBS model)	1.28	0.5263
Test of H_0: delta = 0 and gamma = 1 (NBR model)	82.36	0.0000

Table 1B. Parameter Estimates Associated with the Quarterly Dummy Variables (Q_1, Q_2, and Q_3) and with the Customer Count Variable for the Synthetic Barten Model

Brand	Coefficient	Standard Error	p-value
Full Throttle			
Q1	-0.0015	0.0028	0.5842
Q2	-0.0002	0.0027	0.9285
Q3	-0.0009	0.0028	0.7315
Customer Count	8.72E-08	6.67E-08	0.1921
Monster			
Q1	0.0091	0.0058	0.1203
Q2	0.0027	0.0057	0.6302
Q3	0.0016	0.0057	0.7844
Customer Count	-1.18E-07	1.38E-07	0.3923
Red Bull			
Q1	-0.0075	0.0071	0.2876
Q2	-0.0018	0.0069	0.7938
Q3	-0.0021	0.0069	0.7642
Customer Count	-4.11E-08	1.67E-07	0.8060
		$\chi 2$	p-value
H_0: no seasonality in the Full Throttle equation		0.37	0.9458
H_0: no seasonality in the Monster equation		2.90	0.4071
H_0: no seasonality in the Red Bull equation		1.30	0.7289

The uncompensated and compensated elasticity matrices are exhibited in Table 2. The price elasticities refer to the percentage change in volume sold due to unit percentage changes in prices. The expression for the uncompensated elasticity of brand *i* with respect to the price of brand *j* is ($\in_{ij}$) given in equation (3).

(3)
$$\in_{ij} = \frac{[c_{ij} - \gamma w_i(\delta_{ij} - w_j)]}{w_i} - w_j n_i,$$

where w_i denotes the market share of brand i, w_j denotes the market share for brand j, $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ if $i \neq j$, and n_i corresponds to the total expenditure elasticity of brand i. The expression for n_i is given in equation (4).

(4) $n_i = \frac{b_i + \delta w_i}{w_i}$

The expression for the compensated elasticity of brand i with respect to the price of brand j ($\in_{ij}^*$) is given in equation (5).

$$(5)\ \epsilon_{ij}^{*} = \epsilon_{ij} + w_j n_i$$

Equation (5) rests on the use of Slutsky's equation which relates compensated and uncompensated price elasticities. The notions of substitutability and complementarity among the brands in our system are based on the compensated (Hicksian) cross-price elasticities. Substitutes in the Hicksian sense are evident for positive compensated cross-price elasticities, while complements in the Hicksian sense are evident for negative compensated cross-price elasticities.

The respective own-price, cross-price, and expenditure elasticities are functions of estimated parameters and market shares. We calculated the elasticities using the sample means of the expenditure shares. The magnitudes of the own-price elasticities were indicative of elastic demands for all energy drinks. This result is consistent with economic theory given the level of disaggregation of this market by major brands. Monster and Rockstar were the most responsive to price changes. On this basis, to raise revenue, at least in the short run, this retailer should lower prices of the major brands of energy drinks. On the basis of the compensated cross-price elasticities of demand, energy drink brands were substitutes for each other.

Table 2. Elasticity Matrices for the Respective Energy Drink Brands

Uncompensated Elasticities

	Full Throttle	Monster	Red Bull	Rockstar	Expenditure	Market Share
Full Throttle	-1.2122	0.1315	0.3079	-0.1145	0.8873	0.0623
Monster	0.0187	-1.8240	0.5548	0.2272	1.0233	0.3012
Red Bull	0.0297	0.3345	-1.5054	0.1078	1.0334	0.4950
Rockstar	-0.0502	0.5259	0.4518	-1.8106	0.8830	0.1415

Compensated Elasticities

	Full Throttle	Monster	Red Bull	Rockstar
Full Throttle	-1.1569	0.3988	0.7471	0.0110
Monster	0.0825	-1.5158	1.0613	0.3719
Red Bull	0.0941	0.6458	-0.9939	0.2540
Rockstar	0.0049	0.7919	0.8889	-1.6857

Red Bull was the major substitute for the respective brands. Monster was the leading substitute for Red Bull followed by Rockstar. Monster was the next best substitute for Full Throttle, Rockstar was the next best substitute for Monster, and Monster was the next best substitute for Rockstar. Among the major energy drinks considered, Full Throttle was the least substitutable brand. This set of results is consistent with the market shares among the brands.

Conclusions

This analysis allows a better understanding in regard to purchase behavior of major energy drink brands. This analysis may be replicated for other H-E-B stores, for other retailers, or for various convenience store and gas station outlets. This analysis will allow manufacturers of the major energy drink brands as well as retailers to improve strategic decision-making. Specifically, with our quantitative analysis, forecasts of item movement can be made to assist in inventory management, and pricing strategies can be developed to maximize sales revenue.

A number of limitations exist in the present analysis. The data pertain to only one store, H-E-B, and do not reflect competitor actions. Additionally, due to the lack of available data, the model does not take into account in-store promotion or local advertising effects. Moreover, other potential substitutes from the set of non-alcoholic beverages, particularly those rich in caffeine, are not considered (e.g., coffee, tea, and carbonated soft drinks). This work certainly may be replicated in other areas throughout the United States. To be sure, future work should accommodate a longer list of potential substitutes/complements from the non-alcoholic beverage category as well as the impacts of advertising and promotion. Nevertheless, our pilot study approach fills a research void on the examination of the energy drink market. Future research should provide dividends to analyses of this growing “new age” beverage category.

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Appendix 1.

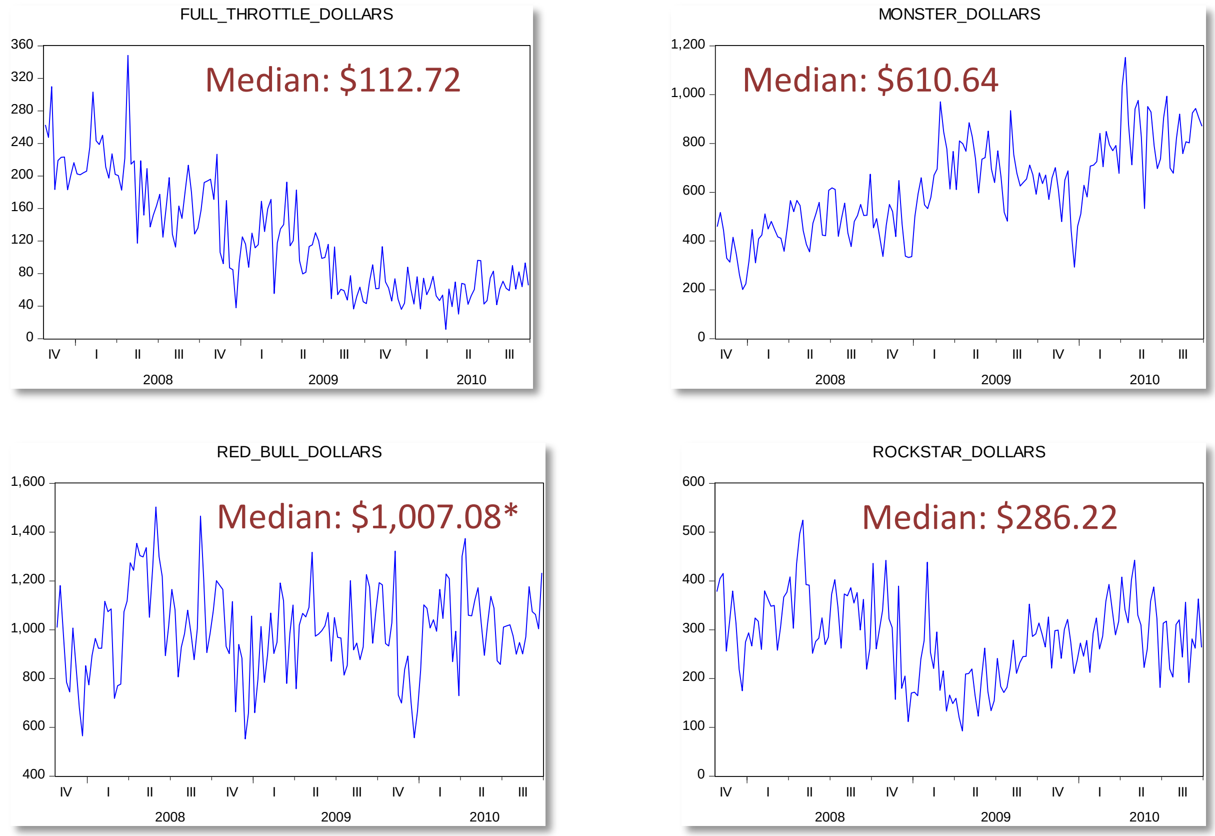

Figure 4. Nominal Dollar Sales Associated with Energy Drinks Sold at the Local H-E-B Supermarket in the Bryan/College Station Area*

*Period: Week Beginning10/29/2007 to 11/4/2007 Through Week Ending 9/27/2010 to 10/3/2010.
Source: H-E-B.

Appendix 2.

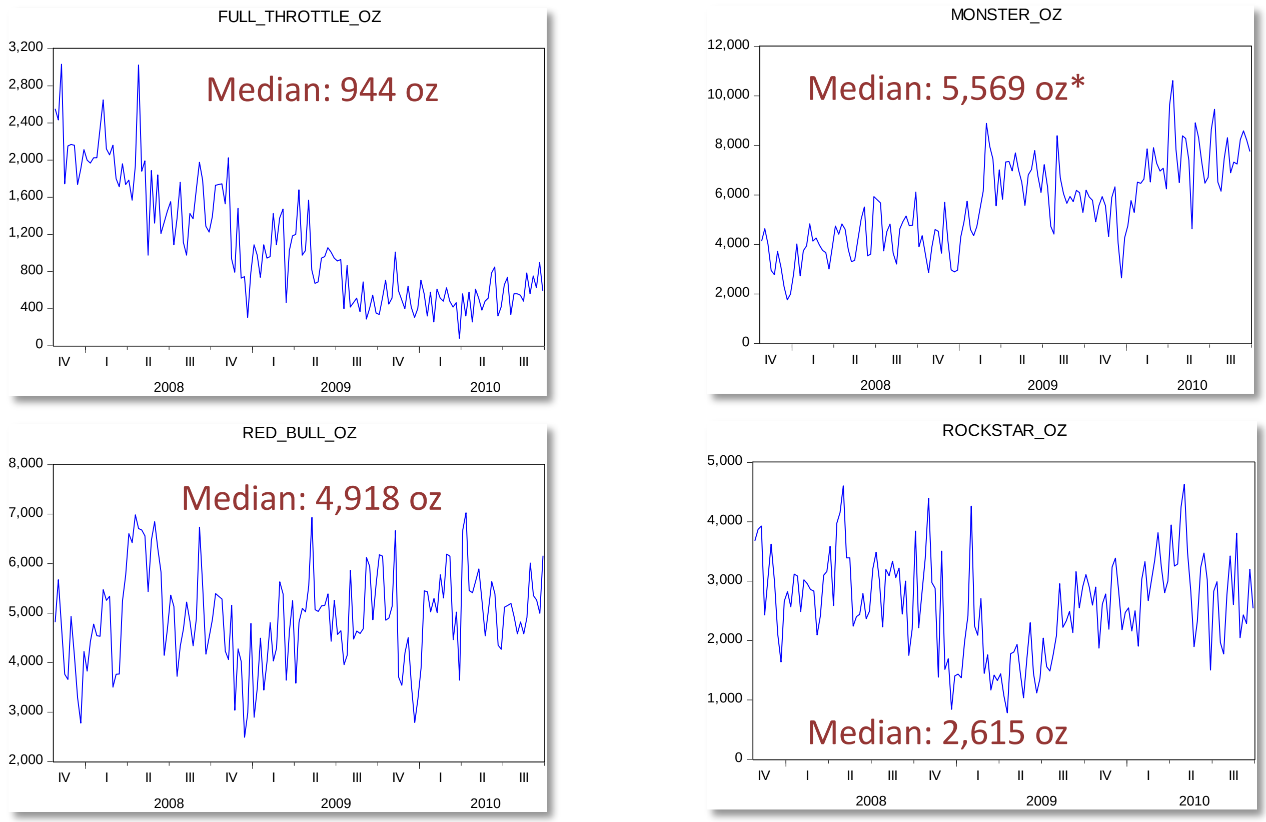

Figure 5. Ounces of Energy Drinks Sold at the Local H-E-B Supermarket in the Bryan/College Station Area*

*Period: week beginning 10/29/2007 to 11/4/2007 through week ending 9/27/2010 to 10/3/2010.

Source: H-E-B.

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Economic Impacts of Increasing the Minimum Size for Idaho Fresh Potatoes

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Abstract

The Idaho Potato Commission funded a project to help answer the question: What would be the economic impact if the potato industry increased the minimum size for fresh potatoes? We estimate that increasing the minimum size from 4 to 5 ounces would divert about 5 million hundredweight (cwt) to dehydrators. Idaho fresh potato revenue would increase $73 million. Idaho dehydrated potato revenue would increase $18 million. The total impact would be increased revenue of $91 million. A sensitivity analysis showed that revenue increases are larger when more potatoes are diverted.

Keywords: fresh potatoes, dehydrated potatoes, size standards

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Introduction

Market Situation

The Idaho fresh and dehydrated potato industries are closely linked. Growers deliver bulk potatoes to fresh packers who sort them into two main categories. Packers put the 4-8 ounce potatoes into five- and ten-pound bags known as 'consumer packs' for sale in retail markets. Larger potatoes are put into 50-pound cardboard boxes known as 'count cartons' and are sold in both retail and foodservice markets. Potatoes that are less than four ounces and those that do not meet fresh-market standards because they are cut, bruised, blemished or misshapen are sold to dehydrators.

A typical pack-out rate for Idaho's most popular potato variety–the Russet Burbank, is 60% fresh and 40% dehydration. Dehydrators rely on this fresh packer by-product, known as Washed Processed Grade (WPG), as a major source of raw product. The processors convert the potatoes to flakes and granules for three market channels. In addition to foodservice and retail markets, dehydrated potatoes go to other food processors, including snack food firms that make extruded chips such as Pringles®.

The fresh potato industry uses two price indexes to communicate price information. At the packer level, the Fresh Weighted Average (FWA) accounts for typical fresh pack-out rates and current prices for different sizes and containers. The North American Potato Market News (Huffaker 2011) reports weekly FWA prices based on (1) consumer packs in 10-pound bags, (2) 50-pound cartons of 40, 50, 60, 70, 80, 90, and 100 counts and (3) US #2 potatoes. Each package has a respective weight in the formula. At the grower level, the Grower Return Index (GRI) accounts for the FWA pack-out plus WPG prices and a packing charge. Changing the minimum size standard would impact pack-out rates and prices. The Agricultural Marketing Agreement Act of 1937 allows the Idaho potato industry to set quality standards and they do it through Federal Marketing Order 945. Changing the standard would require approval by two-thirds of the Idaho growers and the US Secretary of Agriculture. Growers in Colorado and other regions sometimes change their minimum size requirements based on current crop conditions, weather challenges, and market strategies while Idaho has maintained consistent standards.

