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Promoting Fruit and Vegetable Consumption

Are Coupons More Effective Than Pure Price Discounts?

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Promoting Fruit and Vegetable Consumption

Are Coupons More Effective Than Pure Price Discounts?

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Abstract

The U.S. Department of Agriculture administers food and nutrition assistance programs that promote fruit and vegetable consumption. But consumption remains relatively low among program recipients as well as among the general U.S. population. The perceived high cost of produce is often cited as a deterrent to more consumption. This study looks at coupons and price discounts, two methods of lowering the cost of fruits and vegetables, and uses household purchase data and a consumer demand model to examine each method. Coupons influence consumer behavior through a price-discount effect and an informational/advertising effect. Because of this dual effect, the use of a coupon to increase fruit and vegetable purchases may be more effective than a pure price-discount policy or other noncoupon promotion. Assuming a coupon usage rate of 10 to 50 percent, lowering prices through a "10 percent off" coupon would increase average weekly fruit and vegetable quantities purchased by 2 to 11 percent, as compared with a 5- to 6-percent effect for a pure price discount.

Keywords: fruit and vegetable consumption, coupons, price discounts, consumer demand, dual effect of coupons, informational advertising effects

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Summary

The U.S. Department of Agriculture administers food and nutrition assistance programs that promote fruit and vegetable consumption. But consumption remains relatively low, with price cited as the main deterrent.

What Is the Issue?

A price-discount strategy in conjunction with existing programs might encourage participants in food and nutrition assistance programs to consume more fruits and vegetables. This study looks at coupons and price discounts, two methods of lowering the cost of fruits and vegetables, and uses household purchase data and a consumer demand model to determine which method may be more successful in encouraging produce consumption.

What Did the Study Find?

Coupons influence consumer behavior through a dual effect—a price-discount effect and an informational advertising effect. Because of this dual effect, the use of a coupon to increase fruit and vegetable purchases may be more effective than a pure price-discount policy or other noncoupon promotion.

- For a 10-percent coupon usage rate, lowering prices by 10 percent with a coupon would increase average weekly quantity purchases by 2 percent for fruits and 2.1 percent for vegetables. (A "coupon usage" rate is defined as the percentage of purchases in which households use the coupon when buying fruits and vegetables in a given time period.) A 30-percent usage rate simulation shows a larger effect—over 6 percent for fruits and over 6.5 percent for vegetables—while a 50-percent usage rate shows just over a 10-percent effect for both fruits and vegetables.
- By comparison, a pure price discount of 10 percent would likely have about a 6-percent effect for both fruits and vegetables.
- If coupon usage turned out to be less than 30 percent, then the overall effect of coupons would be lower than a pure price-discount policy because the price discount applies to everybody (it has a 100-percent usage rate).
- The informational effect of coupons might decline as coupon use became more common or if coupons were distributed electronically instead of in paper form.
- Even a 10-percent increase in purchases of fruits and vegetables—the result assuming the highest coupon usage rate—would still leave consumption at about 65 percent of the recommended level of 5 or more servings a day.

The success of attempts to use coupons to increase consumption of fruits and vegetable by low-income households would depend on the distribution method (paper or electronic), on the number of households that actually use the coupons, on the size of the discount offered by the coupon, and on the coupon's ease of use.

How Was the Study Conducted?

This analysis relies on data from the 2004 Nielsen Homescan panel. The data include household purchase information for fruits and vegetables, coupon usage information, and households' demographic characteristics. The 2004 panel was made up of 8,482 households that reported purchases of products marked with bar codes as well as other purchases.

To estimate the dual effect of coupons on fruit and vegetable demand, the marked purchase renewal model was used, including three variables that may affect purchase quantity and/or frequency: (1) the gross price paid, (2) an indicator variable that tracks whether a coupon was used, and (3) the value of a redeemed coupon used during a given shopping trip. Elasticity estimates from the analysis then were used to conduct a simulation to compare the effect of coupons as compared with a pure price discount on fruit and vegetable purchase behavior.

Introduction

With growing evidence of an association between increased fruit and vegetable consumption and a reduced risk of obesity-related and other diseases such as stroke, cardiovascular disease, diabetes, and cancers, the U.S. Departments of Agriculture and Health and Human Services and other Federal agencies recommend that individuals consume more fruits and vegetables in their daily diets. Many of USDA's food and nutrition assistance programs, including the Supplemental Nutrition Assistance Program (SNAP) (formerly known as the Food Stamp Program), the WIC Farmers' Market Nutrition Program, the Senior Farmers' Market Nutrition Program, and various informational campaigns provide financial resources, increase the availability of fruits and vegetables, and educate Americans on how to make more nutritious food choices. However, Americans are not consuming the recommended amounts of fruits and vegetables (Dong and Lin, 2009).

Households that are eligible to participate in current food assistance programs have expressed the opinion that the high cost of a healthy diet, including fruits and vegetables, prevents them from eating better (Eikenberry and Smith, 2007). As part of the Food, Conservation, and Energy Act of 2008 (2008 Farm Act), Congress authorized $20 million for the Healthy Incentives Pilot to determine if incentives provided to SNAP recipients at the point of sale would increase the purchase of healthful foods, including fruits and vegetables.

We examined the effect of supplementing existing food assistance programs with policies that change the effective price of foods to improve consumer food choices. A price discount or coupon are two possible options to help overcome some of the perceived cost barriers associated with affording a healthier diet. Our analysis looked at potential effects of coupons versus other price discount plans to encourage fruit and vegetable consumption. We used household fruit and vegetable purchase data that include information on coupon usage to estimate the impact of coupons on all fruit and vegetable purchases, both fresh and processed, and compared the coupon effects to a pure price discount. If the effect of a coupon discount were larger than a pure price-discount effect, this would imply that a coupon strategy would be more effective than just a price discount to increase consumers' purchases of fruits and vegetables.

Currently, a number of canned and frozen fruit and vegetable manufacturers provide coupons to the general public in order to entice consumers to try new products and to increase the quantity of a given product that is purchased (increase market share). Some fresh produce distributors and retailers also have issued coupons for fresh fruit and vegetables in order to promote sales of these items. But the use of coupons for fresh fruits and vegetables is less common than the use of coupons for fruits and vegetables overall (including dried, frozen, and canned).[1] However, if coupons that could be used at any store chain or retail outlet type were provided by the Federal Government, those coupons might be used by more households than those issued by a single manufacturer or retailer since the Government-issued coupons would not be brand- or store-specific.

[1]Based on estimates from 2004 Nielsen Homescan data, described later in this report, about 11 and 9 percent of households used coupons for *fresh* fruit and vegetable purchases, respectively, as compared with about 20 and 12 percent of households that used coupons for *all* fruit and vegetable purchases, respectively, during the course of a year.

Previous studies have focused on the effect of coupon use on other foods and found that coupons have a significant impact on a household's demand for some types of foods. For example, there is a great deal of research that has focused on how coupons affect brand switching (Gupta, 1988; Neslin et al., 1985; Bawa and Shoemaker, 1987). However, few papers focus on how coupons are used to increase the demand for a food category in general. Pioneering work by Ward and Davis (1978) and a later study by Lee and Brown (1985) investigated the effects of coupons on Florida households' demand for frozen concentrated orange juice. Both studies revealed a significant, positive relationship between coupon redemption and product purchases. In a study by Dong and Kaiser (2005), coupon usage was found to be effective in expanding household cheese purchases. Although large-scale studies of coupons' effect on the purchases of fruits and vegetables are nonexistent in the literature to the best of our knowledge, there has been some recent work focusing on the related issue of the impact of vouchers on fruit and vegetable purchases. Herman et al. (2008) conducted an experiment by providing $10 vouchers for the purchase of fresh fruits and vegetables to WIC participants in Los Angeles and found statistically significant effects on the servings of fresh fruits and vegetables consumed.