The Idaho Potato Commission (IPC) promotes Idaho potatoes through advertising, public relations and quality control. As a result, Idaho fresh potatoes have long sold for price premiums that more than offset transport cost differences. Idaho's price premiums have been partly related to grade requirements that are higher than USDA standards. For example, USDA requires a 1-7/8 inch minimum size, while Idaho has used 2 inches or a 4-ounce minimum. In recent years Idaho's price premiums have shrunk and sometimes disappeared. Seeking answers for the price premium erosion, IPC asked University of Idaho faculty to analyze the economics of increasing minimum size requirements for fresh Idaho potatoes.

Diversion

Increasing the minimum size for fresh Idaho potatoes would cause a diversion from one market to another. Several researchers addressed the issue of agricultural product diversion. Nguyen and Vo (1985) and Price (1967) analyzed the economics of discarding low quality produce. Bockstael (1984) claimed that diverting off-grade product from fresh to dehydrated markets would benefit consumers in the secondary market due to lower prices, but net social welfare would decline. IPC is more interested in the producer benefits of diversion. Minami, French, and King (1979) found that volume controls via marketing orders increased grower profits in the California peach industry. Saitone and Sexton (2008) showed that marketing order enforcement of minimum quality standards benefit producers who divert from a market with inelastic demand to a market with elastic demand.

A number of researchers concluded that demand for fresh potatoes is inelastic. Guenthner, Levi & Lin (1991) estimated an elasticity of -0.14 for US fresh potatoes in retail markets. Miranda and Glauber (1993) calculated fresh potato elasticities ranging from -0.52 to -0.27 depending on the time of year. Richards, Kagan, and Gao (1997) estimated fresh potato price elasticity at -0.48. Babula, McCarty, Newman, and Burket (1998) used monthly data from 1987 to 1996 to conclude that price elasticity of fresh potatoes is between -0.30 and -0.50. Greenway, Guenthner, Makus and Pavek (2011) found elasticities of -0.60, -0.65 and -0.75 for red, russet and organic potatoes.

Objectives

The overall objective is to estimate the impacts of increasing the minimum size standard on Idaho potato industry revenue. To accomplish that, the specific objectives are to estimate:

1. quantity of potatoes that would be diverted from fresh to dehydrated
2. impact on fresh packer revenue
3. impact on dehydration processor revenue

Methods

Quantity

We used data from the Idaho Agricultural Statistics Service (2011) to determine the amount of fresh potatoes that would be diverted as a result of the minimum size increase. IASS conducts annual random field digs to estimate the grade and size profile of each Idaho potato crop. The data is available for five areas: Southwest, South Central, Eastern, Eastern seed counties (high elevation counties in Eastern Idaho), and other counties. We chose the Eastern region as most representative of the Idaho fresh potato industry for this study. It consists of Bannock, Bear Lake, Bingham, Bonneville, Franklin, Jefferson, Madison, Oneida, and Power counties. IASS provides annual data for thirteen size categories ranging from 1½ inches to 14 ounces & over.

Fresh Market

Monthly Model

We attempted to build a monthly model, using ordinary least squares (OLS), to estimate an inverse demand function:

$P = f(Q_{ID}, Q_{US}, S_{ID}, S_{US}, I, A, Q_i)$

Where:

P = price of fresh Idaho potatoes ($/cwt)
Q_{ID} = quantity of fresh Idaho potatoes shipped (million cwt)
Q_{US}, = quantity of fresh non-Idaho US potatoes shipped (million cwt)
S_{ID} = stocks of Idaho potatoes in storage (million cwt)
S_{US} = stocks of non-Idaho US potatoes in storage (million cwt)
I = disposable personal income per capita ($1000 deflated by CPI)
A = binary variable to depict an increase in advertising funding in 2007
Q_i = binary variables for three quarters of the year (base Q4).

Our period of analysis was 120 months from August 2000 to November 2010. We obtained data on Idaho fresh potato prices and shipments from the Federal State Market News Service (2011). The formula for the fresh weighted average (FWA) price came from a potato market analyst (Huffaker 2011). The Bureau of Labor Statistics (2011) provided consumer income data. The Idaho Potato Commission was the source of advertising information.

When we chose variables, we considered Tomek and Robinson's (1990) four demand shifters: U.S. population; income; other goods and tastes & preferences. Since population changed little during the period of analysis we did not include it in the model. The other three demand shifters are represented by the explanatory variables. Since Greenway et al. (2010) found that the best substitute for potatoes is other potatoes, we included non-Idaho potatoes in the model. The advertising variable is a proxy for consumer tastes and preferences. It has a value of 0 for all months before 2007 and a value of 1 beginning with the 2007 crop. That is when IPC, bolstered with increased funding, switched from regional to national advertising.

We expected negative coefficients on the monthly shipments and stocks variables. Hypothesizing that fresh potatoes are an income-inferior good (consumption drops when income increases) we expected a negative sign for income. Increased advertising should have a positive impact on consumer tastes and preferences and therefore a positive coefficient sign. We hypothesized that potato prices would follow a seasonal pattern. The fourth quarter (October – December), when most potatoes are harvested, was when we expected the lowest average price. We thought that the first, second and third quarter dummy variables would have positive signs due to increasing storage costs during the marketing season.

Annual Model

Due to poor results with the monthly model, we developed a simple annual model. The idea came from a potato market analyst who uses a fresh potato price forecasting model consisting of two explanatory variables: fresh potato shipments and changes in total potato production (Huffaker 2011). Our annual model, estimated by Ordinary Least Square (OLS), is specified as:

$P = f(Q_{ID}, \Delta Q_{US})$

Where:

P = Idaho fresh weighted average (FWA) price divided by the consumer price index ($/cwt)

Q_{ID} = is the quantity of fresh Idaho potatoes shipped divided by US population (lb/person).

ΔQ_{US} = is the change in the quantity of all US potatoes produced (%)

The period of analysis was the 21 crop years from 1990 through 2010. The source of the price data was United Potato Growers of Idaho. The Federal State Market News Service provided the fresh shipment data and the potato production data came from USDA NASS. All potato price and quantity data was for the August through July crop year used by USDA. US population and CPI data came from the US Census Bureau (2011) and US Bureau of Labor Statistics (2011).

From the fresh potato demand equation we estimated price flexibility. We used the quantity of fresh potatoes to be diverted along with the price flexibility to estimate changes in Idaho potato shipper revenue.

Dehydration Market

Data needed to build a similar model for the dehydration market were not available from public sources. We were unable to find Idaho-specific data so we built a simple US model. Compounding the lack of data problem was the fact that dehydrated potatoes are sold in multiple product types and multiple markets. Using ordinary least squares (OLS) we estimated an inverse demand function for all dehydrated potato products that included two explanatory variables. The dependent variable is:

P = average price paid by the US School Lunch program for dehydrated potatoes ($/lb)

The explanatory variables are:

Q_{US} = Quantity of US potatoes dehydrated (million lb)

T = Year

We were able to obtain data only for 2000-2010. We expected a negative sign for the quantity coefficient but did not have a hypothesis about the time variable. We hoped that changes in market forces through time would be captured in the annual time variable. Like with the fresh potato demand model, we used the dehydration price flexibility to estimate impacts on dehydration processor revenue. Since we needed to convert US information to Idaho, we sought expert opinion regarding the share of US dehydrated potatoes produced in Idaho.

Results

Quantity

A graph of the average size distribution for the 2000 to 2010 crops shows that the largest category in the size distribution is ‘2” or 4-6 ounces’ (Figure 1). This category comprises more than one-fourth of the Eastern Idaho crop, at 26.8%. The values in this category ranged from a minimum of 21.9% in 2002 to a maximum of 32.7% in 2010. The category relevant to this research is the 4-6 ounce category. We assumed that one half of the 4-6 ounce range is made up of 4-5 ounce potatoes. This results in an average of 13.4% of the potato crop in the 4-5 ounce category.

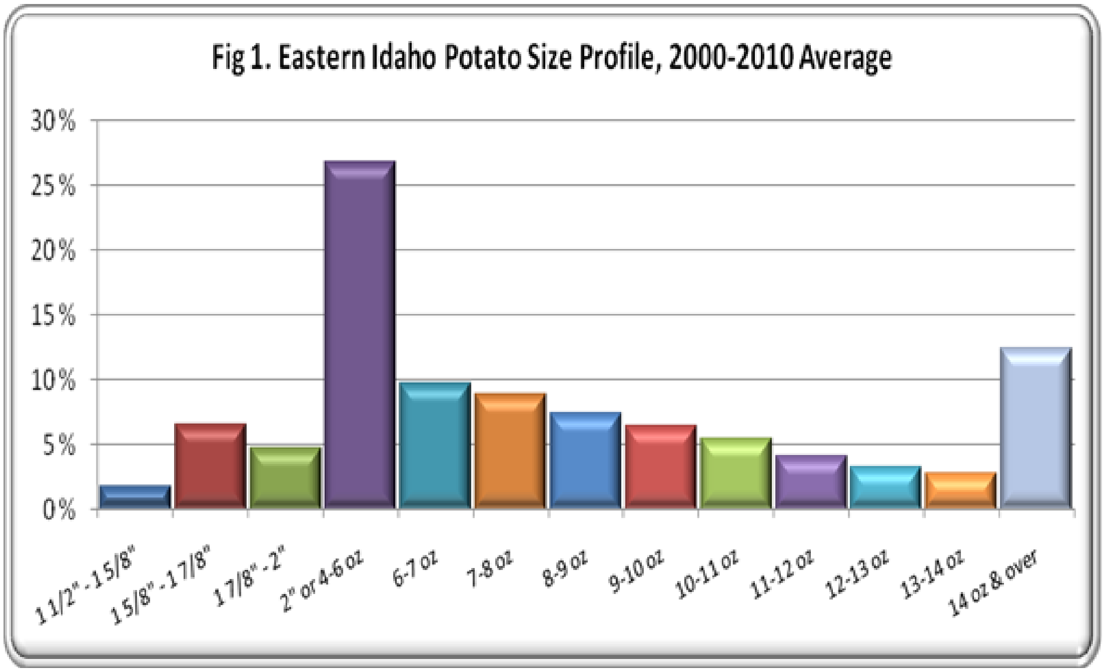

Figure 1. Eastern Idaho potato size profile

The three smallest categories (1 1/2" - 1 5/8"; 1 5/8" - 1 7/8"; 1 7/8" - 2") of potatoes would not typically make it to the fresh market. Excluding them from shipment quantities, provides an estimate that 15.4% of Idaho's fresh potato shipments have been in the 4-5 ounce category. According to the Federal-State Market News Service the 2000-2010 average for Idaho fresh shipments was 33.34 million cwt. That means that an average of 5.14 million cwt of 4-5 ounce potatoes would be diverted from fresh to dehydration if the minimum size were increased to 5 ounces. The average amount of Idaho fresh potatoes shipments would decrease from 33.34 million cwt. to 28.20 million cwt.

Fresh Market

Results for the monthly fresh model were disappointing (Table 1). We evaluated this model in terms of: (1) economic theory, (2) statistics and (3) econometrics and found serious shortcomings in all three. First, coefficient signs for two variables were contrary to economic theory. We expected a negative coefficient for US stocks because higher stocks would push down prices. The negative sign for the Quarter 3 dummy variable was also a problem. We hypothesized that increasing storage costs would put Q3 prices higher than harvest-time prices and give the variable a positive coefficient.

Table 1. Estimated coefficients and t-values for the monthly fresh potato model.

Variable	Coefficient	T value
Constant	38.2	
Q_{ID} (Idaho fresh potato shipments)	-0.43	3.25
Q_{US} (non-Idaho fresh potato shipments)	-0.18	2.56
S_{ID} (stocks of Idaho potatoes in storage)	-0.58	3.10
S_{US} (stocks of non-Idaho US potatoes in storage)	0.19	2.98
I (disposable per capita personal income)	-0.15	0.81
Adv (binary variable for national ads)*	3.76	2.98
Q1 (binary variable for quarter 1)	1.58	1.26
Q2 (binary variable for quarter 2)	2.88	2.02
Q3 (binary variable for quarter 3)	-0.94	0.79
$R^2 = 0.33$		

Another problem was the model's elasticity of -1.08, depicting an elastic fresh-potato demand, which contradicted previous research. One statistical concern was the insignificant t-value for the income variable. Another was the low R^2 value of 0.33, which indicated that the model only explained 33% of the variation in price. One econometric problem was multicollinearity because of a 98% correlation between the stocks variables. Based on these shortcomings we rejected the monthly model.

Price volatility within the market year may be one reason the monthly model was not a good fit. Since the consensus among other researchers is that fresh potato demand is inelastic, volatile prices are expected. Price volatility within the marketing year is likely exacerbated by uncertainty in the actual quantity of potatoes in storage, the possibility of excessive storage shrink due to diseased potato tubers, the size profile of potatoes yet to be shipped and the uncertainty about the supplies of fresh potatoes to be harvested during winter, spring and summer.

Table 2. Estimated coefficients and t-values for the annual fresh potato model.

Variable	Coefficient	T value
Constant	40.23	
Q_{ID} (Idaho fresh potato shipments)	-2.39	4.73
Q_{US} (non-Idaho fresh potato shipments)	-29.22	3.37
$R^2 = 0.73$		

We thought that an annual model could more accurately depict the fresh potato price-quantity relationship because total production of Idaho and US potatoes may be the most significant variables that influence average prices. The coefficient signs for the explanatory variables were as hypothesized (Table 2). The negative signs on the variables indicate that the demand for Idaho fresh potatoes is normal and that non-Idaho potatoes are substitutes. According to the R^2 value, the model explains 73% of the changes in annual Fresh Weighted Average (FWA) prices. The variables were statistically significant at the 5% level for type 1 error. Diagnostic tests revealed heteroskedasticity was not present, autocorrelation was inconclusive, and no problems existed for multicollinearity. In order to check for heteroskedasticity, the critical value for the χ^2 distribution is compared to the independent variables. At 1 degree of freedom and α=0.025, the critical value is 5.024 (Griffiths, Hill, & Judge 1993). The critical value for the P-Values is 0.05. The test results for heteroskedasticity are:

Table 3. Test results for heteroskedasticity

	Chi-Square *Test Statistic*	**D.F.**	**P-Value**
E^2 on $\hat{Y}$:	0.042	1	0.83746
E^2on $\hat{Y}^2$:	0.087	1	0.76820
E^2 on LOG($\hat{Y}^2$):	0.018	1	0.89349
E^2 on LAG(E^2) Arch Test:	0.342	1	0.55883
LOG(E^2) on X (Harvey) Test:	4.013	2	0.13447
ABS(E) on X (Glejser) Test:	0.977	2	0.61349
E^2 on X Test:			
Koenker (R^2):	0.120	2	0.94165
B-P-G (SSR):	0.075	2	0.96307
E^2 on X X^2 (White) Test:			
Koenker (R^2):	1.109	4	0.89286
B-P-G (SSR) :	0.694	4	0.95205

Comparing the Chi-Squared test statistics and the P-values to their respective critical values, it is concluded that heteroskedasticity is not present. The critical values for the Durbin –Watson Test at a 5% significance level are found where k=2 and t=11 (Griffiths, Hill, & Judge 1993). K is the number of dependent variable and t is the number of years in our regression. These values are: d_{LC} = .927 and d_{UC} = 1.324. Since the d value for this regression is between the critical values we do not reject H_0: ρ=0. This leads to the conclusion that autocorrelation likely does not exist.

The variables were regressed on each other, and the highest R^2 was 0.38, lower than the annual model R^2. This suggests that no problems exist for multicollinearity.

The price flexibility (F) at mean values of the variables is -2.5. For each 1% change in the quantity of Idaho potatoes shipped, the FWA moves 2.5% in the opposite direction. The inverse of that number, which is an approximation of elasticity (Tomek and Robinson 1990), is -0.4 which puts Idaho fresh potato demand in the 'inelastic' category.

Table 4. Impact of 5-ounce minimum on Idaho potato shipper revenue.

	Min = 4 oz	**Min = 5 oz**	**Difference**
Quantity (million cwt)	33.34	28.2	-5.14
Price ($/cwt FWA)	$12.84	$17.78	$4.94
Revenue ($ million)	$428	$501	$73
	Average 2000-2010	*Estimated*	

For the 15.4% reduction in fresh Idaho potato shipments, we expect the price to increase 38%. The fresh weighted average price in Idaho for 2000-2010 was $12.84. An increase by 38% will result in a FWA price of $17.78 per cwt after diversion of the 4-5 ounce potatoes. The average revenue for Idaho fresh potatoes from 2000-2010 was $428 million. Revenue after diversion of the 4-5 ounce potatoes would have been $501 million, a difference of $73 million (Table 3). Given that non-Idaho potatoes are substitutes for Idaho potatoes, it is reasonable to assume that the substitute effect will come into reason when consumers are at the market.

Dehydration Market

The two-explanatory-variable model explains 92% of the variation in prices for dehydrated potatoes (Table 5). The coefficient of +0.083 for the time variable indicates that there is an upward trend in prices of about $0.08 per cwt each year. Although the model does not explain the economic forces that are pushing the price up, it shows that demand for dehydrated potatoes has been increasing. Both variables are statistically significant at the 90% level. Diagnostic tests revealed that autocorrelation likely does not exist, heteroskedasticity was inconclusive, and no problems existed for multicollinearity.

Table 5. Estimated coefficients and t-values for the dehydrated potato model.

Variable	Coefficient	T value
Constant	-164.5	-5.8
Q (US dehydrated potato quantity)	-0.001	-1.5
T (2000-2010)	0.083	5.8
$R^2 = 0.92$		

F is -0.54 at the mean values of the variables. The inverse is -1.8, which indicates that the demand for dehydrated potatoes is in the ‘elastic’ category. Diverting 5.14 million cwt from the fresh market to the dehydrated market, at an 8:1 raw to finished product conversion rate (USDA ERS 1992), would increase the US dehydrated supply by 11.65%. This would cause finished product price to decline by 6.3% from $0.99 to $0.93 per pound. The 2000-2010 average dehydrator revenue was $545 million. Revenue with the diversion would have been $570 million, a $25 million, or 4.6% increase (Table 6).

Table 6. Impact of 5-ounce minimum on Idaho potato dehydrator revenue.

	Min = 4 oz	Min = 5 oz	Difference
US Quantity (million lbs.)	550.4	614.5	64.1
US Price ($/lb.)	$0.99	$0.93	**($0.06)**
US Revenue ($ million)	$545	$570	$25
ID Revenue ($ million)	$381	$399	$18
	Average 2000-2010	*Estimated*	

We interviewed several anonymous industry experts about the share of US dehydrated potatoes that are produced in Idaho. We used an average estimate of 70%. Applying that percentage to the US figures, we estimated that the diversion would increase Idaho dehydrator revenue by $18 million.

Sensitivity Analysis

The impact estimates are based on averages for the quantity of Idaho fresh potatoes shipped and the portion of potatoes in the 4-5 ounce range. We conducted a sensitivity analysis to estimate the impacts when those two variables were at their highest and lowest values from 2000 to 2010 (Table 7). We found that the largest impact would have been when Idaho fresh shipments were at the largest, which was 37.3 million cwt for the 2000 crop. With that quantity and a 5-ounce minimum, revenue would have increased $132 million in the fresh industry and $20 million in the dehydration industry. The next largest increase in revenue ($105 million) would have been when the largest share of fresh potatoes were in the 4-5 ounce category, which was 19.7% in 2010. The biggest benefits occur when large quantities of potatoes are diverted from fresh to dehydration.

Table 7. Sensitivity analysis for Idaho potato industry revenue.

	Fresh	Dehy	Total	Change
Actual 2000-10 average	$428	$381	$809	-
Min = 5 oz	$568	$399	$900	$92
ID Quantity shipped:				
Largest (37.3 mcwt)	$561	$401	$961	$152
Smallest (30.7 mcwt)	$462	$398	$859	$50
Size profile:				
Highest 4-6 oz (19.7%)	$518	$396	$914	$105
Lowest 4-6 oz (12.3%)	$489	$399	$888	$78

Note: Revenue is million $

Conclusion

Through our final annual model, we have predicted that by shifting Idaho's 4 to 5 ounce supply of potatoes (5.14 million cwt) from the fresh to the dehydrated market, an increased revenue of nearly $150 million can be expected.

The fresh potato market has flexibility of -3.5, resulting in a $6.93 FWA increase per cwt. This results in an overall $130 million increased revenue for the Idaho's fresh potato industry.

The dehydrated potato market has a flexibility of -0.5, resulting in a $0.06 decrease per pound of dehydrated potatoes. The quantity being shifted from fresh to dehydrated markets is enough to offset this price decline, and result in a $20 million increase for the dehydrated market.

Discussion

Diverting 4-5 ounce potatoes from the fresh market to the dehydrated market would affect multiple parts of the Idaho potato industry. Total revenue would increase in both market sectors and economic benefits would spill over into agricultural supply businesses, other parts of the potato industry and the overall Idaho economy. This research project provided some answers for the IPC question about the impacts of increasing the minimum size, but some unanswered questions and issues are discussed below.

Monthly Model

We intended to build a model for monthly fresh potato prices, but were not successful. One reason may be price volatility due to uncertainty about storage stocks and potatoes harvested in winter, spring and summer. Total potato supply may be a more reliable predictor of annual prices than monthly shipments are for monthly prices. If prices are unusually high or low early in the marketing season, price corrections later could bring the average price back to a level that is easier to predict.

Quality Impact

More uniform sizing could increase demand for Idaho fresh potatoes. During summer 2011 United Potato Growers of Idaho suggested price premiums of $0.75 to $1.50 per cwt for consumer packs with a five ounce minimum. (United Potato Growers of Idaho 2011). Since we did not include a price premium in our analysis, the impact estimates may be conservative.

Costs

Reducing fresh potato shipments could increase packing fixed costs per unit. Declines in volume would mean that some packers would spread the same amount of fixed costs over fewer units shipped. The dehydration industry might also face changes in costs due to changes in volume. Cost analysis was not part of this study.

Price Sensitivity

Previous research sponsored by IPC found a fresh potato price elasticity of -0.14 (Guenthner 2001). This implies that a one percent change in supply causes a seven percent change in price. Our research found smaller price sensitivity, for which there are several reasons. First, the earlier study analyzed a different product— US fresh potatoes. Second, the earlier study was conducted at the retail level and this one was at the packer level. Third, the earlier study used data from 1975-1988 and market behavior may have changed since then.

Grower Impacts

The analysis was conducted at the fresh shipper and dehydration processor links of the marketing chain, but the results can be extended to growers. Impacts on Idaho fresh potato growers would include lower fresh pack-out rates, higher prices for fresh potatoes, lower prices for dehydrated-quality potatoes, and a higher net price. Using the estimated price flexibilities, we estimated that the average GRI price of $5.63 per cwt for the 2000-2010 crops would have been 24% higher at $6.97 had the five-ounce minimum standard been in place.

Supply Response

Our analysis focused on short-run impacts only. A long-run analysis would include a model of how growers' plantings and production would respond to changing fresh potato prices. Guenthner (1987) estimated Eastern Idaho potato plantings elasticity at 0.25 but that was based on data from 1962-1985. The supply control programs of the United Potato Growers cooperatives have likely made acreage response more inelastic (Guenthner 2012).

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Greenhouse Gas Emissions Labeling for Produce: The Case of Biotech and Conventional Sweet Corn

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Abstract

Agriculture's significant global contribution to greenhouse gas (GHG) emissions has spurred consumer and retailer mitigation interest. Biotechnology, designed to enhance the marketable portion of yield via improved disease, weed and pest management with the same or lower use of inputs, is thus well positioned to gain from producer and consumer concerns about GHG emissions. Compared to conventional sweet corn, identical lines embedded with insect control showed statistically significant higher marketable yield and no effect to lesser insecticide application. Pending seed cost and consumer acceptance of biotechnology, this should enhance returns for producers and allow marketing of multifold, consistent declines in GHG per ear.

Keywords: greenhouse gas emissions, sweet corn, agriculture, biotechnology

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Introduction

Agriculture has been reported to be a significant source of GHG emissions, both in the US and globally (Causarano et al. 2006; Robertson et al. 2000; Lal 2004; Nelson et al. 2004). The US EPA (2009) estimated that approximately 6.3 percent of US GHG emissions come directly from agricultural production. From a life cycle perspective, however, the total value is probably significantly larger, since the life cycle approach accounts for the inputs used on farm as well as the emissions from the production of said inputs.

Comprehensive U.S. climate change legislation had never been closer to law than the House passage of the Waxman-Markey bill in 2008. Despite the death of the bill in the Senate, the White House, the United States Department of Agriculture (USDA), and the Environmental Protection Agency (EPA) continue to support carbon reduction initiatives. Perhaps more importantly, agricultural producers face increasing demand to reduce GHG emissions associated with crop production from consumers, non-governmental organizations, and from the retailers of their product. Eco- and carbon-labeling is on the rise; 34 carbon footprint labels existed globally in 2009 and the number is increasing (Baddeley 2011). One survey found that 56.3% of US consumer respondents and 64.4% of UK respondents desired climate impact information on their products (Bolwig and Gibbon 2010). While US consumer demand lags that of UK and Europe as a whole, agricultural producers that supply to global markets can expect to face increasing pressure from abroad regardless of US demand or regulations.

Walmart has announced a potential plan to label each of its products with a sustainability rating and has subsequently requested that every Walmart supplier provide its GHG footprint, a direct measure of climate impact.[1] The Carbon Trust, a not-for-profit entity in the UK, has already labeled over 2,800 products for carbon emissions (Bolwig and Gibbon 2010). Tesco, the British-based supermarket chain, has begun carbon labeling some of its products and intends to expand efforts to all 70,000 of its products (Bridges 2008). Both Japan and France have trial governmental programs in place for carbon labeling (Baddeley 2011). At the same time, the International Standards Organization (ISO) has been developing an international standard (ISO 14067) on carbon footprinting (Baddeley 2011). This will make it easier to create a common footprint value and label, which may reduce consumer confusion and uncertainty, and increase demand for low carbon products. With all of these efforts coming from different segments, one can expect that there will be growing pressure from numerous angles to reduce carbon emissions for agricultural products.

Producers are experiencing GHG polices at the field level as well. For example, since 2007, the California Rice Commission (CRC) has worked with the Environmental Defense Fund (EDF) to reduce the methane emissions associated with California rice production. As a result, a list of management practices that can reduce methane emissions are under review by the American Carbon Registry and the Verified Carbon Standard to allow California rice producers to participate in voluntary carbon offset markets. Also, Kellogg's, a large purchaser of U.S. rice, is working with Louisiana rice producers in various pilot programs aimed at increasing sustainability of

[1] See http://walmartstores.com/Sustainability/9292.aspx for more information on Wal-Mart's "Sustainability Index."

rice destined for use in Kellogg's products.[2] Large purchasers of commodities are now directly working with industries or cooperatives to source commodities that have a "green advantage" so they can use them to market their goods as such.

Use of biotech sweet corn (Seminis® or Performance Series™ Sweet Corn, abbreviated as PSSC here) to enhance GHG efficiency in agricultural production is potentially an effective way to lower GHG emissions per acre and per unit of output for sweet corn production. Fresh sweet corn provides an interesting case study for biotech vs. GHG interactions because of: 1) the high reliance on insecticides to combat ear worms and other similar pests; 2) the high incidence of down grading and waste in fresh corn markets due to insect damage; 3) PSSC's embedded insect control lessening damage and reducing or eliminating the need for insecticide applications which can lower GHG emissions per acre while maintaining or increasing marketable yield per acre. Greenhouse gas emissions from insecticides make up only a small percentage of total greenhouse gas emissions from production, and so a reduction in pesticides will have a relatively small impact on total greenhouse gas emissions. Nevertheless, a reduction in pesticide use carries many other significant environmental benefits. Thus, if marketable yield remains constant or increases and GHG emissions per ear decrease then the ratio of marketable ear per unit of GHG emitted declines.

Field corn has been analyzed in depth from a life cycle perspective (Kim and Dale 2003; Landis et al. 2007; Shapouri et al. 2002; West and Marland 2002). Greenhouse gas emission estimates ranged from a low of 157 lbs Carbon Equivalent (CE)/ac (West and Marland 2002) to a high of 616 lbs CE/ac (Kim and Dale 2003). However, relatively little literature exists with respect to sweet corn production and its effects of different production practices on life cycle and GHG impacts. While comparisons can be made between sweet corn and field corn on a per acre basis, the two are very different products and are hard to compare on a per unit basis. Field corn kernels are stripped at the field, and measured by the bushel in dry weight which can have ear worm damage. Sweet corn is harvested and boxed by the ear. Worm and pest damage only affects the kernels damaged in field corn, whereas with sweet corn, a small damage to the ear percentage-wise may result in complete wastage and thus reduced marketable yield. Therefore the seed stock used and the pesticides used vary from field corn to sweet corn.

Production practices (irrigation, tillage, cropping systems, and fertilization) can affect GHG generation by as much as a factor of 2.5 (Sainju et al. 2008). In addition, seed variety and technology affect the level of inputs required, as well as the effectiveness of such inputs on yield and yield loss. Marketable yield, the portion of ears harvested that is deemed marketable, is a key factor in producer production choices and is the dominant variable in assessing efficiency and sustainability of crop production (Negra et al. 2008).

The objectives of this study were thus to 1) conduct a life cycle inventory from pre-plant tillage to harvest to arrive at estimates of the carbon-equivalent (CE) GHG emissions of production practices for conventional vs. PSSC sweet corn as adapted to the main sweet corn producing regions across the U.S.; 2) to showcase the relative contribution to total GHG emissions of

[2] See http://deltafarmpress.com/rice/sustainability-rice-farming-lsu-agcenter-kellogg-co-collaborate for full information.

insecticides, fungicides and herbicides (agro chemicals), fuel use for production and irrigation, and finally fertilizer including N_2O emissions from fertilizer application; 3) determine the impact of reducing the number of insecticide applications on marketable yield; and 4) quantifying CE per acre and per ear of sweet corn along with GHG uncertainty as affected by weather related differences in irrigation and number of insecticide applications. Results should provide marketing insights for retailers and producers considering the adoption of PSSC about what to expect in terms of GHG footprint per ear.