Our objective here is to examine how coupons affect the demand for fruits and vegetables. In order to obtain the coupon effects on average fruit and vegetable purchases from our data, we investigate coupon influence on both the quantity and the *frequency* of a household's purchases. As a group, U.S. households make fruit and vegetable purchases irregularly. Some buy every week. Others may purchase once every few weeks. How much a household buys each week, on average, depends on the quantities it prefers to consume as well as the frequency of these purchase occasions. By determining how coupons affect both decisions—how often to buy and how much to buy—we are able to establish how coupons impact average weekly purchases.

It is possible that coupons cause only short-term purchase stockpiling without longrun consumption increases, as Helsen and Schmittein maintained (1992). We can test this hypothesis by examining coupon effects on both purchase frequency and purchase quantities during purchase weeks.

In addition to the ability to be provided to specific subgroups without influencing the price for the general population, coupons have a dual effect on consumption as compared with pure price discounts (Ward and Davis, 1978). First, the price discount associated with the coupon lowers the price for coupon holders. This effect is likely to generate the change in demand predicted by Dong and Lin (2009), who found that if prices are lowered by 10 percent, U.S. low-income households would increase their fruit purchases by 5.2 percent and their vegetable purchases by 6.9 percent. Secondly, coupons provide information about the existence or availability of foods, functioning as an "informational stimulant" (Ward and Davis, 1978). In other words, coupons remind consumers about the availability of fruits and vegetables, possibly causing a household to buy those foods on occasions when the household might not have done so otherwise. Due to this dual effect, a coupon-based incentive for fruit and vegetable purchases may have a bigger impact on demand than would pure price adjustments or increased information alone.

U.S. Fruit and Vegetable Purchases and Coupon Usage

We used 2004 Nielsen Homescan data to investigate the quantity and frequency of households' fruit and vegetable purchases as well as their associated coupon usage throughout the year. Nielsen Homescan data include information on the fruits and vegetables households bought for at-home consumption as well as the households' demographic information. Households that reported both random-weight and universal price code (UPC) purchases are used in this study since a large share of fruits and vegetables are purchased on a random-weight (non-UPC) basis. The data are recorded at the purchase/transaction level by households whose members use handheld scanners to record purchase information after each shopping trip. Recorded information includes the date of purchase, dollars paid, quantities purchased, coupon usage, and other product attribute variables, such as flavor, form, and container type. The raw purchase data were aggregated from daily transactions to weekly totals and combined with household demographic information for 8,482 households.

Weekly Produce Purchases Are Examined

Weekly purchase quantities and expenditures are defined as the sum of quantities and expenditures on all types of fruits or vegetables in all formats, including fresh, frozen, dried, and canned, that are purchased within a given week. A total of 52 weeks for each of the households is in our final sample. Among these 8,482 households, 131 did not purchase any fruits and 185 did not purchase any vegetables for at-home consumption during the sampling period.

Statistics calculated over purchase and nonpurchase households show that, relative to vegetables, fruits are purchased in larger quantities and at higher prices (table 1). On average, households purchase 1.56 and 1.02 pounds of fruits and vegetables, respectively, each week for at-home consumption. The histograms of purchase frequencies for fruits and vegetables of the sampled households show that purchasing households buy fruits, on average, in 21 of the 52 weeks (40 percent) and vegetables in 18 of the 52 weeks (35 percent) (see figs. 1 and 2). The average length of time between two purchases is 2.5 weeks for fruits (52/21 = 2.5) and 2.9 weeks for vegetables (52/18 = 2.9). In other words, on average, households make fruit and vegetable purchases roughly once every 3 weeks.

A comparison of purchasing and nonpurchasing household characteristics is helpful for determining potential determinants of fruit and vegetable demand and market penetration. The number of nonpurchase households is small, but the demographic differences are noticeable for both fruits and vegetables. Fruit and vegetable purchasers have slightly higher income ($3,000 to $4,000 more per year), larger household size (2.4 vs. 1.8 household members), and are more likely to have a female head of household employed at least 35 hours per week (table 1). This study focuses only on those households that purchased fruits or vegetables in order to estimate the impact of coupons on current purchasers. Future research on nonpurchase households also would be important in revealing the factors that hinder consumption of

Table 1
U.S. household weekly average purchases of fruits and vegetables, 2004

	Fruits			Vegetables		
	Non-purchasers	All purchasers	Purchasers with 2 or more purchase weeks	Non-purchasers	All purchasers	Purchasers with 2 or more purchase weeks
Purchases						
Number of households	131	8,351	8,145	185	8,297	8,096
Average quantity purchased per week, all weeks *(pounds)*		1.56	1.60		1.02	1.03
Average quantity purchased per week, purchase weeks *(pounds)*		3.84	3.91		2.89	2.90
Number of purchase weeks		21.1	21.3		18.3	18.5
Unit value *(dollars/pound)*		1.63	1.63		1.47	1.47
Household characteristics						
Household income *(dollars)*	51,183	54,320	54,332	50,149	54,364	54,371
Household size *(number of people)*	1.80	2.39	2.39	1.75	2.39	2.39
Age of female head *(years)*	48.8	51.9	52.0	49.6	51.9	51.9
Employment of female head *(proportion)*[1]	0.66	0.45	0.45	0.68	0.45	0.45
Education of female head *(proportion)*[2]	0.37	0.40	0.40	0.50	0.40	0.40
White households *(proportion)*	0.68	0.68	0.68	0.71	0.68	0.68
Black households *(proportion)*	0.15	0.14	0.14	0.16	0.14	0.14
Hispanic households *(proportion)*	0.07	0.08	0.08	0.05	0.08	0.08
Asian households *(proportion)*	0.02	0.03	0.03	0.03	0.03	0.03
Other race households *(proportion)*	0.08	0.07	0.07	0.05	0.07	0.07
East *(proportion)*	0.21	0.22	0.22	0.29	0.22	0.22
South *(proportion)*	0.44	0.39	0.39	0.32	0.39	0.39
West *(proportion)*	0.18	0.22	0.22	0.24	0.22	0.22
Central *(proportion)*	0.17	0.17	0.17	0.15	0.17	0.17

[1]Employment of female head: the female head of the household is employed at least 35 hours a week.
[2]Education of female head: the female head of the household had at least some college education.
Source: USDA, Economic Research Service.