Data and Methodology

Locations and Trials

Data from university and private farm field trials that were performed at 10 locations in the Southeast and Midwest during the fall of 2009 continuing through the summer of 2010 were provided by Monsanto. These locations included two locations in Wisconsin (Cambridge and Verona), Florida (Felda and University of Florida at Belle Glade), Illinois (Hinckley and University of Illinois at Urbana), two locations in Georgia (University of Georgia at Leesburg and Tifton), Mississippi (Leland), North Carolina (Maxton) and Ohio (Ohio State University at Fremont). Corn was planted seasonally, such that there were spring or fall harvest seasons, primarily in the southern locations, and a summer harvest season for the northern locations. At Felda, Florida, corn was harvested in both the spring and the fall. Hinckley, Illinois, University of Illinois, Ohio State, and Cambridge were not included due to lack of production input data. Maxton was excluded as irrigation was terminated prematurely.

Experimental Design

Ultimately, for purposes of statistical comparison, the locations were segregated into two trials, a "variety trial" and a "regional trial." The variety trial consisted of four season/location combinations: Felda Fall, Felda Spring, UGA Fall at Leesburg, and Mississippi Fall. The main effect for the variety trial was insecticide use, with treatment levels varying from either zero applications (ZERO), to once every 48 hours (FULL) after tasseling, or once every 96 hours (HALF) after tasseling. The sub-effects were sweet corn hybrid (Obsession® vs. Passion®) and seed technology (conventional – (CONV) vs. biotech – (PSSC)). The data for these locations were balanced with two replicates for a total of 96 yield observations.

The "regional trial" consisted of three locations and two seasons (UGA Spring at Tifton, UFL at Belle Glade Spring and Verona Wisconsin Summer). The regional trials were arranged as split plots with the main effect of insecticide and sub-effect of seed technology. Passion® was the only variety used in the regional trials. This set of experiments was replicated four times but the data set was not balanced since the HALF insecticide treatment was not performed at Wisconsin. 64 yield observations were analyzed for these comparisons.

Herbicides

All seed was treated with Cruiser 250 which provides protection against pythium and fusarium fungal diseases using fludioxonil, mefenoxam, and azoxystrobin as well as secondary soil insect pests using thiamethoxam, excluding rootworm and billbug. All locations had Bicep II Magnum (s-metolachlor and atrazine) applied as a pre-plant herbicide. Some locations used only Impact (topramezone) as a post-plant herbicide, while other locations (Felda, Maxton, Leesburg, Leland) also tested Roundup on the biotech seeds given their herbicide tolerance to glyphosate as well as no post-emergent herbicides on the conventional seeds. Only yield data using Impact as a herbicide was used in this study to ensure appropriate comparison between conventional and biotech seed as Roundup would lead to plant injury for the conventional seed and herbicide effects were not the primary goal of this study.

Marketable Ears

Data collected included yield, as well as input use. Yield measures included total ears from harvested area, marketable ears, marketable ears husked (out of 10 ear subsample), ears with worm damage (out of 10 ear subsample), and ears with poor pollination (out of 10 ear subsample). In addition, data included ear diameter and ear length as well as plants harvested per plot. Marketable yield per acre was calculated as total ears harvested multiplied by percentage of ears without worm damage divided by plants harvested and then multiplied by the targeted 23,000 plant population per acre. The percentage of ears without worm damage was taken as a subsample of 10 ears selected at random from each trial plot. Data was also collected on ears with low pollination, but because the purpose of this biotech seed technology is primarily to prevent worm damage, and because poor pollination is not the target of this seed technology, it was deemed irrelevant in this study. Further, consumer rejection of corn is more likely due to worm damage than due to poor pollination.

Ear Size

Sensitivity tests were performed to see if using ear diameter and ear length in the yield calculations made significant differences in the results. The range of differences when using diameter and length resulted in approximately 5% differences in total yield expressed in terms of volume rather than ears. However, seed technology, variety, and insecticide effects were much greater, in some cases by an order of magnitude. Therefore, given the complexity of the formula, with little added benefit, length and diameter measurements were not used in the yield calculations.

Fertilizer and Irrigation

Inputs monitored were nitrogen (urea and ammonium nitrate), phosphate, and potassium. In addition, all insecticides, herbicides and fungicides were included based upon available information from field trials and included quantification of active ingredients of insecticides and the number of trips across the field for application of all inputs. Seeding rate was standardized to achieve a target plant density of 23,000 plants per acre at harvest. Irrigation amounts applied, expressed in acre-inches (ac-in), were determined based upon ranges from production budgets available from state extension specialists and by budgets provided by Monsanto.

It was assumed that irrigation was applied to maximize yield. Because rainfall varies from year to year, and the year under study may have been above or below average, irrigation quantities for each location were simulated using a triangular distribution. Minimum, most likely, and maximum values for these distributions were verified by phone with state specific sweet corn specialists. Florida primarily uses furrow irrigation while the other states primarily use center pivot irrigation. Each method requires different levels of energy for water delivery (Tables 1 and 3).

Table 1. Inputs for each production practice and location (quantities per acre).

		UF FL Spring	Felda FL Spring	Felda FL Fall	GA Fall	WI	MS
Nitrogen: Urea	lb	200	200	200	0	0	0
Nitrogen: Ammonium Nitrate	lb	0	0	0	113	150	160
Phosphorus	lb	150	150	150	65	25	50
Potash	lb	300	300	300	65	40	80
Fungicide	oz	17.8	0.0	0.0	0.0	1.4	4.5
Insecticide	oz	4.1, 3.1, 0	17.8, 16.7, 0	53.4, 25.9, 0	87, 49, 0	0.9, *, 0	73.2, 44.7, 0
Applications*	#	7, 4, 0	5,3,0	15, 8, 0	19, 11, 0	4, *, 0	19, 13, 0
Herbicide	oz.	19.9	0.2	0.2	78.3	22.2	27.0
Applications	#	2	1	1	3	2	3
Diesel Field Prep	gal	7.1	7.1	7.1	7.1	8.2	8.2
Diesel - Harvesting	gal	1.8	1.8	1.8	1.8	1.8	1.8
Irrigation Furrow**	ac-in	5.0	10.0	10.0	0.0	0.0	0.0
Irrigation Center Pivot**	ac-in	0.0	0.0	0.0	7.0	5.0	7.0

Notes: *The Wisconsin data had no *HALF* treatment. *FULL* and *HALF* insecticide application treatments refer to applications every 48 and 96 hours post tasseling, respectively. The *ZERO* treatment was the control with no insecticide applications.
** Values based upon estimates from Monsanto Production Budgets.

Plot vs. Field Yields

As stated above, field trial sites were only approximately 120 sq. feet and therefore did not use large machinery. However, for the sake of analysis, we assumed that yields and non-fuel inputs would be representative of larger scale production. While the plot yields may differ from those found in larger fields, the relative differences across production method (level of insecticide application) and seed technology should be similar. Although a gap between experimental and actual yields exists, Brennan (1984) wrote, “The only reliable sources of relative yields are cultivar trials” (182). Hence, the desired comparisons of conventional vs. PSSC seed stock across location and insecticide should be valid.

Equipment and Fuel Use

Further, to estimate fuel use associated with actual on-farm production, actual field operations needed to be estimated. The Mississippi State Budget Generator (MSBG) provides estimates of fuel use based upon specified equipment operating under specific production conditions. While similar equipment was assumed to be used across most sites, some exceptions are noteworthy. All sites used a mule train (30ft working width and 80% field efficiency) and trailer (16ft length to hold crates of harvested sweet corn deemed marketable by the pickers) pulled by tractors (2WD 75 HP) at 1.5 miles per hour for harvesting. Harvesting was thus estimated to require 1.77 gallons of diesel per acre for tractor, trailer and mule train.

Sweet corn fields located in Florida and Georgia are generally larger and therefore use larger 8 row rather than 4 row equipment for fieldwork, planting, and spraying. This results in more efficient use of fuel. Therefore different equipment was modeled for Florida and Georgia. Florida and Georgia were modeled with 130 to 170 HP MFWD tractors with wider implements (20ft to 24ft and 8 rows) for fieldwork whereas the other states were modeled using 2WD 75 HP tractors with smaller width implements (7 to 10ft and 2 to 4 rows). Fuel for fieldwork, not including spraying or harvesting was estimated at 7.09 gallons of fuel per acre for Florida and Georgia, and 8.16 gallons per acre for the other states using the Mississippi State Budget Generator (McLaughlin and Spurlock 2012). Sprayers were all assumed to be 47 HP, 30 foot, 110 gallon capacity units. Field efficiency was modeled at 55%, 65%, and 75% efficiency, and at field speeds of 9, 12, and 15 mph to arrive at a range of diesel fuel use for insecticide applications. This resulted in a median diesel fuel usage per chemical application of 0.076 gallons per acre, with a range of 0.061 to 0.101 gallons of diesel per acre.

Direct vs. Indirect Emissions

The carbon footprinting analysis put forth in this study included both direct and indirect GHG emissions of agricultural inputs involved in the production of commodities up to placing the ears into the packing boxes (e.g. fertilizer, herbicides, insecticides, fuel, agricultural plastics, and other chemicals). Excluded are the emissions generated during refrigeration, transport, or processing of a commodity that occur after the farm gate, as these would be the same regardless of production system chosen. Also excluded from this study are embedded carbon emissions as a result of upstream production of equipment and tools used on-farm for agricultural production up to the farm gate. Direct emissions are those that come from farm operations such as combustion of diesel by tractors and irrigation equipment. Indirect emissions, on the other hand, are emissions generated off-farm as a result of the manufacturing of inputs used on the farm. Examples are GHG emissions from the use of natural gas in commercial fertilizer production (Wood and Cowie 2004).

Carbon-Equivalent (CE) Emissions Factors

CE factors come primarily from EcoInvent v2.2 using the IPCC 2007 100-year methodology (EcoInvent IPCC 2007). These values estimate the emissions over the whole life cycle of the input, including production, transportation, delivery, and use. For diesel fuel, this includes both the production as well as the combustion of the fuel on farm. For nitrogenous fertilizers, this includes both the production as well as the direct and indirect emissions of N_2O, a potent greenhouse gas resulting from the application of nitrogen fertilizer to the soil (Table 2). Irrigation CE values are estimated using the amount of fuel required to pump an acre-inch of water using a diesel pump, with different values for gravity-fed furrow irrigation (0.98 gal/ac-in) and center pivot irrigation (1.63 gal/ac-in). These values come from an average fuel use required to pump an acre-inch as determined by state production budgets in Arkansas, Mississippi, and Louisiana[3].

[3] It is assumed that water is pumped from 100ft at a 5 percent drive loss. The value assumes a 75 percent pump efficiency.

Table 2. Carbon equivalent emissions (lbs CE emitted/Input used) for fertilizer (per lb of elemental N, P or K), fuel (per lb and per ac-inch) and insecticides (lbs CE per lb of a.i.).

Description	**lbs CE / lb**
Corn Seed	0.53
N	
Urea Upstream	*0.90*
Urea Indirect	*0.43*
Urea Total	1.33
Ammonium Nitrate	2.33
N_2O Emissions	1.69
P	0.55
K	0.14
Fuel	
Diesel Upstream (per gallon)	*0.99*
Diesel Combusted (per gallon)	*6.05*
Diesel Total (per gallon)	7.04
Irrigation Furrow (calculated based on fuel use per ac-in)	6.90
Irrigation Center Pivot (calculated based on fuel use per ac-in)	11.46
Fungicides (common name)	
Manzate 200F (mancozeb)	1.44
Quadris (azoxystrobin)	2.89**
Headline (pyraclostrobin)	2.89**
Herbicides (common name)	
Atrazine (atrazine)	2.56
Dual Magnum II (s-metolachlor)	2.40
Round Up (glyphosate)	2.88
Impact (topramezone)	2.80**
Razincane	2.80**
Prowl (pendimethalin)	1.55
Bicept II Magnum (atrazine – 33.7%, s-metolachlor – 26.1%)	2.49
Callisto (mesotrione)	2.80
RUP (sodium methyl dithiocarbamate)	1.44
Avaunt (indoxacarb)	
Belt (flubendiamide)	4.55**
Baythroid (cyfluthrin)	2.89
Karate (lambda-cyhalorthrin)	4.79
Lannate (methomyl)	4.79
Mustang Max (zeta-cypermethrin)	2.76
Warrior (lambda-cyhalorthrin)	4.79
Tilt (propiconazole)	4.79
Silencer (lambda-cyhaolthrin)	4.55**
Brigade (bifenthrin)	4.79
Radiant (spinetoram)	4.79
Steward (indoxacarb)	4.55**

*Data source is EcoInvent v2.2 for all entries except indirect urea and N_2O emissions (IPPCC, 2007) and diesel combustion (USEPA, 2011).

**Specific chemical was not tracked separately in EcoInvent v2.2 and hence a chemical average for all fungicides, herbicides and insecticides was used. Under insecticides pyrethroid compounds were averaged at 4.79 lbs CE/lb of a.i.

Soil and Nitrogen Effects

Soil nitrous oxide (N_2O) emissions stemming from the application of nitrogen fertilizer have been identified as a major contributor to GHG emissions from crop production (Bouwman 1996; Smith 1997; Yanai 2003; Del Grosso et al. 2005; Snyder et al. 2009). The IPCC 2007 Third Assessment Report conversion factor of 298 units CO_2 emitted per unit N applied is commonly used and based on a one percent emissions loss from nitrogen application. This amounts to 1.28 lbs of carbon equivalent CE emissions per pound of elemental nitrogen applied. Additionally N_2O is emitted indirectly from volatilization of N as well as leaching and runoff of managed soils. Total direct and indirect emissions of N_2O result in an estimated 1.69 lbs of CE per pound of nitrogen applied. There is large variation in N_2O release depending upon timing, region, and method of application of nitrogen as well as climatic and soil conditions (Snyder 2009). A process based model used to estimate N_2O emissions by location and all of the other factors might be appropriate in some studies. Given that the goal of this study was to look at relative differences in carbon equivalent emissions within and not across locations based upon the specific production methods, and holding fertilizer application constant, the emissions factor approach was deemed appropriate.

Simulation of Variability

Due to variations in climatic and agronomic conditions, variability analysis was performed to account for different weather scenarios. That is, in an abnormally wet year, irrigation will be curtailed and thus so would the GHG emissions per acre of production associated with irrigation equipment. Conversely, in a dry year, irrigation will increase resulting in higher GHG emissions. Also, under different pest pressures, producers may choose to apply more or less insecticides. A triangular distribution with an upper and lower boundary was applied to both irrigation (ac-in) and insecticide applications. Uncertainty analysis was performed using Microsoft Excel @Risk software (Palisade) with defined distributions shown in Table 3. These simulations were performed to provide a minimum, maximum, and mean GHG estimate per acre under varying production and climatic conditions.

Statistical Methods

To perform comparisons of mean yields of marketable ears per acre between conventional sweet corn, treated at conventional levels of insecticide or current common practice, with their biotech counterparts, treated at varying levels of insecticide ranging from zero to full levels, least significant differences across these treatment combinations were calculated using the GLM procedure in SAS software (SAS 2004) with location/season as a random effect at the 10% level of statistical significance. Random effects for location and production season were chosen rather than fixed effects to be able to generalize across the production region.

Table 3. Values for Monte Carlo smulation using triangular distributions on irrigation water use and number of insecticide applications.

Location	Irrigation/Insecticide Treatment*	Min	Most Likely**	Max
University of Florida	ac-in	5	5	16
	FULL	0	7	24
	HALF	0	4	24
Felda Spring	ac-in	5	10	16
	FULL	5	5	24
	HALF	0	3	24
Felda Fall	ac-in	5	10	16
	FULL	0	15	24
	HALF	0	8	24
University of Georgia	ac-in	5	7	14
	FULL	4	19	19
	HALF	4	11	15
Wisconsin	ac-in	3	5	6
	FULL	4	4	10
Mississippi	ac-in	5	7	14
	FULL	4	19	19
	HALF	4	13	19

Notes: *Irrigation refers to number of acre-inches of water applied usually with 2 to 2.5" applied each time. Insecticide treatment refers to the number of passes applied. The *FULL* and *HALF* treatments refer to applications every 48 and 96 hours post tasseling, respectively.
**Note that use of the triangular distribution does not imply that observations cannot fall outside the specified range, but rather that expert opinion was used to elicit a likely range of observations.

Results

Carbon Equivalent per Acre by Location and Source

Figure 1 summarizes location differences across the three insecticide management practices on a per acre basis. While regional differences exist as expected, the difference in per acre emissions across insecticide management practice are quite small given small application of active ingredient of insecticide per acre as well as low fuel use per acre for application of insecticide. Figure 1 also provides a breakdown of the total carbon footprint by source and includes the simulated range of water and insecticide use by presenting 95% error bars. Note that agricultural chemicals applied included insecticide, herbicide, and fungicide; thus, footprint from agricultural chemicals does appear in the graph under the zero insecticide management practice. Overall, fertilizer use dominates carbon footprint at each location and does not vary by seed technology or insecticide management practice.

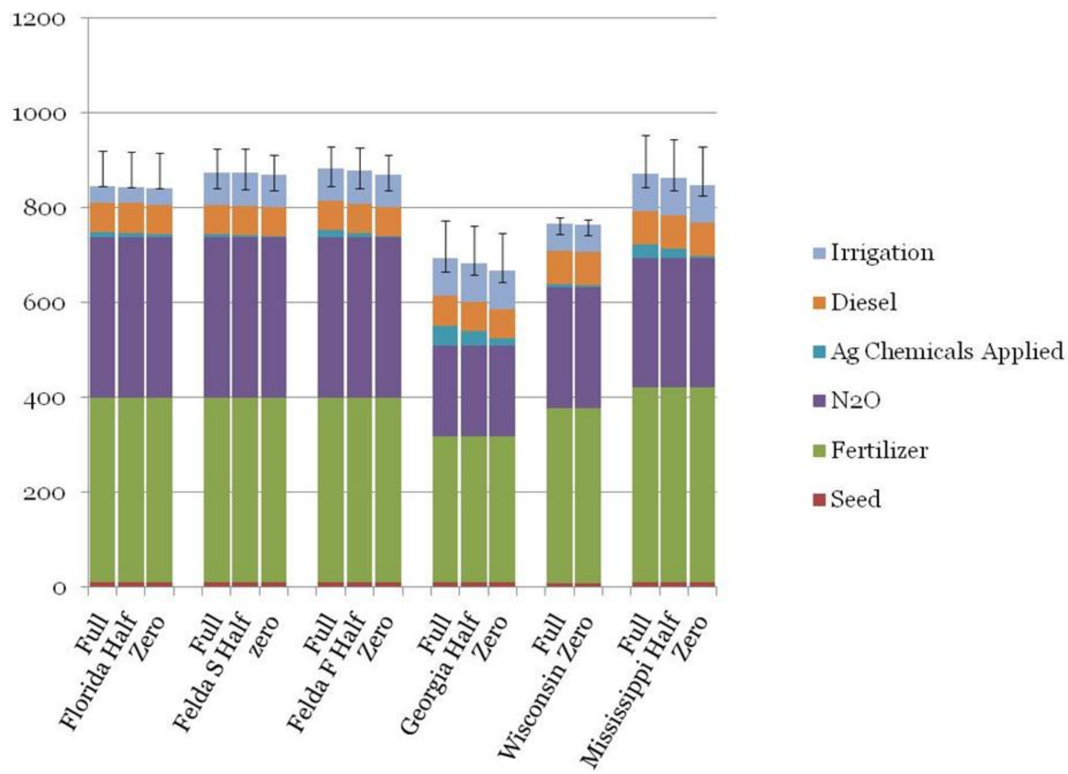

Figure 1. Carbon Emissions (lbs) per acre by location and insecticide application with simulated range of irrigation water and insecticide use for both conventional and biotech seed stock.

Yield

Marketable yields showed vast differences across practices in both regional and variety trials (Table 4). There were strong numerical differences across locations as well as differences by seed technology, variety, and insecticide.

Table 5 shows F- and p-values of the treatment effects and their interactions on marketable ear yield per acre for the variety and regional trials. Use of biotech had a statistically significant effect on its own at $p < 0.05$ in the variety trials. Also, the two-way interaction of variety × seed technology was statistically significant at $p < 0.1$. The top half of Table 6 shows marketable yield comparisons by variety. Use of PSSC seed technology was superior to conventional seed. Insecticide and variety effects, however, were not statistically significant. This suggests that producers choosing PSSC seed should be able to use less insecticide without a yield penalty regardless of variety chosen. Even though statistically speaking, effects in Table 5 for the regional trials were only marginal (insecticide ($p=0.174$) and insecticide × seed technology ($p = 0.183$)), the bottom half of Table 6 shows a similar trend in results as portrayed for the variety trials in the top half of the table. PSSC seed performs better than conventional with no significant differences across number of insecticide applications. Note that the lack of the *HALF* insecticide treatment at Wisconsin partially explains the drop in yield for that treatment under the PSSC column in the table.

Note further, that using no insecticides at all lead to higher yields than when the crop was sprayed with insecticide at full frequency. Excessive plot traffic with spraying equipment can lead to soil compaction and plant damage and is offered as an explanation for those results.

Table 4. Marketable yields from regional and variety trials by location/season, seed technology (*CONV* vs. PSSC), insecticide treatment (*FULL*, *HALF* or *ZERO*), and variety (*Passion*® vs. *Obsession*®).

Variety			**Passion®**		**Obsession®**	
Seed Technology			*CONV*	PSSC	*CONV*	*PSSC*
Trial	**Location/ Season**	**Insecticide**	----- Avg. Marketable Ears per Acre -----			
	Felda Fall	*FULL*	20,700	22,395	18,938	23,000
		HALF	17,020	23,000	19,550	23,034
		ZERO	17,405	21,722	18,430	20,639
	Felda Spring	*FULL*	9,702	17,731	2,355	15,559
		HALF	3,335	16,560	6,149	13,747
Variety Trials		*ZERO*	931	20,034	9,200	15,206
	Georgia Fall	*FULL*	10,551	19,406	12,267	18,662
		HALF	9,156	19,974	14,203	21,467
		ZERO	-	20,639	1,150	20,289
	Mississippi Fall	*FULL*	5,339	12,963	10,007	18,236
		HALF	7,240	11,962	8,050	12,624
		ZERO	3,424	17,500	4,273	12,078
	Florida Spring	*FULL*	14,826	14,475		
		HALF	11,002	11,463		
		ZERO	13,311	21,948		
Regional Trials	Georgia Spring	*FULL*	15,331	19,176		
		HALF	1,382	16,885		
		ZERO	-	13,644		
		FULL	3,758	25,666		
	Wisconsin Summer	*ZERO*	-	26,400		

Table 5. Analysis of variance results on marketable ear yield with location/season combination as random effect for variety trials at Mississippi, Florida and Georgia as well as regional trials at Florida, Georgia and Wisconsin.

		Degrees of Freedom		**F-**	**p-**
Trial	**Effect**	Num.	Denom.	**value**	**value**
	Insecticide	2	6	2.12	0.201
	Variety	1	3	0.64	0.482
	Insecticide × Variety	2	6	0.28	0.768
Variety Trials	Seed Technology	1	3	20.29	0.020
	Insecticide × Seed Technology	2	6	2.52	0.161
	Variety × Seed Technology	1	3	9.49	0.054
	Insecticide × Variety × Seed Technology	2	6	2.86	0.134
	Insecticide	2	3	0.11	0.450
Regional Trials	Seed Technology	1	1.99	4.32	0.174
	Insecticide × Seed Technology	2	3	3.15	0.183

Table 6. Mean marketable ear yield comparisons by variety and seed technology for variety trials and by insecticide and seed technology for regional trials.

Trial	Variety/Insecticide	Seed Technology # of obs.	*CONV*	*PSSC*
			---- Avg. Marketable Ears per Acre ----	
Variety Trials*	Obsession®	24	10,381	17,878
	Passion®	24	8,734	18,657
Regional Trials	*FULL*	12	11,305	19,772
	HALF	8	6,192**	14,174
	ZERO	12	4,437***	20,664

Notes: *$LSD_{0.10}$ = 6,436 – to compare *CONV* with PSSC for a particular variety.
$LSD_{0.10}$ = 4,727 – to compare *CONV* with PSSC of one variety with *CONV* with PSSC of another variety.
**Three of the eight yield observations had zero yield (Georgia).
***Eight of the twelve yield observations had zero yield (Georgia and Wisconsin).

Overall, these results suggest that the common practice of insecticide use to combat against ear worm damage is difficult given potential daily deposition of eggs near the top of the ear and subsequent hatching and migration of larvae under the husk where insecticides can't reach. The use of biotech alleviates this issue and, more importantly, statistically significantly so at all level of insecticide use and across variety. Results for the second set of locations (Florida - Spring, Georgia - Spring and Wisconsin - Summer) or the regional trial where varietal differences between Passion® and Obsession® were not performed demonstrated less significant statistical results for yield comparisons. These results may be a function of greater range of pest pressure expected as the region has greater north-south variation. Also, at Georgia, reduced and zero levels of insecticide-use programs lead to a large number of complete yield losses due to pest damage in the conventional treatments which substantially reduced variation of yield in a particular treatment which significantly lowers degrees of freedom. A similar issue occurred at Wisconsin where *ZERO* insecticide programs under the conventional treatment led to complete yield losses. Recall also that the Wisconsin location did not have a *HALF* insecticide treatment, leading to a more unbalanced data set. These zero observations greatly reduced variation and made statistical comparisons in an already small sample set difficult.

The same statistical analysis was also performed for CE footprint per ear of marketable yield. Table 7 shows the analysis of variance for both sets of experiments. Varietal differences were not significant but the levels of insecticide and seed technology were for the variety trials. Similar to the yield results, lesser statistically significant results were found for the regional trials. This lack of significance may again be partially a function of the zero yield observations as discussed above. Further, zero yield observations that were included as data points in the analysis above, could not be analyzed in the CE footprint per ear information as carbon footprint per acre cannot be divided by zero yield. Hence the number of observations dropped from 96 to 92 for the variety trials and from 48 to 41 for the regional trials.

Table 7. Analysis of variance results on C.E. per ear with location/season combination as random effect for variety trials at Mississippi, Florida and Georgia as well as regional trials at Florida, Georgia and Wisconsin.

Trial	Effect	Degrees of Freedom Num.	Degrees of Freedom Denom.	F-value	p-value
Variety Trials	Insecticide	2	6.41	4.07	0.072
	Variety	1	3.05	0.84	0.676
	Insecticide × Variety	2	5.95	1.06	0.403
	Seed Technology	1	3.04	5.71	0.096
	Insecticide × Seed Technology	2	6.19	3.77	0.085
	Variety × Seed Technology	1	2.98	3.31	0.167
	Insecticide × Variety × Seed Technology	2	5.05	1.14	0.390
Regional Trials	Insecticide	2	0.02	16.28	0.932
	Seed Technology	1	0.81	3.98	0.339
	Insecticide × Seed Technology	2	0.98	0.49	0.712

Given the results of Table 7, means comparisons were performed by insecticide level and use of *PSSC* seed but are not shown in the top half of Table 8, as no statistically significantly differences were revealed. This is likely a function of the impact of zero-yield observations as well as the small number of replications. Also, since the degree of use of insecticide level does not appreciably change the carbon footprint per acre (Figure 1), dividing by statistically significant yield differences did not automatically also yield statistically significant CE per ear results. Nonetheless, the magnitude of change is large and always lower for PSSC seed than its conventional counterpart. Performing the analysis using location/season combinations as a fixed effect may prove to show some additional statistically significant results on carbon footprint per ear but these results would not be generalizable to the region and hence were not performed here.

Table 8. Mean carbon footprint per ear across location / season combination by insecticide level and seed technology for variety trial and regional trials.

Trial	Insecticide	Seed Technology: # of obs.	*CONV (carbon footprint per ear)*	# of obs.	PSSC *(carbon footprint per ear)*
Variety Trials	*FULL*	16	0.161	16	0.048
	HALF	16	0.134	16	0.054
	ZERO	12	0.255	16	0.046
Regional Trials	*FULL*	12	0.112	12	0.044
	HALF	5	0.187	8	0.062
	ZERO	4	0.070	12	0.040

Comparison of carbon footprint per ear means in the regional trial in bottom half of Table 8 also shows only numerical differences. Values using PSSC seed are consistently smaller than for conventional seed, and while the conventional values were lower in the regional trial when compared to the variety trials, the average values for the PSSC seed showed less variation in carbon footprint per ear numbers. This suggests that use of PSSC seed may add more consistency to carbon footprint per ear numbers as marketable yields are less prone to complete loss due to insect pests. Finally, as in the yield results, a lack of statistically significant differences across insecticide levels when using PSSC seed suggests that producers may safely switch from a conventional insecticide program to the *HALF* and/or *ZERO* application levels without affecting carbon footprint per ear.

Conclusions

Agricultural production in the United States has experienced increased demand from private industry and consumers to reduce GHG emissions associated with crop production and will likely receive similar attention from the government. The availability of varietal and technology-specific emissions data is thus tantamount for decision makers to provide either economic incentives for GHG mitigation or to determine ramifications of GHG mitigation regulations.

With this in mind, increased marketable yields of PSSC sweet corn compared to its conventional counterpart were primarily responsible for multifold reductions in GHG per ear for PSSC sweet corn. These effects persisted across variety (Obsession® and Passion®) as well as by insecticide application (*FULL*, *HALF* and *ZERO*). Marketable yield differences between conventional and PSSC seed technologies were significant and lead to a significant reduction of ears left in the field due to insect damage. Hence, the same number of acres of sweet corn will produce more marketable sweet corn with PSSC seed than conventional seed.