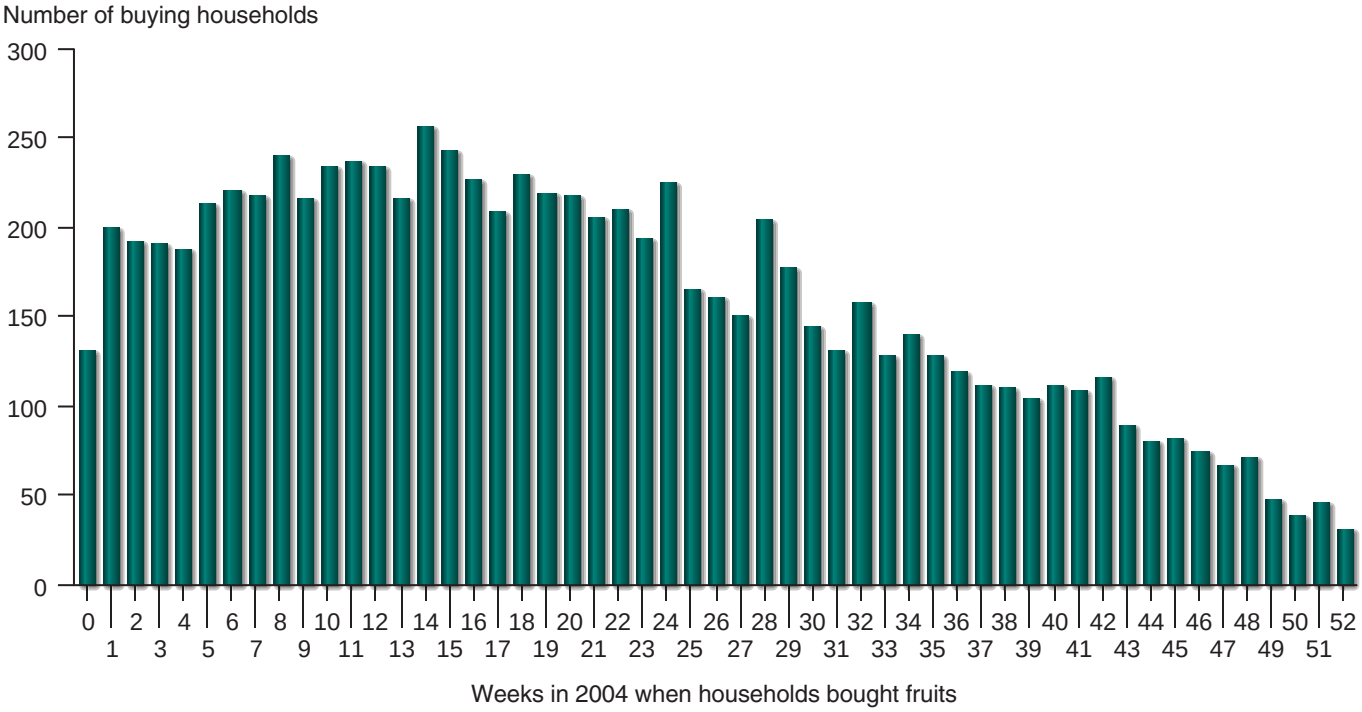
fruits and vegetables for those who currently choose not to purchase fruits and vegetables at all.

Coupon User Households Are Characterized

Household characteristics and purchase statistics for coupon users and nonusers show that among the 8,351 households who purchased fruit, 1,634 used coupons at least once during the year (19.57 percent) (table 2). The average value of redeemed coupons was about $1.55 in weeks when fruit coupons were used, implying about a 16-percent discount on fruit purchases for coupon users during weeks in which they used coupons. Coupon users made purchases in about 27 out of the 52 weeks and used coupons in about 4 out of these 27 weeks (14.81 percent).

Figure 1

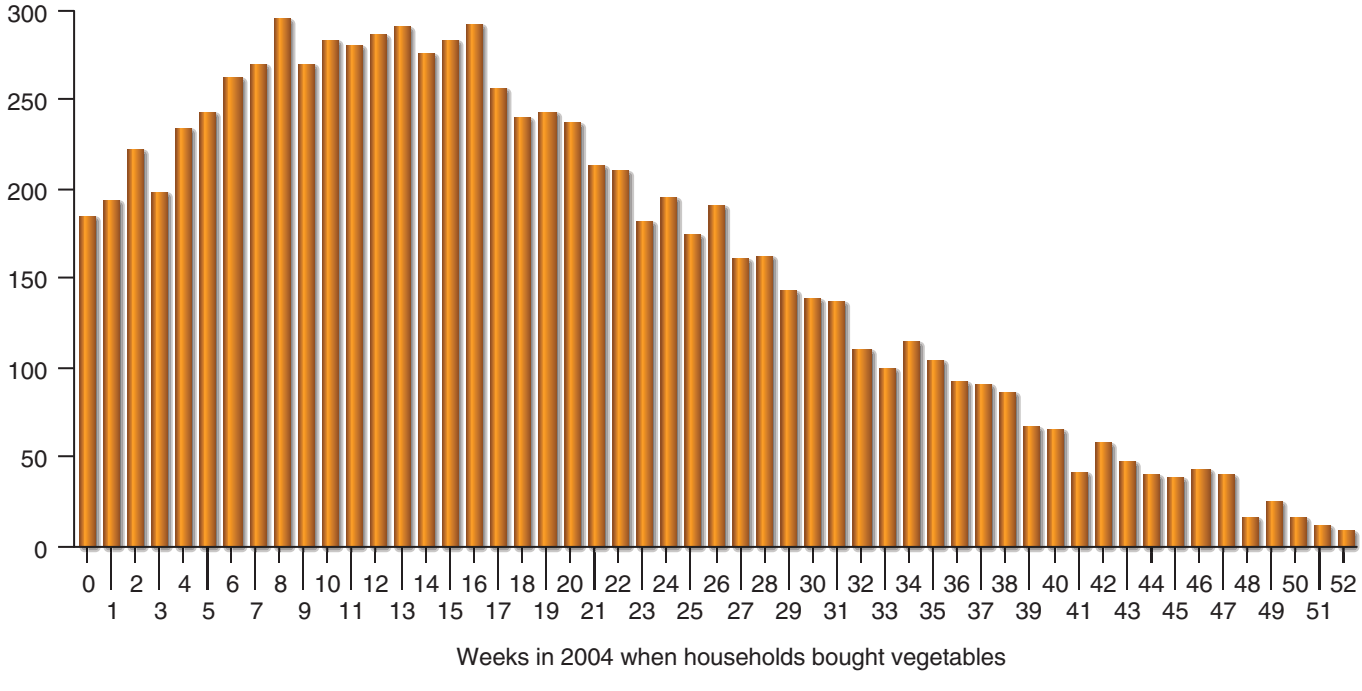
Fruit purchasing frequency among U.S. households, 2004



Source: USDA, Economic Research Service.

Figure 2

Vegetable purchasing frequency among U.S. households, 2004



Source: USDA, Economic Research Service.

Table 2

U.S. household weekly average purchases of fruits and vegetables with or without coupons, 2004

	Fruits				Vegetables			
	All	With coupons	Without coupons	Low income[1]	All	With coupons	Without coupons	Low income
Purchases								
Number of households	8,351	1,634	6,717	1,241	8,297	1,000	7,297	1,241
Quantity purchased over all weeks *(pounds)*	1.56	2.19	1.42	1.53	1.02	1.37	0.97	1.02
Quantity purchased over purchase weeks *(pounds)*	3.84	4.21	3.75	3.63	2.89	3.04	2.87	2.92
Quantity purchased over coupon-redeemed purchase weeks *(pounds)*	5.77	5.77	0	5.38	4.04	4.04	0	3.60
Number of purchase weeks	21.1	27.1	19.7	21.9	18.3	23.4	17.6	18.2
Unit value *(dollars/pounds)*	1.63	1.71	1.61	1.58	1.47	1.53	1.46	1.42
Coupon usage								
Coupon value over redeemed weeks *(dollars)*	1.55	1.55	0	1.53	1.23	1.23	0	1.19
Number of coupon-redeemed weeks	0.78	4.05	0	0.66	0.45	3.77	0	0.34
Household characteristics								
Household income *(dollars)*	54,320	57,518	53,542	17,794	54,364	56,939	54,010	17,892
Household size *(number of people)*	2.39	2.61	2.33	2.78	2.39	2.51	2.38	2.79
Age of female head *(years)*	51.9	51.8	52.0	51.9	51.9	53.2	51.8	51.8
Employment of female head *(proportion)*	0.45	0.38	0.47	0.18	0.45	0.35	0.47	0.18
Education of female head *(proportion)*	0.40	0.42	0.40	0.20	0.40	0.43	0.40	0.20
White households *(proportion)*	0.68	0.75	0.66	0.70	0.68	0.75	0.67	0.69
Black households *(proportion)*	0.14	0.10	0.15	0.16	0.14	0.10	0.14	0.16
Hispanic households *(proportion)*	0.08	0.06	0.09	0.12	0.08	0.06	0.03	0.13
Asian households *(proportion)*	0.03	0.04	0.03	0.01	0.03	0.04	0.09	0.01
Other race households *(proportion)*	0.07	0.05	0.08	0.01	0.07	0.05	0.07	0.01
East *(proportion)*	0.22	0.27	0.21	0.20	0.22	0.28	0.21	0.19
South *(proportion)*	0.39	0.33	0.40	0.46	0.39	0.28	0.41	0.46
West *(proportion)*	0.22	0.20	0.23	0.18	0.22	0.23	0.22	0.18
Central *(proportion)*	0.17	0.20	0.16	0.26	0.17	0.21	0.18	0.27

[1]The low income group includes households that have income up to 185 percent of the poverty level.