The relative contribution that various production inputs make toward total CE emissions per acre was also analyzed. The CE per acre differences were relatively small for reductions in insecticide use when compared to emissions from other sources, such as fuel and fertilizer input use, as well as soil N_2O emissions from nitrogen application. In essence, this fortified the finding that marketable yield improvements enhance CE emissions, albeit per ear rather than per acre, the most. While not statistically significant across region and production environment, two to threefold reduction in CE per ear using PSSC seed are expected to aid consumer acceptance of PSSC vegetables and provide agricultural policy makers with information about the value of biotechnology related to GHG mitigation.

Insignificant differences in marketable yield across all levels of insecticide use for PSSC seed supports further benefits of biotechnology. Using a combination of PSSC seed and likely one to three insecticide applications to control other pests not covered by the PSSC technology provides marketable yield greater than achievable with the current practice of full insecticide applications using conventional seed. This provides environmental benefits in the sense that both GHG emissions per acre and, more importantly, per ear, can be lowered. Lower input use coupled with higher yields could also potentially provide monetary benefits to producers, pending the cost of PSSC seed and consumer acceptance of PSSC sweet corn.

CE per acre and CE per ear results suggest that in combination with changes in yield across location some relocation of sweet corn production may be likely. Those locations that can markedly increase their yields because of improved earworm and other insect pest control by using PSSC seed, while at the same time reducing insecticide use, may see growth. Texas seems to be a logical place for this growth of sweet corn with imbedded seed technology due to its heat and high humidity, leading to high pest pressure, combined with large populations with high demand for sweet corn. Collection of additional data at the larger field level, at locations currently not producing sweet corn, will most likely support these findings and make them stronger by providing added statistical significance. This should allow for making producer recommendations under alternative seed cost and marketable ear price scenarios.

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Increased Purchases of Locally Grown Ethnic Greens and Herbs due to Concerns about Food Miles

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Abstract

The purpose of this study was to highlight locally grown ethnic greens and herbs purchases due to concern about food miles and associated impact on purchasing these greens and herbs. A telephone survey was conducted in 16 East Coast states and Washington D.C., May through October of 2010, to document ethnic consumers' behavior and demand for greens and herbs traditionally used in cuisine, important to their cultures. Data collected can be used to assist small and medium-sized farmers with better understanding consumer perceptions and factors that drive ethnic greens and herbs markets.

Keywords: ethnic consumers, purchasing behaviors, carbon foot print, logit model

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Introduction

As our food system becomes increasingly globalized, the number of miles that food travels from producer to consumer through its supply chain has rapidly expanded. In 2001, an estimated 39 percent of fruits and 12 percent of vegetables that Americans consume were produced in other countries (Pirog and Benjamin 2003). Exporting and importing of food can come with a high price; it can be environmentally critical, spoil regional economies, and hamper many aspects of local communities. Reducing food miles may support local farms, reduce dependency on fossil fuels, and help strengthen local economy and create more self-sufficient communities. The fresh fruit and vegetable trade has raised concerns about the distance that food travels, cost of food, freshness, and climate change associated with the transport. Several studies in the United Kingdom have also indicated that in 2002 the overall transportation contributed to 12 percent of Green House Gas (GHG) emissions (Garnett 2011) and food transportation alone contributed to 77 percent of carbon emissions and produced 19 million tons of carbon dioxide (DEFRA 2005). Buying locally grown produce can help reduce the environmental impact and costs of transportation.

In countries with vast amount of land, like the United States, food must travel great distances from source to market thus affecting energy cost and increases in food prices. According to 1969 data, food traveled an average of 1,346 miles (U.S. Department of Energy 1969) and Hendrickson (1996) estimated that fresh produce traveled 1,500 miles. In 1997 the average pound of fresh produce travelled 1,685 miles from farm to the main wholesale market in Baltimore, Maryland (Hora and Tick 2001), ultimately requiring a great amount of fossil fuels to transport these products. A Canadian study also found that each food item travels an average of 2,811 miles, producing 51,709 tons of greenhouse gas emissions annually (Xureb 2005). Most of fresh produce grown in the U.S. is transported by truck. This transportation cost is making the country increasingly dependent on foreign oil resources with record prices of fuel impacting produce cost. Most projections concluded that food prices would remain relatively high for many years to come because of expanded bio-fuel production, high oil prices, and increased international demand (Diao et al. 2008).

A goal of promoting locally grown foods is to provide a readily available, fresh, nutritious, safe, and sustainable food supply (Kaufman and Jongman 2004). While studying the local food system in Philadelphia, Kremer and DeLiberty (2011) found that only a small portion of the city's food is currently sourced locally. A strong local food system could also contribute to healthier eating practices and supporting local agriculture to develop better links between farmers and consumers, and greater community control over food issues. Locally grown produce travels fewer miles and consumes less fuel than produce transported from distant regions or countries. Locally grown fruits and vegetables are considered fresher as they are usually transported to market shortly after being harvested. There is also the perception that transporting fresh fruits and vegetables great distances can affect the taste and nutritional value. Previous studies have indicated that consumers feel that locally produced foods were more authentic and of higher quality (Boyle 2003; Lee 2000), fresher (La Trobe 2001), more nutritious, tasty, and safe (Seyfang 2004). These characteristics influence consumers' overall purchasing decisions. Most consumers look for attributes such as buying locally, promoting good health (Magnusson et al. 2003), protecting the environment (Lea and Worsley 2008; Pretty et al. 2005; Smith et al. 2005; Stagl 2002), and supporting the local economy (Chambersa et al. 2007). According to a fresh produce survey of New Jersey, respondents preferred Jersey Fresh produce to non-local produce (Govindasamy et al. 1998). Surveys conducted in Iowa, Missouri, Nebraska, and Wisconsin also indicated that consumers were more interested in purchasing locally grown produce (NCIFSP 2002). Studies conducted during 2006 in East Coast states found that 65 percent of Asian consumers (Puduri and Govindasamy 2011) and 80 percent of Hispanic consumers (Govindasamy and Puduri, 2011) were willing to buy locally grown ethnic produce.

Ethnic population concentration in the eastern U.S. is also one of the major reasons to focus and document ethnic consumers' behavior towards buying culturally significant greens and herbs. The 2010 Census results indicated that Hispanics and Asians were the fastest-growing minority population in the U.S. (U.S. Census Bureau 2010). According to the data, more than half of the growth in the total U.S. population between 2000 and 2010, 27.3 million, was because of the increase in the Hispanic population. Between 2000 and 2010, the Hispanic population grew by 43 percent, rising from 35.3 million in 2000 to 50.5 million in 2010, which was 16 percent of the total U.S. population. During this same period, the Asian population grew faster than any other major racial group, an increase of 44-3 percent. Asians were the second-largest population growing from 10.2 million in 2000 to 14.7 million in 2010 (U.S. Census Bureau 2010). The increasing immigrant population has led to a growth in the number of produce stores that cater to ethnic population in the region. Studies conducted throughout the region have shown that the rising demand for ethnic produce provides a potential opportunity for farmers in the region (Govindasamy et al. 2006; Mendonca et al. 2006; Sciarappa 2003; Tubene 2001). The main objective of this study was to predict ethnic consumer's increased purchases of locally grown ethnic greens and herbs due to concern about food miles. The study analyzes the results and compares the effects of ethnic consumers' socio-economic and demographic characteristics on their willingness to buy locally grown ethnic greens and herbs due to concerns about food miles.

Data

A telephone survey of consumers residing in 16 East Coast states (Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont and Virginia) and Washington D.C. by Perceptive Marketing Research, Inc. (Gainesville, Florida). A separate survey questionnaire was prepared in Spanish for those who were more comfortable responding in this language. The survey was conducted from May through October of 2010 to gather information to assist small and medium-sized farmers with better understanding consumer perceptions and factors that drive ethnic greens and herbs markets, specifically attitudes and behaviors of Asian Indian, Chinese, Mexican, and Puerto Rican consumers. In total, 1,117 completed survey responses were obtained from Chinese (276), Asian Indian (277), Mexican (280), and Puerto Rican (284) ethnic groups. Consumers who met the age requirement of 18 years and older, were the primary food shoppers for the household, and belong to ethnic groups of interest were interviewed. A logit model was developed based on a survey question relating to food miles and purchase of locally grown ethnic greens and herbs.

Model Framework

One of the survey questions respondents answered was whether they increased purchase of locally grown ethnic greens and herbs because of concerns about food miles, and based on this, a logit model was developed to predict the influence of increased purchase of locally grown ethnic greens and herbs. As for the model specification, the binary dependent variable was defined as one if the respondent increased purchase of locally grown ethnic greens and herbs due to concerns about food miles. This study analyzes consumers' likelihood of increased purchase of locally grown ethnic greens and herbs due to concerns about food miles in order to take advantage of such a scenario within the random utility discrete choice framework.

Following the random utility framework, every consumer faces a choice between increased purchase of locally grown ethnic greens and herbs due to concerns about food miles (dependent variable) and otherwise. The logit model was selected because of its asymptotic characteristics that constrain the predicted probabilities to a range of zero to one. Additionally, the logit model was favored given its mathematical simplicity and is often used in a setting where the dependent variable is binary. The estimation method utilizes the maximum likelihood estimation procedures (MLE) characterized as they provide consisted parameter estimates that are asymptotically efficient (Gujarati 1992; Pindyck and Rubinfeld 1991).

The relationship between dependent variable and socioeconomic characteristics was explored by modeling the indicator variable Z_i for the i^{th} consumer as a function of his/her socioeconomic and demographic characteristics as follows:

$$(1)\ Z_i = \mathbf{\beta X}_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} + \nu_i,\quad \text{i} = 1, 2, \ldots, \text{n}$$

Where x_{ij} denotes the j^{th} socioeconomic and demographic attribute of the i^{th} respondent, $\boldsymbol{\beta} = (\beta_0, \beta_1, \ldots, \beta_k)$ was the parameter vector to be estimated and ν_i was the random error or disturbance term associated with the i^{th} consumer. Under the logistic distributional assumption for the random term, the probability P_i was expressed as:

$$(2)\ P_i = F(Z_i) = F(\beta_0 + \sum_{j=1}^{k} \beta_j x_{ij}) = F(\mathbf{\beta X}_i) = \frac{1}{1 + \exp(-\mathbf{\beta X}_i)}$$

The estimated β-coefficients of equation (2) did not directly represent the marginal effects of the independent variables on the probability P_i. In the case of a continuous explanatory variable, the marginal effect of x_j on the probability P_i was given by:

$$(3)\ \partial P_i / \partial x_{ij} = \left[\beta_j \exp(-\mathbf{\beta X}_i)\right] \Big/ \left[1 + \exp(-\mathbf{\beta X}_i)\right]^2$$

However, if the explanatory variable is qualitative or discrete in nature $\partial P_i / \partial x_{ij}$ does not exist. In such a case, the marginal effect is obtained by evaluating P_i at alternative values of x_{ij}. For example, in the case of a binary explanatory variable x_{ij} that takes values of 1 and 0, the marginal effect is determined as:

$$(4)\ \partial P_i / \partial x_{ij} = P(x_{ij} = 1) - P(x_{ij} = 0)$$

The following empirical model is specified to capture the relationship between consumers' socioeconomic and demographic variables and increased purchase of locally grown ethnic greens and herbs due to concerns about food miles.

The description, means, and standard deviation of explanatory variables are shown in Table 1 (see Appendix). The vector of explanatory variables in equation (2) included socioeconomic attributes of ethnic consumer as well as variables related to consumers' demographic variables. The behavioral/perceptional and demographic attributes of ethnic consumers included were similar to a University of Guelph study exploring factors influencing the purchase intentions of Canadian consumers with respect to locally produced foods using likelihood method (Cranfield et al. 2008) and those included in a study of consumer response to state sponsored marketing programs: the case of New Jersey (Govindasamy et al. 1998) and those included in other analyses of consumer preferences for local products (Jekanowski et al. 2000). In addition, other consumer perceptions and behavioral attributes towards increased purchase of locally grown greens and herbs were also hypothesized to influence their choice. The following model was developed to predict characteristics of ethnic respondents increased purchases of locally grown ethnic greens and herbs because of concerns about food miles. The model framework and computed results were based on the LIMDEP Econometric Software (Econometric Software Inc. 2007).

$$\begin{aligned} \text{FOOD\_MILES} = {} & \beta_0 + \beta_1 \text{ BUY\_ETH\_STORE} + \beta_2 \text{ PROXIMITY} + {}+\beta_3 \text{ ETH\_EXP\_VISIT} \\ & + \beta_4 \text{ LANG\_SPEAK} + \beta_5 \text{ PACKG\_INFO} + \beta_6 \text{ STRAGR\_QULTY} \\ & + \beta_7 \text{ URBAN} + \beta_8 \text{ YEARS\_CUR\_LOC} + \beta_9 \text{ AGE17} + \beta_{10} \text{ 2Y\_COLG\_DEG} \\ & + \beta_{11} \text{ 4Y\_COLG\_DEG} + \beta_{12} \text{ POST\_GRAD} + {}+\beta_{13} \text{ INC>\$200K} \\ & + \beta_{14} \text{ FEMALE} + \beta_{15} \text{ INDIAN} + \beta_{16} \text{ MEXICAN} + \beta_{17} \text{ PUER\_RICAN} \end{aligned}$$

Results

Explanatory variables that were used in the logit model to predict which consumers have increased purchases of locally grown ethnic greens and herbs because of concerns about food miles are presented in Table 1. Among the explanatory variables, PROXIMITY, ETH_EXP_VISIT, YEARS_CUR_LOC, and AGE17 are continuous variables, and all remaining variables are defined as binary dummy variables. In Table 1, the continuous variables are explained in terms of average units and the binary dummy variables are explained in terms of percentage distribution. In total, 34% of ethnic consumers have increased purchases of locally grown ethnic greens and herbs because of concerns about food miles (FOOD_MILES) and the remaining 64% of them were not. Around 88% of respondents bought ethnic greens and herbs from ethnic stores (BUY_ETH_STORE) and 22% of them bought from typical American grocery stores, Community farmers' markets, on-farm markets or road side stands, pick-your own (PYO) and other sources. The average distance from residence to the nearest ethnic grocery store was about 8.07 miles. On average, each respondent's family spent (ETH_EXP_VISIT) about $23.85/per visit on ethnic greens and herbs. Around 31% of respondents felt that language the employees of the store speak is very important (LANG_SPEAK) when they purchase ethnic greens and herbs and 69% of them did not. About 43% of respondents felt that the information on the package is very important (PACKG_INFO) when they purchase ethnic greens and herbs and 53% of them did not. Only 34% of respondents strongly agree in finding and purchasing ethnic greens and herbs that are the level of quality (SRTAGR_QULTY) that he/she expects and desire. No hypothesis was made towards behavioral and perceptional attitudes of ethnic consumers.

Table 1. Variables used to predict ethnic purchases of local herbs and greens

Variable	Description	Mean Units/ Percentage	Std. Dev. Units/%
FOOD_MILES	1 if the respondent increased purchases of locally grown ethnic greens and herbs because of concerns about food miles; 0=otherwise	34%	48%
BUY_ETH_STORE	1 if the respondent tend to buy ethnic greens and herbs from ethnic store: 0=otherwise	88%	32%
PROXIMITY	Distance to the nearest ethnic grocery store	8.07	15.89
ETH_EXP_VISIT	Average expenditure per visit on greens and herbs	$23.85	$13.54
LANG_SPEAK	1 if the respondent felt that language the employees of the store speak is very important when they purchase ethnic greens and herbs;0=otherwise	31%	46%
PACKG_INFO	1 if the respondent felt that information on the package is very important when they purchase ethnic greens and herbs;0=otherwise	43%	50%
STRAGR_QULTY	1 if the respondent strongly agree in finding and purchasing ethnic greens and herbs that are the level of quality that he/she expects and desire; 0=otherwise	34%	48%
URBAN	1 if the respondent resides in urban area; 0=otherwise	47%	50%
YEARS_CUR_LOC	Average number of years living at current location	13.18	10.90
AGE17	Average number of people at age 17 or younger in a household	1.21	1.31
2Y_COLG_DEG	1 if the respondent had 2 year college degree; 0=otherwise	9%	28%
4Y_COLG_DEG	1 if respondent had 4 year college degree; 0=otherwise	18%	38%
POST_GRAD	1 if the respondent had post graduate or advanced degree; 0=otherwise	23%	42%
INC>$200K	1 if the respondent household income had $200,000 or more	4%	19%
FEMALE	1 if the respondent gender was female: 0=otherwise	66%	47%
INDIAN	1 if the respondent was Asian Indian: 0=otherwise	24%	43%
MEXICAN	1 if the respondent was Mexican: 0=otherwise	25%	43%
PUER_RICAN	1 if the respondent was Puerto Rican: 0=otherwise	26%	44%

In terms of demographic characteristics, among respondents, 47% of them were residing in urban areas (URBAN). The average number of years living at current location (YEARS_CUR_LOC) was about 13.18 years. The average number of people at age 17 or younger (AGE17) in a respondent's household reported was 1.21 persons. Among the respondents, 9% of them had an education of 2-year college degree (2Y_COLG_DEG), 18% of them had 4-years college degree (4Y_COLG_DEG) and 23% of them had post graduate or advanced degree (POST_GRAD). In terms of respondents annual household income, only 4% of them had income over $200,000 (INC>$200K). With respect to gender, 66% of females (FEMALE) and 44% of male were participated in this survey. Among the respondents, 24% of them were Asian Indians (INDIAN), 25% of them were Mexicans (MEXICAN), 26% of them were Puerto Ricans (PUER_RICAN), and 25% of them were Chinese. No priori expectations were made towards demographic characteristics of ethnic respondents.

Results from the logit model explain ethnic consumers' increased purchases of locally grown ethnic greens and herbs due to food miles. The model correctly predicted the outcome of the dependent variable in 66.04% of total observations (Table 2). The chi-square statistics rejected the null hypothesis that the explanatory variables as a set were insignificant in explaining variations in the dependent variable at 0.001 level and the McFadden's R^2 was 0.107. The χ^2 value was 93.91 with 17 degrees of freedom.

Table 2. Logit Model Predictive Accuracy

	Predicted		
Actual Value	**0**	**1**	**Correct Total**
0	654 (59.00%)	73 (6.60%)	727 (65.60%)
1	299 (27.00%)	82 (7.40%)	381 (34.40%)
Total	953(86.00%)	155 (14.00%)	1108 (100.00%)

Number of correct predictions: 736
Percentage of correct predictions: 66.4%
McFadden R^2: 0.07
Chi squared: 93.91
Degrees of freedom: 17
P-value=0.80 with degrees of freedom = 8
Overall Model Significance: 0.00

As the model results indicated (Table 3), BUY_ETH_STORE, PROXIMITY, LANG_SPEAK, PACKG_INFO, STRAGR_QULTY, POST_GRAD, INC>$200K and INDIAN variables are positively influencing on the increased purchases of locally grown ethnic greens and herbs due to food miles, whereas, URBAN, AGE17, and 4Y_COLG_DEG are negatively impacting on the increased purchases of locally grown ethnic greens and herbs due to food miles.

Since a limited literature exists in ethnic consumers produce study, the significant variables in this paper are compared with available general literature. As model results indicate in Table 3, among the respondents, those who tend to buy ethnic greens and herbs from ethnic stores (BUY_ETH_STORE) are 9% more likely to be willing to buy locally grown ethnic greens and herbs because of concerns about food miles compared to those who thought otherwise. In terms of proximity, those who travel more miles to the nearest ethnic grocery store are 0.03% more likely to be willing to buy locally grown ethnic greens and herbs due to concerns about food miles. Though the PROXIMITY variable is significant at 95% level but the impact on dependent variables is not economically significant. On average, each respondent is traveling about 8 miles to visit a grocery store (Table 1) and most of these ethnic populations are living in New Jersey, New York, Pennsylvania, Florida, Virginia, and Connecticut of eastern United States (U.S. Census 2000) and the majority of established ethnic grocery stores are near to these ethnic communities.

Table 3. Ethnic consumer increased purchases of locally grown ethnic greens and herbs because of concerns about food miles: Logit model estimates

Variable	Coefficient	Standard Error	t-ratio	Probability	Marginal Change
Constant***	-1.8711	0.3011	-6.22	0.0000	-0.41161***
BUY_ETH_STORE**	0.4537	0.2290	1.98	0.0476	0.0932**
PROXIMITY**	0.0014	0.0006	2.22	0.0266	0.0003**
ETH_EXP_VISIT	0.0002	0.0002	1.21	0.2278	
LANG_SPEAK***	0.5069	0.1673	3.03	0.0025	0.11461***
PACKG_INFO***	0.5588	0.1425	3.92	0.0001	0.12401***
STRAGR_QULTY**	0.3108	0.1398	2.22	0.0262	0.0694**
URBAN*	-0.0019	0.0010	-1.80	0.0718	-0.00041*
YEARS_CUR_LOC	0.0014	0.0009	1.48	0.1385	
AGE17**	-0.0014	0.0006	-2.24	0.0250	-0.00031**
2Y_COLG_DEG	-0.2766	0.1864	-1.48	0.1379	
4Y_COLG_DEG**	-0.3254	0.1490	-2.18	0.0290	-0.07157**
POST_GRAD***	0.6033	0.1418	4.25	0.0000	0.13272***
INC>$200K***	0.0005	0.0002	2.54	0.0112	0.00012***
FEMALE	0.2194	0.1443	1.52	0.1283	
INDIAN**	0.3811	0.1937	1.97	0.0491	0.08636**
MEXICAN	0.2732	0.2210	1.24	0.2162	
PUER_RICAN	0.0735	0.2176	0.34	0.7356	

*** Significant at 1%; **Significant at 5%; * Significant at 10%

Respondents who felt that the language the employees of the store speak is very important (LANG_SPEAK) are 11.5% more likely to be willing to buy locally grown ethnic greens and herbs because of food miles compared to those who thought otherwise. Since some of ethnic immigrants may not speak or understand English, these consumers would like to speak with customer service representative who speaks the same ethnic language. With respect to information on package, those who felt that the information on the package is very important (PACKG_INFO) when they purchase ethnic greens and herbs are 12% more likely to be willing to buy locally grown ethnic greens and herbs due to concerns about food miles compared to those who thought that the information on the package is not very important. In terms of level of produce quality, those who strongly agree in finding and purchasing ethnic greens and herbs that are the level of quality that they expect and desire (STRAGR_QULTY) are about 7% more likely to be willing to buy locally grown ethnic greens and herbs because of food miles compared to those who thought otherwise.

In the case of demographic variables, among respondents, those who had post-graduate or advanced degree (POST_GRAD) are 13.3% more likely to be willing to buy locally grown ethnic greens and herbs due to concerns about food miles compared to those who had up to high school education. Those who had income over $200,000 (INC>$200K) are 0.01% more likely to be willing to buy locally grown ethnic greens and herbs because of concerns about food miles compared to those had income less than $200,000. The variable INC>$200K is also similar to PROXIMITY and the impact on dependent variable is not sizable. Similar results were also found while studying willingness to buy locally grown ethnic produce items in east-coast US (Puduri and Govindasamy 2011). According to that study results, Asian ethnic consumers those had income over $200,000 were 0.01% more likely to be willing to buy locally grown ethnic produce items. Another Hispanic ethnic study was also found that those had less household income were less likely to be associated with willingness to buy locally grown produce (Govindasamy and Puduri 2011). It indicates that higher income is somewhat associated with willingness to buy locally grown produce compared to lower household income levels. Willingness to buy locally grown products increased with income in Indiana (Jekanowski et al. 2000). With respect to education and income levels, similar attitude found by other studies (Brooker and Eastwood 1989: Eastwood et al. 199; Govindasamy et al. 1998) in which general consumers were local food patrons and were more educated and earning above average income. In the case of ethnic dummy variable, Asian Indian (INDIAN) respondents are 8.6% more likely to be willing to buy locally grown ethnic greens and herbs because of concerns about food miles compared to Chinese respondents. The other ethnicities such as Mexicans and Puerto Ricans are not significant in this model.

Furthermore, respondents who live in urban areas (URBAN) are 0.04% less likely to be willing to buy locally grown ethnic greens and herbs due to concerns about food miles compared to those who live in suburban and rural areas. Southeast Missouri rural residents were also more willing to seek out local products than urban residents (Brown 2009). On the contrary, Patterson et al. (1999) discovered that the Phoenix metro area were more likely to prefer locally grown products. Respondents had more people at 17 or younger (AGE17) in their family are 0.03% less likely to be willing to buy locally grown ethnic greens and herbs due to concerns about food miles compared to those had fewer number of people at 17 or younger. Those who had four years college degree (4Y_COLG_DEG) are 7% less likely to be willing to buy locally grown ethnic greens and herbs due to concerns about food miles compared to those who had up to high school education.

Summary

Locally grown ethnic greens and herbs help reduce food miles and provide fresh produce to the local ethnic consumers while saving fuel costs. As the survey results indicated, 34% of ethnic consumers have increased purchases of locally grown ethnic greens and herbs because of concerns about food miles. As model results indicated, among respondents, those who tend to buy ethnic greens and herbs from ethnic stores, those who travel more miles to the nearest ethnic grocery store, those who felt that language the employees of the store speak is very important, those who felt that the information on the package is very important when they purchase ethnic greens and herbs, those who strongly agree in finding and purchasing ethnic greens and herbs that are the level of quality that they expect and desire, those who had post-graduate or advanced degree, those who had income over $200,000, and Asian Indians are more likely to be willing to buy locally grown ethnic greens and herbs because of concerns about food miles, whereas, those who lives in urban areas, those households have more number of people at 17 or younger, those who had four years college degree are less likely to be willing to buy locally grown ethnic greens and herbs because of concerns about food miles. These results may be useful to the local farmers in growing possible ethnic greens and herbs based on the demand and target markets.

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Assessing the Status of Farmers Markets in the Black Belt Counties of Alabama

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Abstract

The study used a case study approach and a survey questionnaire to collect data on farmers markets in the Alabama Black Belt. Specific objectives were to describe the current state of development of farmers markets, categorize the farmers markets, and make comparisons between and assessments of the various markets. The data were summarized and tabulated using descriptive statistics. A typology was developed with three categories and associated intervention policy or program attributes identified for farmers markets. It was found that there were three developed markets, all in urban areas; four developing markets, which had one market in the urban, two in the suburban, and one in the rural areas; and seven underdeveloped farmers markets, most of which were in rural areas. Consequently, it was recommended that for underdeveloped and developing farmers markets to move into the developed category, assistance must be provided with a mix of interventions that comprise facilities, proper organization, and efforts to strengthen the customer base. Such technical assistance will contribute to increased sales and economic activity in the communities.

Keywords: typology of farmers markets, market development, Black Belt counties, technical assistance, economic activity

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Introduction

Although agriculture's gross domestic product in Alabama is only 1.25 percent of the state total, it still represents one of the largest economic enterprises and provides a mainstay for its rural communities. A large majority of farmers in Alabama produce agricultural commodities on family or individual farms of 200 acres or less. Individual and family sole proprietorships account for 94 percent of these farms. Also, a majority of farms (nearly 99 percent) had sales of less than \$250,000, while less than 2 percent of Alabama farms had sales over \$1 million. According to the USDA-National Agricultural Statistics Service (2002), over 6 percent of Alabama farmers are Black or Native American, and approximately 11 percent are women, most of whom, gross less than \$20,000 annually, and therefore, are considered limited resource farmers.

Small and limited resource farmers make up a large portion of the farming operations in Alabama and minority farmers make up a disproportionate number of the socially disadvantaged and low income category. The challenges they face include the lack of information and low receipts due to relatively low prices received for their produce, which in turn, make technology and equipment hard to purchase. Other issues affecting limited resource farmers are related to the shortage of labor, limited access to insurance and credit, lack of appropriate technological information, the perception that farming is a low-income job, the realization that farming is a risky business, the issue of farmers not being able to meet their contract deadlines, and the necessity of appropriate marketing strategies for greater access to buyers (O'Sullivan 2005).

Direct marketing, in general, has thus been one the strategies promoted by government and land grant programs to help Alabama farmers increase their customer base and reduce the role of the middleman. It increases income for the producer and also helps other farmers like the large farmers who use direct selling methods to dispose of excess capacity and, in some cases, reduce operational costs (Tippins, Rassuli, and Hollander 2002). These direct forms of marketing include farmers markets, pick-your-own, roadside stands, farm stands, and wholesale markets.

Farmers markets, in recent years, have become one of the most popular forms of delivering fresh fruits and vegetables to consumers at specific locations, either through open lots or sheltering structures where farmers either rent stalls or set up displays for direct marketing (Tippins, Rassuli, and Hollander 2002). The growth in popularity of farmers markets has been variously attributed to factors of changing consumer interest and the changing economics of agriculture (Brown 2002). In Alabama, for example, the Alabama Farmers Market Authority (FMA) assists farmers in the marketing of agricultural products by providing information, leadership, and modern facilities necessary to move agricultural products from the farm to consumers. The intent is to provide the consumer with better quality products at reasonable prices and a fair return to the producer by providing a convenient, dependable place through which producers and consumers can meet, sell, and buy (FMA 2006).

Ashman et al. (1993), Hilchey, Lyson, and Gillespie (1995), and Festing (1998), for example, note that the benefits of farmers markets include economic stimulation and sustainability, enhanced vitality of the local economy, reduced produce prices for consumers, and increased produce quality. Abel, Thompson, and Maretzki (1999) explored the benefits of farmers markets and ways that Extension educators could help support and sustain these efforts in their communities. In surveys conducted in several farmers markets throughout the country, consumers ranked freshness as the main factor that they considered when buying produce. Consumers indicated that farmers markets provided freshness of produce. It was also found that farmers markets are also effective at keeping food dollars in a given region, and keeping family farms in business. When farmers markets are well managed, they can provide economic, nutritive, educational, social, and psychological benefits to vendors and the community. Extension's role in farmers markets is to help promote the growth of markets through education, advocacy, and advertising.