Source: USDA, Economic Research Service.

Fewer households used coupons for purchasing vegetables. Among the 8,297 vegetable-purchasing households, 1,000 used coupons (12.1 percent). The redeemed coupon values for vegetables were smaller in absolute terms than those for fruits, but similar as a share of the average amount spent. On average, $1.23 was redeemed over those weeks when coupons were used, implying about a 20-percent discount on vegetable purchases for coupon users during weeks in which they used coupons. However, households who used vegetable coupons used them a little more often relative to fruits. Among the 23.4 weeks in which vegetables were purchased, these households used vegetable coupons in 3.77 weeks (16.32 percent).

Compared with nonusers, coupon users purchased a greater quantity of food, paid higher original prices, and bought both fruits and vegetables more often. Household characteristics of coupon users and nonusers are quite different for some variables. On average, coupon users appear to have higher household incomes and larger household sizes. They also include a lower proportion of employed female heads, but a higher proportion of college-educated female heads. In terms of ethnicity, Caucasian households are more likely to use coupons than African-American households. Interestingly, coupon usage appears to be related to residential regions. Households in the South purchase vegetables more frequently, but redeem fewer coupons relative to people in other regions, such as those in the West and Central States. This may be caused by different levels of coupon availability across regions due to advertisers' different geographic strategies. The regional differences in coupon redemption also could be due to differences in food shopping behavior and/or store format type availability across U.S. regions.[2]

[2]See Leibtag (2006) for additional discussion of regional differences in store format types.

Applying the Marked-Purchase Renewal Model

Using the Homescan data as described, we estimated the dual effect of fruit and vegetable coupons and other variables on fruit and vegetable purchases. Coupons can provide information to consumers to alter their preferences as well as create a price discount to increase the likelihood of purchases. We separated the informational or advertising effect of coupons from the price-discount effect for both purchase quantity and frequency by using the marked-purchase renewal model originally developed by Cox and Oakes (1984) and later applied by Boizot, Robin, and Visser (2001). A statistical analysis follows (for more details, see appendix A).

The marked-purchase renewal model allows us to determine how coupons impact both the quantity and frequency of a household's food purchases. Specifically, the marked-purchase renewal model has two equations: one for the quantity purchased[3] and one for the interpurchase time (time between purchases). The interpurchase time measures the number of weeks elapsed between purchases. For example, if a household made a purchase in 26 out of 52 weeks, that household was recorded as typically allowing 2 weeks to elapse between purchases. Therefore, the interpurchase time is the inverse of the purchase frequency.

[3]Quantity purchased is defined as the total pounds of fruits or vegetables a household bought in the weeks when it made a purchase.

Households who bought fruits and vegetables on fewer than two occasions total are not included in this statistical analysis since no interpurchase time could be calculated for those households. However, we do not believe that dropping these households has a major impact on our analysis since the number of very infrequent buyers who purchased fruits and vegetables during only 1 week during the year are 337 (4.0 percent) and 386 (4.6 percent), respectively. Given the small proportion of dropped households (see table 1, columns 3 and 6), possible selection bias is expected to be negligible.

To estimate the dual effect of coupons on fruit and vegetable demand, we use both a continuous variable of the dollar value of coupons used by a household in a given week (coupon discount effect) and a dummy variable indicating whether any coupons were used in a given week. Since the first variable accounts for the response to the price effect of a coupon, the dummy variable that indicates use of a coupon is assumed to estimate the "nonprice" (informational/advertising) effect that is unique to the dual nature of a coupon. If this variable is statistically significant in either the purchase-quantity equation or the purchase-frequency equation, then we view this as evidence of the dual effect of coupons. If the combined effect of the coupon price discount and informational (dummy variable) effect are larger than the standard price effect, this would imply that a coupon strategy would be more effective than a pure price discount to increase consumers' purchases of fruits and vegetables.

To bolster the accuracy of our results, we also controlled for other factors that might influence households' behavior. Those factors included the price paid by a household during the previous purchase (lag price), following Boizot, Robin and Visser (2001), as well as a dummy variable that indicated whether purchases were made using noncoupon promotions such as store features or displays. In addition to price and promotion (coupon and other

activities) information, seasonality and a number of household characteristics are also incorporated as explanatory variables in the model. Tables 1 and 2 provide overviews of these household characteristics for purchasers (for all purchasers, those purchasers included in the estimation, and low-income households) and nonpurchasers as well as coupon users and nonusers.

Price, Season, and Household Characteristics Affect Produce Buying

Price and Information/Advertising

Our results show that coupons have a dual effect on the demand for fruits and vegetables. Both the coupon-discount effect and the coupon dummy variable (information effect) are statistically significant in both purchase quantity and purchase frequency equations (appendix A tables A-1 to A-3). However, to compare the effect of coupons to the standard response to a general price change, we must account for the fact that differences in prices may be a function of differences in the *quality* of fruits and vegetables purchased by a given household in the data. Since our data are aggregated across all fruit and vegetable purchases, some of the difference in prices (and subsequent difference in purchase behavior) may be a function of differences in the type of produce purchased. Thus, we calculate quality-adjusted elasticity estimates of the price effect (as detailed in appendix A) since an unadjusted elasticity estimate would be larger in magnitude than the true price elasticity (table 3).

We find that coupons have a statistically significant effect for both fruit and vegetable interpurchase time, reducing the time between purchases both from an informational effect and from a coupon-discount effect. The elasticity of interpurchase time with respect to the coupon dummy is -12.1 for fruits and -8.6 for vegetables. This implies that the use of coupons in a given week reduces interpurchase time by about 12 percent for fruit purchases and 8.5 percent for vegetable purchases. The additional effect of the actual redeemed value of the coupon, though statistically significant, is quite small in terms of the impact on interpurchase time dropping an additional fraction of a percent for both fruits and vegetables (table 3). To put these coupon effects in a broader context, note that a standard price effect has a small, but statistically significant effect on interpurchase time and the store or other promotion decreases interpurchase time by 0.02 percent for fruits and 3.8 percent for vegetables.

From both an information and a discount effect, coupons encourage households to buy a greater quantity of fruits and vegetables in the weeks in which they make a purchase. For fruits, the use of a coupon in a given week raises quantities purchased by 3.9 percent (information/advertising effect), while the actual discount value has a small but significant marginal effect (coupon-discount effect) as well. For vegetables, the information/advertising effect is even greater, increasing purchase quantities by over 10 percent, with again a small, but statistically significant, coupon-discount effect. Comparing these coupon effects to other price and promotion options, we find that the quality-adjusted standard price-discount effect would be an increase in fruit purchases of 5.5 percent and vegetable purchases of 5.6 percent for a 10-percent decrease in the shelf price, while store-based promotions increase fruit and vegetable purchases by 4.0 and 1.6 percent, respectively.

Seasons

Seasonality also plays a role in household fruit and vegetable purchases. For fruits, households purchase the least in the winter and most in the summer. For both fruits and vegetables, the time between purchases is longer in

Table 3
Elasticity estimates of purchase and interpurchase time equations for fruits and vegetables

	Fruits				Vegetables			
	Purchase quantity		Interpurchase time		Purchase quantity		Interpurchase time	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Number of households	3.9024	3.08	-12.083	-5.77	10.027	7.17	-8.5858	4.33
Coupon face-value effect	0.0092	6.26	-0.0004	-3.53	0.0031	2.63	-0.0007	-2.16
Shelf-price effect	-0.5466(*)	-11.16	0.0746	5.44	-0.5652(*)	-10.64	0.0064	3.97
Other, noncoupon promotion effect (dummy)	4.0445	7.46	-0.0179	-4.03	1.6068	4.64	-3.8470	-4.31
Household income	0.1046	2.67	-0.0633	-5.35	0.0821	8.74	-0.0473	-3.54
Household size	0.7613	9.12	0.1105	2.26	0.4153	3.48	0.2122	4.81
Age of female head	--	--	-0.5678	-19.2	--	--	-0.5202	-10.98
Employment of female head	-3.5500	-1.86	9.9305	3.77	-1.5596	-1.21	11.159	4.51
Education of female head	7.5804	3.83	-5.1563	-4.58	4.5077	3.35	-2.6065	-3.99
Black	8.8091	3.25	15.630	3.58	0.5287	0.32	17.066	7.61
Hispanic	14.779	3.93	-7.1803	-2.46	3.9749	1.98	-4.6573	-2.54
Asian	22.662	4.50	0.4979	1.07	18.713	5.77	-8.8954	-4.71
Spring	6.5526	7.22	-5.2757	-2.92	1.5256	2.30	-10.467	-3.35
Summer	39.605	2.43	5.9079	4.79	-0.3275	-0.42	5.5825	2.28
Fall	12.070	6.78	13.812	6.63	-0.7290	-1.23	19.802	4.88

(*) Prices are quality-adjusted. The estimates for unadjusted prices (unit value) are -0.6920 for fruits and -1.0104 for vegetables. See appendix A for the details of the adjustment.

(**) For the dummy variable, the elasticity is the percentage change in the dependent variable between the dummy taking the value 0 and 1.

Source: USDA, Economic Research Service.

summer and fall, but shorter in spring relative to winter. Households buy a small, but statistically significant amount more vegetables in the spring relative to other seasons (table 3).

Household Characteristics

Household characteristics shape tastes and preferences for fruits and vegetables and are important factors in determining purchase behavior. Higher-income households are found to purchase both fruits and vegetables in greater amounts and with greater frequency than lower-income households. Larger households purchase larger amounts of fruits and vegetables than smaller households, which is intuitive, but purchase fruits and vegetables less frequently.

Regarding household race and ethnicity, Caucasian households are found to buy fewer fruits per week relative to all other races, and fewer vegetables relative to Hispanic and Asian households. However, Caucasian households buy fruits and vegetables more frequently than African-American households. Hispanic households buy fruits most frequently, while Asian households buy the largest quantities of vegetables (table 3). As was mentioned before, fruits and vegetables in this study include all products (e.g., potatoes) and in all formats (e.g., frozen and canned).

Application of Results Through a Simulation

In order to get a sense of how the elasticity estimates presented here would translate into a hypothetical coupon policy created to increase fruit and vegetable consumption, we conducted a simulation exercise using the following scenario. Suppose that a Government agency supplied a paper coupon[4] to a targeted subpopulation. The coupon would be valid for 10 percent off the price of any fruit and vegetable purchased in a given time period. Given the inverse relationship of purchase frequency and interpurchase time, we can use our elasticity estimates to simulate the impact of this hypothetical 10-percent off all fruit and vegetable prices to contrast with a standard (noncoupon) price discount. We use the elasticity estimates from table 3 to estimate the impact of this coupon plan on fruit and vegetable purchases and compare the dual effect from the coupon to the predicted effect from a noncoupon price discount.

A key driver of this analysis is the coupon usage rate assumed in the policy simulation.[5] It is uncertain exactly what share of eligible households that receive this coupon would actually use it when making fruit and vegetable purchases. Standard manufacturer coupons are usually used at a low rate, partially due to the untargeted nature of the distribution of these types of coupons and partially due to the fact that most coupons are brand- or product-specific. For example, in the 2004 Homescan data used in this study, coupons were used in the purchase of fruits in 3.7 percent of the purchase weeks, while coupons were used in 2.5 percent of the purchase weeks for vegetables. However, the Homescan data used in our analysis also showed that 12 to 20 percent of households used coupons at least some of the time when purchasing fruits and vegetables, implying that increasing the *frequency* of usage by current coupon users may be possible.

Although one might argue that the usage rate in our policy simulation would be lower than the observed rate in Homescan since low-income households may have lower initial preferences for fruits and vegetables, we believe that the usage rate is more likely to be larger because:

1. the targeted (low-income) population would have more ready access to the coupons and may be more price-sensitive than the overall Homescan population, and
2. the coupons would be usable for all fruits and vegetables, not just a specific brand or type.

How *much* higher the usage rate would be is an open question, but there is some evidence that a targeted coupon can yield significantly higher usage rates. For example, the 2008 Government Accountability Office report *Food Stamp Program: Options for Delivering Financial Incentives to Participants for Purchasing Targeted Foods* cites results from pilot studies that show usage rates of coupons to targeted groups to be over 80 percent.[6] We calculate the effect of the 10-percent coupon at three possible usage rates: 10, 30, and 50 percent (table 4).[7]

[4]Our analysis is based on conventional paper coupons. Additional testing of distribution methods would be needed before fully applying our results from paper coupons to electronic methods of distribution and/or redemption.

[5]It should be noted at this point that some of the coupon research literature focuses on coupon redemption rates, defined as the number of redeemed coupons divided by the total number of *coupons distributed* by manufacturers and retailers. This redemption rate is usually smaller than the coupon usage rate discussed and used here. A coupon usage rate is defined as the percentage of purchases in which households use a coupon when buying fruits and vegetables in a given time period.

[6]The 2008 GAO report also discusses the relative strengths and weaknesses of paper versus electronic coupons.

[7]Results of the simulation with usage rates of 1, 5, and 100 percent are also available from the authors upon request and details of the simulation estimation procedure are provided in appendix B.

Table 4

Simulation results comparing the percentage changes in purchase quantity and purchase frequency of fruits and vegetables for a pure price discount and a 10-percent-off coupon by coupon usage rate, 2004[1]

	Fruits				Vegetables			
	Pure price effect	Coupon effect			Pure price effect	Coupon effect		
		10% usage rate	30% usage rate	50% usage rate		10% usage rate	30% usage rate	50% usage rate
Purchase frequency: Total effect	0.75	1.31	3.98	6.73	0.06	0.91	2.88	4.85
Advertising/information effect		1.30	3.94	6.66		0.90	2.73	4.59
Coupon discount effect		0.01	0.04	0.07		0.01	0.15	0.26
Quantity during purchased weeks: Total effect	5.47	0.69	2.07	3.45	5.65	1.23	3.70	6.16
Advertising/information effect		0.39	1.17	1.95		1.00	3.01	5.02
Coupon discount effect		0.30	0.90	1.50		0.23	0.69	1.14
Average weekly quantity[2]: Total effect	6.22	2.00	6.11	10.31	5.71	2.14	6.66	11.24
Advertising/information effect		1.69	5.17	8.74		1.90	5.82	9.84
Coupon discount effect		0.31	0.94	1.57		0.24	0.84	1.40

[1]See appendix B for details of how these calculations are derived from the elasticity estimates of table 3.

[2]The average weekly quantity effect is the sum of the effect from purchase frequency and quantity purchased during purchased weeks.

Source: USDA, Economic Research Service.