Focusing on the growth of farmers markets would require knowledge and understanding of their current growth levels. Most existing studies use a variety of factors to describe or classify farmers markets. Govindasamy and Nayga (1996) assessed the characteristics of customers patronizing farmer-to-consumer direct marketing centers in New Jersey. The results were expressed in terms of average number of visits per month to a direct marketing facility, average dollar amount spent per visit, and respondents' household family composition and annual income. Uva (2002) looked at direct marketing activities of vegetable farms in New York State and concluded that farmers markets were an important source of their income. And since many of those farms were considering expansion of direct marketing, it was necessary that more attention be paid to marketing and business management in order to ensure future profitability and success.

Kreesta (2005) examined the growth of farmers markets in Manitoba, Canada. A case study of 21 farmers markets showed that Manitoba farmers markets provided increased choice for both vendors and consumers, while providing many community benefits. He reported that contributions of farmers market go beyond the provision of agricultural products and include providing ways for people to make a living, build their communities, address issues of health, and create rural-urban and agricultural awareness. Farmers markets also create food security, and help rural and urban residents to diversify their household incomes.

Rural and low-income communities in general and those in the south in particular have not fared well in terms of sustained attention paid to the viability and role of their farmers markets. Fisher (1999) looked at farmers markets in low-income communities. Low-income people face many barriers in obtaining a healthy and nutritious diet including price considerations, lack of transportation, and food access. Farmers markets can play an integral role in providing nutrition education and access to healthy foods. Additionally, farmers markets can help foster cooking skills through recipe distribution, cooking demonstrations, and other similar activities. Fisher concluded that markets serving low-income consumers should consider weekend or evening hours of operation to accommodate the needs of working people.

Baker (2003) analyzed farmers markets in low-income neighborhoods based on results of a community-based research project undertaken in two low-income communities in Toronto. He found that farmers markets are under researched spaces, which offer a valuable place for the understanding of the theoretical and practical challenges involved in combining social justice and environmental sustainability. He also noted that low-income farmers markets force community food security advocates to simultaneously and creatively address disparate issues such as food and agriculture subsidies, organic agriculture, community economic development, public space revitalization, growing cultural diversity, poverty, urban sprawl, and farmland preservation.

The USDA Agricultural Marketing Service (2001) conducted a study on improving and facilitating a farmers market in a low-income urban neighborhood in Washington, DC. This study found that while the number of farmers markets in the United States has increased dramatically in recent years, many low-income customers, particularly in the urban areas, have not benefited from this growth. Also, many low-income customers in these areas have difficulty accessing fresh fruits and vegetables. Thus, the importance of location and publicity, in particular, should not be overlooked, and more signage, such as banners, would help to overcome this challenge. Customer surveys confirmed indeed that outreach into the community and semi-permanent signs are the most effective long-term methods of advertising.

Suarez-Balcazar et al. (2006) analyzed African Americans' perceptions of a local farmers market and access to healthy produce in a community in Washington D.C. The results showed that individuals living in low-income communities face many barriers in accessing fresh produce, such as lack of adequate transportation and high fresh food prices. Furthermore, the results showed that low-income Latino and African-American neighborhoods have fewer numbers of supermarkets that are easily accessible to them compared with higher income neighborhoods. The majority of community residents believed that they were underserved by the lack of farmers markets, since the local grocery stores lacked fresh, healthy, and organic produce at affordable prices. However, they were satisfied with the access to fresh fruits and vegetables provided by the summer farmers markets than they were with the access, quality, variety, and prices of produce available to them year round through local grocery stores.

Onianwa, Mojica, and Wheelock (2006) examined the characteristics and views of farmers market consumers. Consumers were randomly selected and interviewed in two selected markets—one in Huntsville and one in Birmingham. Results showed that when buying fruits and vegetables, consumers are interested in freshness, appearance, variety and selection of produce, availability of locally grown items, price and atmosphere of the store. It was also reported that Alabama consumers at these farmers markets thus generally prefer farmers markets to supermarkets.

Biermacher et al. (2007) used an example from a south-central region in rural Oklahoma to actually determine the net return from a mix of producing and on-site retailing of produce. The initial project intent was to provide farm producers with information regarding possible opportunities that might be available to them from small-scale production and retailing of fresh fruits and vegetables. Although the project did not generate a profit, results showed that a substantial number of consumers were willing to pay premiums for certain types of produce. However, there were not enough such consumers to overcome production and harvesting expenses.

And yet, government programs and resources at all levels and through the land-grant system-based research, extension, and outreach continue to promote the use of direct marketing and farmers markets by small-scale producers and consumers in rural and minority communities. These efforts would be much enhanced if there is better understanding of the different types, associated factors, and thus, the levels of development of the farmers markets. Fisher (1999) in particular classified farmers markets into two main categories depending on patronage. The first is about markets located in low-income neighborhoods, which are almost only attended by residents from that neighborhood. The second consists of markets located in low-income neighborhoods, but attract both low-income and wealthier consumers. Tiemann (2004) also assessed farmers markets in seven states and reported a great variety among farmers markets. However, he grouped them into two major categories, “indigenous” and “experience” farmers markets. The latter is a grower-only market, managed by farmers, and offering customers a unique experience along with the market produce.

It is obvious from the above that farmers markets will continue to vary greatly in size. They have certain characteristics in common, in that they feature small scale farmers and a wide variety of locally grown seasonal produce in vibrant settings at prices higher than those at other farmers markets. However, there is lack of current assessment on how well farmers markets are developed within a frame that uses key factors related to producers, consumers, the market infrastructure, and management itself. The purpose of this study was to assess the development of farmers markets in the Black Belt Counties of Alabama. Specific objectives were to describe the current state of development of farmers markets, categorize the farmers markets, and make comparisons between and assessments of the various markets.

Methods and Data

In order to determine the development level of farmers markets, (1) relevant variables were identified and selected from previous studies, (2) sample farmers markets were selected from Alabama Black Belt Counties, and (3) data collected from producers, and the farmer’s market managers. The variables identified and related parameters are as follows:

(a) Physical facility and management
 a. permanency
 b. proximity with urban, suburban or rural population
 c. open year around or seasonal
 d. paid staff or not
 e. full utilities or not
(b) Producer participation and perceptions
 a. limited to agricultural producers or not
 b. acceptance of farmers market nutrition program (FMNP) coupons
 c. observed or perceived size of participation
 d. perception of satisfaction with price received
(c) Consumer participation and perceptions
 a. observed or perceived size of participation
 b. perception of satisfaction with price paid
(d) Produce marketed
 a. limitation to fruits and vegetables
 b. other/no agricultural products

Data were collected from 16 farmers markets in 13 Black Belt Counties in Alabama. Each farmers market constituted a case study element. A case study is a form of qualitative research which looks at an individual or small participant pool and draws conclusions only about the participants group and only in specific context (Yin 2003). Data were collected through interviews of farmers or vendors and market managers through the use of survey questionnaires at the Bullock County Farmers Market, Crenshaw County Farmers Market, East Chase Farmers Market (Montgomery

County), Fairview Farmers Market (Montgomery County), Greene County Farmers Market, Hale County Farmers Market, Lowndes County Farmers Market, Macon County Farmers Market, Montgomery Curb Market (Montgomery County), Montgomery State Farmers Market (Montgomery County), Pineapple Farmers Market (Wilcox County), Selma Farmers Market (Dallas County), Sumter County Farmers Market, Thomaston Farmers Market (Marengo County), United Farmers Market (Greene County), and Uniontown Farmers Market (Perry County).

Farmer's market managers or coordinators and farmers were interviewed in summer of 2007. Convenience sampling was used to select farmers for the study. The information gathered was on their level and nature of participation as well as other information. Data were summarized and tabulated using descriptive statistics, and based on usable data from 14 farmers markets, 14 managers, and 34 producers, farmers, or vendors.

The use of the word "farmer" or "producer" in the text refers to sellers who were farmers. The word "vendor" refers to other sellers at the market, i.e., non-farmers who sold farm products. The words urban, suburban, and rural in the text were used to describe, respectively, areas in the city with large population, areas outside the city with lower population, and areas further away from the city and distinct from urban and suburban areas.

Results

Table 1 shows summarized key characteristics and a typology in three proposed development levels of farmers markets. The eleven observed attributes are: physical structure; salary support for the staff; seasonality of the market; sale of products limited to only products produced by the producers or not; participation limited to producers or not; farmers acceptance of the farmers markets nutritional program (FMNP) coupons or not; perception on prices being higher or not; limitation to the sale of locally grown produce or not; provision of utilities; level of participation by vendors and consumers; and if sale is limited to only fruits and vegetables or not. The three development levels of farmers markets are: developed, developing, and underdeveloped.

Table 2 represents the overall case profiles of the farmers markets. Based on the variables for categorization in the proposed typology, farmers markets were found to have similarities and differences as well as determination of markets as developed, developing, and underdeveloped markets. Three of the markets in the Alabama Black Belt Region were found to be developed (East Chase Farmers Market, Fairview Farmers Market, and Montgomery State Farmers Market), all of which were in the urban area, four were developing (Crenshaw County Farmers Market, Selma Farmers Market, Macon County Farmers Market, and Montgomery Curb Market), out of which one was found in the urban area, one in the suburban area, and two in the rural area. Seven farmers markets were found to be underdeveloped (Bullock County Farmers Market, Greene County Farmers Market, Lowndes County Farmers Market, Pineapple Farmers Market, Sumter County Farmers Market, United Farmers Market, and Uniontown Market Market) out of which two were found in the suburban area and five in the rural area.

Table 1. Proposed typology and observed attributes of Farmers Markets

Developed Market	Developing Market	Underdeveloped Market
Permanent facility	Permanent or temporary facility	Permanent or temporary facility
Paid staff	No paid staff	No paid staff
Opened year round	Seasonal market	Seasonal market
Sale of products is not limited Not limited to producers	Sale of products is limited Limited to producers	Sale of products is limited Limited to farmers
Not all farmers accept FMNP coupons	All farmers accept the FMNP coupons	All farmers accepted the FMNP coupons however not the WIC FMNP coupons
Higher prices	Lower prices	Lower prices
Both locally grown produce and produce from outside the local area	Both locally grown produce and produce from outside the local area	Locally grown produce
Full utilities	Some utilities	No utilities
Many vendors and consumers	Less number of vendors and consumers	Less number of farmers and consumers
Not only fruits and vegetables	Not only fruits and vegetables	Only fruits and vegetables

The developed farmers markets were situated under a permanent facility. They had full utilities, six or more farmers, a membership fee, a location in urban areas, paid managers, and hired workers who helped with the maintenance of these markets. Items sold at these markets were not limited to farm produce. There was a variety of produce to choose from and markets were usually opened throughout the year and not limited to the growing seasons. Prices at these markets were usually higher in comparison to other farmers markets. These markets attracted more consumers, most of whom were high income earners. They accepted FMNP coupons, and some of the vendors who did not accept the coupons were either because they were not certified to do so, or because they were not farmers. Some of these markets accepted the EBT card.

Farmers markets identified as developing were established in permanent or temporary facilities. They had about two to six farmers, and the markets were usually open-shed structures with no utilities, no managers, no membership fees, and were seasonal markets. In addition, these markets were situated in low-income communities, where most of the consumers are low income earners, and there is less patronage at these markets. The markets had no hired workers. Also, sale of produce at these markets was limited to only producers, only produce from the local areas are allowed, prices were much lower, and all these markets accepted FMNP coupons. However, not all accepted the EBT card.

Table 2. Frequency distribution of farmers markets per type and location

Markets	**Number**	**Percent**
Urban Area		
Developed Markets	3	75.0
Developing Markets	1	20.0
Underdeveloped	0	0
Total	4	100.0
Suburban Area		
Developed Markets	0	0
Developing Markets	1	33.3
Underdeveloped Markets	2	66.7
Total	3	100.0
Rural Area		
Developed Markets	0	0
Developing Markets	2	28.6
Underdeveloped Markets	5	71.4
Total	7	100.0
Urban Markets	4	28.6
Suburban markets	3	21.4
Rural Markets	7	50.0
Total	14	100.0
Developed Markets	3	21.4
Developing Markets	4	28.6
Underdeveloped Market	7	50.0
Total	14	100.0

The underdeveloped markets were all in rural areas and had no permanent facilities or utilities. The farmers met under a tree or in an open space where they just parked their trucks and sold their produce. Some vendors also met in front of buildings to sell, served mainly the low-income population, had zero to three vendors, who were mostly older farmers, had vendors who were inconsistent in attendance, no hired workers, and patronage of these markets was low. Only produce from the local area were allowed, and only producers were allowed at these markets. These markets were seasonal markets. The markets accepted only SFMNP coupons but not the WIC coupons.

The results of the profiles seem to add to those described by Fisher (1999) who reported two categories of low-income markets. The first was about markets located in low-income neighborhoods, which were almost only attended by residents from that neighborhood. The second consisted of markets located in low-income neighborhoods, but attracted both low-income and wealthier consumers. According to Fisher, the markets with only low-income consumers have trouble operating profitably. He argued that it was difficult for these markets to attract vendors, as volume of sales was low. They also tended to be dependent on subsidies. However, he argued that there were examples of successful markets in low-income communities as found in those long-established in a neighborhood.

In addition, the results are consistent with Tiemann (2004) who categorized two types of farmers markets as “indigenous” and “experience farmers” markets. These markets are a grower only market, they are managed by farmers themselves and offer consumers an experience along with the market produce, they vary greatly in size, they feature small- scale farmers, they offer wide varieties of locally grown seasonal produce in a vibrant setting, prices are higher than those of other farmers markets but near what is charged at grocery stores, they restrict sales by casual, distant, and large-scale growers, and competition among vendors is a non-price competition.

Summary and Conclusions

This study extends Fisher (1999) and Tiemann (2004) from a two-category classification to three types of farmers markets in terms of their development levels. This proposed typology of farmers markets uses and describes specific attributes and factors that can be the focus of government, land-grant, and local organization efforts to provide technical assistance, education, and resource support for better produce distribution in rural and Black Belt Alabama. Based on the individual profiles and the proposed typology of farmers markets, there were three farmers markets found to be developed and they were all located in urban areas. These markets had well developed physical structures, a paid staff, and a strong customer base with higher income patrons, and some of these markets had paid mangers to supervise market activities. Seven of the farmers markets were underdeveloped, most of which were the rural areas with small populations. Although some of these markets had well developed physical structures, their location in rural and near low-income communities did not allow for enough patronization of these markets. The remaining four markets were termed developing and were located in places between urban and rural areas. These markets have a mix of characteristics and attributes that could easily lead to less participation by producers and consumers, and could turn them into underdeveloped farmers markets.

Needed assistance for the developing and underdeveloped farmers markets would require a mix of interventions that comprise not only activities or items such as advertising, local promotion, and diversification of products sold, but also other things such as facilities, proper organization, and efforts to strengthen the customer base. Such a strategy or assistance will increase traffic and sales at these markets, and hence, generate much needed economic impact or activity in the communities. The findings of this study are important because first, they add to the literature by extending the typology of farmers markets, and second, the study recommends how underperforming and less developed farmers markets can be improved to benefit farmers, consumers, and community.

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