For the 10-percent coupon usage rate case, we find that lowering prices by 10 percent with a coupon would increase average weekly quantity purchases by 2 percent for fruits and 2.1 percent for vegetables, with the informational/advertising effect comprising 85 percent of the total coupon effect for fruits and 89 percent of the total effect for vegetables.[8] The 30-percent usage rate simulation shows, not surprisingly, a larger effect—over 6 percent for fruit and over 6.5 percent for vegetables—while the 50-percent usage rate simulation results show just over a 10-percent effect for each category (table 4), These overall effects are a function of both aspects of the coupon, with the information effect dominating the price-discount effect, not surprising given the low relative value of most paper coupons.[9] Our results show that merely the use of a coupon at all for a given purchase increases the quantities purchased over time regardless of the exact amount of the coupon discount within the normal range of coupon values (usually anywhere from $0.25 to $1.50 off). The sum of the coupon effects can be contrasted with a standard (noncoupon) price effect of 6.2 percent for fruit and 5.7 percent for vegetables that would arise from a price discount alone. This implies that the effectiveness of a coupon policy as compared with a pure price discount is a function of exactly how often consumers actually use the coupons they are given. If consumers use coupons more than 30 percent of the time, then the effect on fruit and vegetable purchases will be larger than that which would result from a pure price discount, assuming that our estimated underlying effects do not decline as usage rates rise. If usage turned out to be less than 30 percent, then the overall effect of coupons would be lower than a pure price-discount policy.

[8]Without reporting a coupon usage rate, Ward and Davis found that at the price of 0.5 cent/ounce, a 5-cent coupon would increase frozen concentrated orange juice purchases by about 30 percent. They estimate that, at the price of 1 cent/ounce, a 5-cent coupon would increase frozen concentrated orange juice purchases by about 12 percent, where the informational/advertising effect of a 5-cent coupon would be 75 percent to 95 percent of the total coupon effect given the price range of 0.5 cent/ounce to 1 cent/ounce.

[9]The informational/advertising effect is 85 to 89 percent of the total effect in each of these simulations.

In our simulation estimates based on the traditional paper coupon, we assume that the information effect of coupons would not be diminished by an increased use of coupons. One could argue that the informational effect of coupons *would* decline as coupon use became more common since the added boost from additional information about the availability of discounted fruits and vegetables unique to a coupon would not be as large once consumers became accustomed to the coupons. Another argument is that the *form* of coupon distributed may impact usage rates and information effects. For example, a paper coupon may have a larger information effect, but lower usage rate, than an electronic coupon. However, it may also be the case that the coupon *price-discount* effect would increase with electronic coupons and approach the pure price-discount effect as usage rates increase, implying that as long as some positive information effect remains from a coupon that coupons would provide a larger overall impact than would a pure price discount alone.

There are also some more general concerns regarding the implementation of a coupon policy:

- The data used in our study is for the overall population using coupons available to any consumer, while a targeted coupon policy would be restricted to use by only certain consumers and therefore negative stigma associated with coupon use may be a problem regarding potential usage rates.
- Our data include all fruit and vegetable purchases (for at-home consumption), but most coupons are not for fresh fruits and vegetables. Previous work has shown that coupons work well for branded items. A pilot or test program would be appropriate to compare the effect of coupons on fresh versus canned/frozen produce to see if the effects we estimate, and then simulate from, are, in fact, applicable on a larger scale.
- Coupons have the potential to be sold, if they are transferable. This may be a good reason to implement the coupons electronically with a safeguard that ensures exclusive use by the intended individual or group.
- As with any suggested program or policy, the full costs of implementation need to be compared with an estimate of social benefits from increased consumption of fruits and vegetables and the related health and nutritional impacts before any wide-ranging program is implemented.

Additional research or a pilot study could address:

1. how low-income households compare with higher income households in coupon usage.
2. how coupons made available only to qualifying low-income households would differ in usage as compared with those currently made available to the general public.
3. the extent to which coupon usage would differ if coupons were distributed via a Government program as compared with manufacturer coupons.

4. how product or brand-specific coupons differ from more general coupons.

5. how consumers would respond to a more general coupon that would include fresh fruits and vegetables, which do not often have coupons available in the current retail environment.[10]

[10]One exception to the general lack of coupons or price discounts in the retail market for fruits and vegetables is the recent development of programs that provide vouchers for purchase of fresh fruits and vegetables at farmers markets. Over the past 5 years a number of farmers markets, charitable foundations, local governments and nonprofit organizations have collaborated on pilot programs to improve the health and nutrition of low-income families by offering vouchers that can be used to buy fruits and vegetables at farmers markets. These vouchers provide what is in effect up to a 50-percent discount on fruit and vegetable prices and are used by over 80 percent of recipients when distributed at the point of purchase (at the farmers market). Schumacher et al. (2009) provides details for a number of these programs that are currently run in New York, Massachusetts, Maryland, and California.

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Appendix A: Marked Purchase Renewal Model With Coupon Effects

The marked purchase renewal model is also called a marked failure time model (Cox and Oakes, 1984). This model contains two equations: interpurchase time and purchase quantity. The interpurchase time (the duration separating consecutive nonzero purchase weeks) represents the failure time, and the quantity bought represents the mark. In the marked purchase renewal model, each purchase is interpreted as a failure of maintaining the nonpurchase status, and the length (number of weeks) of nonpurchase and the amount of purchase are both determined by the household's demographic and social economic variables.

The length of nonpurchase status or the interpurchase time is modeled as a random variable that follows a certain probability distribution. By definition, the distribution of interpurchase times in a market captures the effect of the time elapsed since the last purchase on the timing of the next purchase. This distribution, in general, is also influenced by marketing variables and household characteristics. In the existing literature, the hazard function approach is widely used to model the effects on interpurchase time (Kiefer, 1988). The hazard function is the conditional probability that an event will occur after a given period of time based on the amount of time already passed, contrasted with an unconditional probability of the duration of time between two events under any circumstances. The hazard function, in other words, is the rate at which events occur. By definition, the hazard function needs only to be finite and nonnegative, whereas the probability-density function must also integrate to one, so use of the hazard function is easier to model in practice, which makes it an intuitively appealing method by which to study purchase-timing decisions (Jain and Vilcassim, 1991).

In our econometric model, we assume that household i faces an occasion to purchase a good. The purchase occasion is measured in calendar time, in our case, in weeks.[1] We further define D_{t_i} as the time in weeks that has passed between the last purchase of that good and purchase occasion t_i. If we use t_i to index all of household i's purchase occasions, and t_i is the series number of 1, 2, until T_i, then D_{t_i} is the interpurchase time and is a random variable that follows a certain distribution. T_i is the actual total number of purchase occasions or the total number of the interpurchase times household i experiences. The value of T_i varies across households. The hazard function of D_{t_i} can be defined as

$$(1) \qquad \lambda(D_{t_i}) = \alpha\theta_{t_i}^{\alpha} D_{t_i}^{\alpha-1}\varepsilon_i,$$

where $\theta_{t_i} = \exp(W_{t_i}\gamma_1 + V_{t_i}\gamma_2 + C_{t_i}\gamma_3 + F_{t_i}\gamma_4)$ and W_{t_i} is a vector of household-related variables; V_{t_i} is the unit value (price per pound) paid by household i at time t_i without any adjustment for coupon use; C_{t_i} is a dummy variable indicating whether at least one coupon was used in a given week or not; F_{t_i} is the dollar value sum of all redeemed coupons in a given week; γs are parameters; ε_i represents a household-specific effect that is not included in W_{t_i}, V_{t_i}, C_{t_i}, and F_{t_i}; and α is the hazard parameter.

[1]The interpurchase time could be defined as number of days as did, for example, Helsen and Schmittlein, 1992. We use weekly data instead of daily to stabilize the estimation of the quantity equation. A great number of daily transactions of fruits and vegetables are very light, for example, a clove of garlic, a bunch of green onions, etc. The possible bias of using weekly data could be small, since most households do grocery shopping on a weekly basis according to the 2004 Nielsen panel data.

Equation (1) implies that the hazard function of interpurchase time D_{t_i} (i.e., the probability of a household making a purchase given that no purchase has been made up to time D_{t_i}) depends on D_{t_i}, the interpurchase time, in a monotonic relationship. Equation (1) belongs to a Weibull family, and the hazard function increases in duration (D_{t_i}) if $\alpha > 1$, decreases if $\alpha < 1$, and is constant if $\alpha = 1$.[2] Thus the Weibull distribution captures the various duration dependencies in the value of α. Duration dependence indicates that the conditional purchase probability increases or decreases with the time elapsed since the last purchase. If the probability increases with the time elapsed since the last purchase, it is called a positive dependence. If the probability decreases with the time elapsed since the last purchase, it is called a negative dependence. If the probability remains the same as time elapses since the last purchase, it is called an independent duration. In the last case, the conditional distribution of D_{t_i} is exponential with parameter θ_{t_i}. The estimation of (1) can be obtained by maximizing the marginal log likelihood function proposed by Boizot, Robin and Visser (2001).

[2]The Weibull distribution is a 2-parameter family, in contrast to the 1-parameter exponential distribution. First identified by Maurice Frechet in 1927 and later described in detail by Walloddi Weibull in 1951 and named after Weibull, the Weibull distribution is more flexible in the statistical analysis of duration data.

The household purchase amount is defined as[3]

$$(2) \qquad Q_{t_i} = X_{t_i}\beta + V_{t_i}\beta_1 + C_{t_i}\beta_2 + F_{t_i}\beta_3 + u_{t_i}$$

where Q_{t_i} is the i^{th} household's purchases of the commodity (with the commodity index suppressed) at time t_i; X_{t_i} is a vector of socio-economic and demographic variables; V_{t_i} is the logarithm of the unit value (price per pound); C_{t_i} is the coupon dummy variable, and F_{t_i} is total dollar value of all coupons redeemed in a given week as defined in equation (1); βs are parameters to be estimated; and u_{t_i} is an error term. There are a number of ways to incorporate coupon effects into a demand function (e.g., the net-price method (Chintagunta et al., 1991) and the separating-redeemed-value method (Dong and Kaiser, 2005)). The net-price method suffers from biased model estimates since the coupon discount is included in the net price, while the separating-redeemed-value method does not allow for both the price and informational effects of coupons to be estimated. We therefore follow the method discussed in Silva-Risso and Bucklin (2004) in equations (1) and (2), as this seems to be the most appropriate method to capture coupon effects in this context. The use of both a coupon dummy and coupon discount value is necessary because coupon usage rates increase with coupon face values (Blattberg and Neslin, 1990). The potential inflation or deflation of redemption rates due to coupon face values can be controlled by incorporating redeemed coupon values in the model (Silva-Risso and Bucklin, 2004).

[3]It would be ideal to estimate a structural model in which the interpurchase time variable is explicitly included in the right hand side of the quantity equation in order to find the direct effect of interpurchase time on quantity. But the model would be hard to estimate given the Weibull distribution of the hazard function. The model we estimated is a reduced form. Though we don't have the direct effect of interpurchase time on quantity, we do have the unbiased estimates of coupon effects on both interpurchase time and quantity.

Since V_{t_i}, the unit value (price per pound) in (1) and (2), is derived from the observed expenditure and quantity purchased in a given week, it is an endogenous variable not truly independent of the quantity purchased in a given week, so we define it as a function of Z_{t_i}, a vector of socio-economic and demographic variables to address this endogeneity issue:[4]

$$(3) \qquad V_{t_i} = Z_{t_i}\alpha + v_{t_i},$$

where v_{t_i} is an error term. In order to capture household heterogeneity effects, both u_{t_i} and v_{t_i} are assumed to have an error component structure (Greene, 2000). The predicted value of V_{t_i} from equation (3) is used in the estimation

[4]The coupon value, like the unit value price, may also be considered an endogenous variable. For example, Dong and Kaiser (2005) and Erdem, Keane, and Sun (1999) address this possibility by defining an additional coupon redemption equation. In their studies, the missing values of coupon usage for nonpurchase observations are determined simultaneously with the purchase amount. This procedure is necessary to correct for the selectivity bias when all the observations including zero purchases are used. In this study, however, we avoid the selectivity problem by using only the positive purchase observations together with the interpurchase time analysis.

of (1) and (2). The maximum likelihood estimation procedure is adopted to obtain parameter estimates of equations (1) to (3).

The parameter estimates of (1) to (3) are presented in appendix tables A-1 to A-3. The estimated hazard parameter (α) for the duration is 1.29 for fruits and 1.26 for vegetables, and both are greater than 1, indicating that the hazard function increases monotonically. This means that the probability of purchase at the present time increases as the time from the last purchase becomes longer.

The estimated coefficients presented in appendix tables A-1 to A-3 can be transformed into elasticities. To do so, we evaluate the coefficients of interest at the predicted values of the interpurchase time, the quantity purchased and the unit value. The prediction of unit values and purchases using (2) and (3) is straightforward:

$$(4) \qquad E(V_{t_i}) = Z_{t_i}\alpha$$

$$(5) \qquad E(Q_{t_i}) = X_{t_i}\beta + V_{t_i}\beta_1 + C_{t_i}\beta_2 + F_{t_i}\beta_3.$$

The prediction of the time between purchases is a bit more complex, but can be obtained as follows. According to Lancaster (1990), the hazard function can be rewritten as

$$(6) \qquad ln(D_{t_i}^{\alpha}) = -ln(\theta_{t_i}^{\alpha}) + ln(\pi),$$

in which π follows a type 1 extreme value distribution, and

$$(7) \qquad E(D_{t_i}) = m(\pi^{1/\alpha}) \cdot \exp(-W_{t_i}\gamma_1 - V_{t_i}\gamma_2 - C_{t_i}\gamma_3 - F_{t_i}\gamma_4),$$

where $m(\pi^{1/\alpha})$ is the $1/\alpha$ moment of π. The marginal effect of the explanatory variables W_{t_i}, V_{t_i}, C_{t_i} and F_{t_i} on the interpurchase time D_{t_i} can be derived as

$$(8) \qquad \frac{\partial E(D_{t_i})}{\partial H_{t_i}} = m(\pi^{1/\alpha}) \cdot \exp(-W_{t_i}\gamma_1 - V_{t_i}\gamma_2 - C_{t_i}\gamma_3 - F_{t_i}\gamma_4) \cdot (-\gamma) = -E(D_{t_i}) \cdot \gamma.$$

where $H_{t_i} = (W_{t_i}, V_{t_i}, C_{t_i}, F_{t_i})$ and $\gamma = (\gamma_1, \gamma_2, \gamma_3, \gamma_4)$.

The calculated elasticities for major variables using (4), (5), and (8) are provided in table 3 with one additional adjustment to account for the fact that a price measured in unit value terms (in this case, price per pound) for a number of different quality-level fruit or vegetable products mixes both quantity and quality changes into any estimated price effect. Since we have defined fruits and vegetables by aggregating over many different individual products whose derived price (unit value) captures not only the marketing price but the *quality* of the aggregate commodity, the unadjusted elasticity derived from these derived-price-effect coefficients presented in appendix tables A-2 and A-3 would be inaccurate. If the quantity rather than quality of fruits or vegetables is the primary concern of the household, the optimal response to an increase in price is to switch to less expensive products with little sacrifice

in the amount purchased. In this situation, a change in price will generate a less-than-proportionate change in unit value. In other words, the same quantity difference will be ascribed to a smaller unit value difference (Dong and Kaiser, 2005). As a result, we need to separate the quality effect from the unit value effect to obtain the true price effect.

In order to do so, we follow Deaton (1987, 1988, 1990). The unit value V_{t_i} defined in equation (3) above encompasses both the exogenous marketing price and the product quality chosen by households. To account for the quality differences that exist in our aggregated unit value measures, we use the following formula developed in Dong, Kaiser, and Myrland (2007):

$$(9) \qquad \eta_P^Q = \eta_V^Q / [1 - \eta_V^Q (\eta_Y^V / \eta_Y^Q)],$$

where η_P^Q is the quantity elasticity with respect to the unobserved price index *(P)*, which is the quality adjusted price elasticity. η_V^Q is the quantity elasticity with respect to the observed unit value *(V)*, which can be obtained from the estimates of equation (2). η_Y^Q is the quantity elasticity with respect to income *(Y)*, which can be also obtained from equation (1). η_Y^V is the unit value elasticity with respect to income *(Y)*, which can be obtained from the estimates of equation (3). Equation (9) gives the true price elasticity that adjusts the quality effect from the estimated unit value elasticity.

Table A-1

Estimates of interpurchase time equations for fruits and vegetables, 2004

	Fruits		Vegetables	
	Parameter	Standard error	Parameter	Standard error
Intercept	-2.0312*	0.0145	-1.9891*	0.0172
Coupon dummy	0.1288*	0.0077	0.0898*	0.0099
Coupon redeemed value	0.0063*	0.0030	0.0254*	0.0048
Log unit value	-0.0746*	0.0016	-0.0064*	0.0023
Log unit value lag	-0.0517*	0.0015	-0.0156*	0.0022
Promotion	0.0181*	0.0023	0.0392*	0.0027
Spring	0.0542*	0.0045	0.1106*	0.0054
Summer	-0.0574*	0.0039	-0.0543*	0.0046
Fall	-0.1294*	0.0036	-0.1807*	0.0042
Log household income	0.0633*	0.0012	0.0473*	0.0014
Inverse household size	0.0613*	0.0091	0.1173*	0.0109
Age of female head	0.0109*	0.0001	0.0100*	0.0001
Employment of female head	-0.0947*	0.0016	-0.1058*	0.0019
Education of female head	0.0529*	0.0015	0.0264*	0.0018
Children $\leq$ 6 years old	0.1027*	0.0033	-0.0095*	0.0040
Children 13 to 17 years old	0.0024	0.0027	-0.0186*	0.0032
Single-person households	-0.0976*	0.0052	-0.1806*	0.0063
Black households	-0.1452*	0.0023	-0.1576*	0.0027
Hispanic households	0.0745*	0.0033	0.0477*	0.0040
Asian households	-0.0050	0.0042	0.0932*	0.0046
Other race households	-0.0598*	0.0035	-0.0329*	0.0045
East	0.0169*	0.0022	0.0626*	0.0027
South	-0.0004	0.0020	0.0522*	0.0025
West	-0.0118*	0.0022	0.0925*	0.0027
Hazard parameter (α)	1.2927*	0.0014	1.2550*	0.0017

*statistically significant at the 5-percent level.

Source: USDA, Economic Research Service.

Table A-2

Estimates of purchase and unit value equations for fruits, 2004

	Purchase equation		Unit value equation	
	Parameter	Standard error	Parameter	Standard error
Intercept	-0.5053	0.6614	0.0010	0.0996
Coupon dummy	0.1623*	0.0591	--	--
Coupon redeemed value	0.7299*	0.0121	--	--
Log unit value	-2.7141*	0.3138	--	--
Promotion	0.1682*	0.0239	--	--
Spring	0.2725*	0.0401	-0.0152*	0.0042
Summer	1.6473*	0.0332	-0.0206*	0.0039
Fall	0.4930*	0.0395	-0.0260	0.0041
Log household income	0.4102*	0.0603	0.0402*	0.0089
Inverse household size	-1.3564*	0.1457	0.0241*	0.0211
Age of female head	--	--	-0.0094*	0.0005
Employment of female head	-0.1477	0.0790	0.0060	0.0012
Education of female head	0.3153*	0.0785	0.0393*	0.0118
Black households	0.3664*	0.1068	0.0659*	0.0159
Hispanic households	0.6147*	0.1323	0.0241	0.0198
Asian households	0.9426*	0.1610	-0.0193	0.0275
Other-race households	0.4131*	0.1576	0.0289	0.0196
East	--	--	0.1423*	0.0140
South	--	--	0.0541*	0.0126
West	--	--	0.0241	0.0135

*statistically significant at the 5-percent level.

Source: USDA, Economic Research Service.

Table A-2

Estimates of purchase and unit value equations for vegetables, 2004

	Purchase equation		Unit value equation	
	Parameter	Standard error	Parameter	Standard error
Intercept	0.2911	0.5448	-0.3205*	0.0628
Coupon dummy	0.4181*	0.0661	--	--
Coupon redeemed value	0.5129*	0.0247	--	--
Log unit value	-4.0835*	0.4790	--	--
Promotion	0.0670*	0.0181	--	--
Spring	0.0636	0.0344	0.0291*	0.0041
Summer	-0.0137	0.0404	0.0566*	0.0038
Fall	-0.0304	0.0311	0.0099*	0.0041
Log household income	0.3316*	0.0520	0.0640*	0.0056
Inverse household size	-0.7344*	0.1128	0.0409*	0.0138
Age of female head	--	--	-0.0047*	0.0003
Employment of female head	-0.0650	0.0633	0.0102	0.0080
Education of female head	0.1880*	0.0638	0.0335*	0.0077
Black households	0.0220	0.0929	-0.0970*	0.0106
Hispanic households	0.1657	0.0980	-0.0320*	0.0123
Asian households	0.7803*	0.1372	-0.0860*	0.0197
Other-race households	0.0243	0.0435	-0.0430*	0.0183
East	--	--	0.0293*	0.0085
South	--	--	-0.0343*	0.0079
West	--	--	-0.0581*	0.0086

*statistically significant at the 5-percent level.

Source: USDA, Economic Research Service.

Appendix B: Calculating Simulation Effects From Elasticity Estimates

Given the inverse relationship between interpurchase time and purchase frequency, if the percentage change in interpurchase time is r, the percentage change in purchase frequency will be - r for continuous variables such as the pure price-discount effect and coupon discount effect presented in table 4 and $(-r/(1+r))*100$ for a dummy variable, such as the coupon informational/advertising effect also presented in table 4. Since the average weekly quantity is the product of purchase frequency and the quantity purchased during purchasing weeks, the percentage change in the average weekly quantity with respect to the change of a continuous variable (e.g., coupon discount effect) is the sum of these two changes. However, the percentage change in the average weekly quantity with respect to the change of a dummy variable (e. g., coupon advertising) is the sum of the two changes plus an additional term that captures the interaction between the two changes.

The current average coupon value over all purchase occasions is $0.05 for fruits and $0.02 for vegetables. Current average price per pound for all purchase occasions is $1.63 for fruits and $1.47 for vegetables. A 10-percent-off coupon at the current price level for a 10-percent coupon usage rate implies an average redeemed value of $0.0163 ($1.63*0.1*0.1) for fruits and $0.0147 ($1.47*0.1*0.1) for vegetables. This implies that redeemed coupon values would increase 33 percent for fruits and 74 percent for vegetables. Similarly, the 10-percent-off coupon at the current price level for a 30-percent coupon usage rate implies an average redeemed value of $0.0489 for fruits and $0.0441 for vegetables, an increase in redeemed coupon value of 98 and 221 percent, respectively for fruits and vegetables. For a 50-percent coupon usage rate, the average redeemed value would be $0.0815 for fruits and$0.0735 for vegetables, implying that redeemed coupon values would increase 163 percent for fruits and 368 percent for vegetables.

The percentage change of interpurchase time and quantity with respect to the coupon discount value given the 10-percent-off coupon is $\beta*\Delta C$, where ΔC is the percentage change in redeemed coupon value and β is the elasticity of coupon face value. The percentage change of quantity with respect to the advertising effect given the 10-percent-off coupon is $\beta*C$, where C is the assumed coupon usage rate and β is the elasticity of coupon advertising. The percentage change of interpurchase time with respect to coupon advertising given the 10-percent-off coupon is $\exp(-\gamma C)-1$, where is the coupon dummy coefficient in the interpurchase time equation, with C = 10, 30, or 50 percent depending on the assumed usage rate.