Consumer Acceptance of a New Product: A Case Study of Precut Carrots

This paper examines consumer responses to the introduction of a new product for which there is a close substitute. Precut carrots are a health and a convenience food and are an alternative to more traditional packaging of carrots. Supermarket scan data are used to evaluate the pricing behavior of a food retailer and food shopper purchases of regular and precut carrots. The time period starts well before precut fresh vegetables were available and continues for an extended period following the introduction.

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Introduction

Consumers are constantly faced with new products. Emerging lifestyles and diet/health related concerns have resulted in the introduction of many new goods and services, especially in the food sector. New Product News reported that for fruits and vegetables, the number of new products were 487 in 1994, 545 in 1995, and 554 in 1996 (ASM Communications 1997). At the same time fresh vegetable consumption has been increasing. In particular, carrot consumption increased from 9.6 pounds per capita to 10.1 from 1994 to 1995, the most recent year for which data are available (Food Institute 1997).

Precut fresh vegetables is one food category that reflects the dynamics of consumer demand and food retailing. Technical advances in packaging permit some fresh vegetables to be packaged in ready-to-eat form by processors and sold in retail outlets. Since their introduction in the 1990s, precut has become an important segment. According to Nielsen data, precut sales for the 52 weeks ending February 27, 1997 were $689 million, of which $481.1 million were for precut carrots, and prepackaged salad sales (a separate category) were $836.0 million for the 52 weeks ending January 25, 1997 (Vance 1997).

Important consumer issues are associated with the introduction of precut vegetables. One pertains to the pattern of consumption of the new product by itself. Another is the effect of the new product on the demand for substitutes and complements. A third is the pricing strategy used when the new items are introduced. These issues can be addressed through an analysis of supermarket scan data, although such analyses have not been presented in the literature. The present paper fills this void using a time-series that spans the period during which precuts were not available, then they were introduced, and subsequently both regular and precut packaging forms were available.

Data

Scan data covering the weeks ending May 14, 1988 through March 16, 1996 for five supermarkets that are part of the same chain operating in a metropolitan area in the Southeast are used. Stores are located in separate neighborhoods that are average to above average in terms of income and are relatively homogeneous with respect to race and age distributions. Weeks represent seven-day periods that begin Sunday morning and end Saturday night. The pricing period matches the seven-day data accumulation week. Price is the price per pound for produce sold by weight, price per item for produce sold by count, and price per package for standardized weights and counts.

Quantity is measured as item movement, which is the number of times the scanners read the respective code. Item movement is considered to be a proxy for units sold, assuming there is little variation in the distributions of weights/counts sold from week to week. Customer counts are the number of times the register drawers are opened. Item movement was converted into item movement per thousand customers.

Altogether, 410 weeks were included. But there were three weeks for which technical difficulties led to no data transfer from any of the five stores to the corporate management information system. There were also a few instances where the item movement per thousand customers data were at least three times their standard errors and were considered to be outliers.

The length of the series provides the opportunity to examine long-run trends, seasonality, and the effects of new produce introductions. The case in point is carrots. At the start of the period, they were for sale in bunches

wrapped in plastic or banded together. Altogether, 49 fresh carrot bar codes were used by the chain over the entire time period. The large number is due to the use of the chain's own codes prior to the introduction of standardized fresh produce codes. Produce descriptions associated with each bar code were used to separate carrots into regular (traditional forms in which fresh carrots are sold), precut, and organic. Changes in fresh produce bar codes occurred at approximately the same time precut carrots were introduced. This resulted in an erratic capture of fresh produce price and item movement data for several weeks while errors in the software were eliminated. As described below, fresh carrots stabilized by April, 1993. Organic sales started with the week ending January 28, 1995.

Item movement per thousand customers and average prices were created for each subgroup. The weekly item moments by bar code were added together across reporting stores and divided by the customer counts of the reporting stores. These were then aggregated by subgroup to obtain carrot sales per thousand customers for regular, precut, and organic. Average prices are weekly weighted averages where the weights are the item movements for the codes included in each carrot type.

Descriptive statistics for the item movement and price series are displayed in Table 1. Notice that average item movement was highest for precut, followed closely by regular. Organic's comprised a very small market share, on average. Coefficients of variation for the three-item movement series indicate that regular had the largest relative variability, precut was second, and organic was third. With respect to average prices, organic was the most expensive. Precut was 40 cents cheaper on average, and regular prices were 43 cents lower than precut's. The precut price series had the highest relative variation, while precut's and organic's were similar.

Table 1
Summary Statistics for Item Movements and Prices

	Number of Weeks	Mean	Standard Deviation	Coefficient Variation
Item Movement				
Regular	400	26.52	18.57	70.04
Precut	216	30.05	15.19	50.54
Organic	55	3.82	1.67	43.67
Price				
Regular	400	.91	.12	12.70
Precut	216	1.34	.29	21.83
Organic	55	1.74	.28	11.85

Pairwise correlations are presented in Table 2. A fairly high degree of substitution is suggested by the negative item movement correlation between regular and precut (-.69). The extent of possible substitution appears to be much smaller between regular and organic item movements. Precut/organic's positive item movement correlation is an indication that both increased relative to regular.

Inspection of the three price correlations reveals that the largest in absolute value is between organic and precut for which approximately two-thirds of the time these two series are changing in the opposite direction. The positive price correlation between regular and precut indicates a tendency for these retail prices to change in the same direction. Regular and organic prices seem to be independent.

Price/item movement (quantity) correlations are in the bottom third of the table. Regular's negative own-price correlation is consistent with demand theory. The small negative own-price correlation for organic suggests a fairly independent relationship between these two series. It is consistent with those food shoppers who purchased this type of fresh produce being willing to pay a high premium over regular and precut. Nonprice considerations are affecting these consumers. The positive precut own price/item movement correlation reflects the product life cycle marketing strategy of introducing a product at a lower price and then gradually raising it as sales increase.

Table 2
Correlations by Package Type

	Item Movement		
Item Movement	Regular	Precut	Organic
Regular	1.00		
Precut	-.69	1.00	
Organic	-.19	.55	1.00

	Price		
Price	Regular	Precut	Organic
Regular	1.00		
Precut	.30	1.00	
Organic	-.05	-.64	1.00

	Item Movement		
Price	Regular	Precut	Organic
Regular	-.35	.14	-.19
Precut	-.69	.60	.17
Organic	.33	.10	-.03

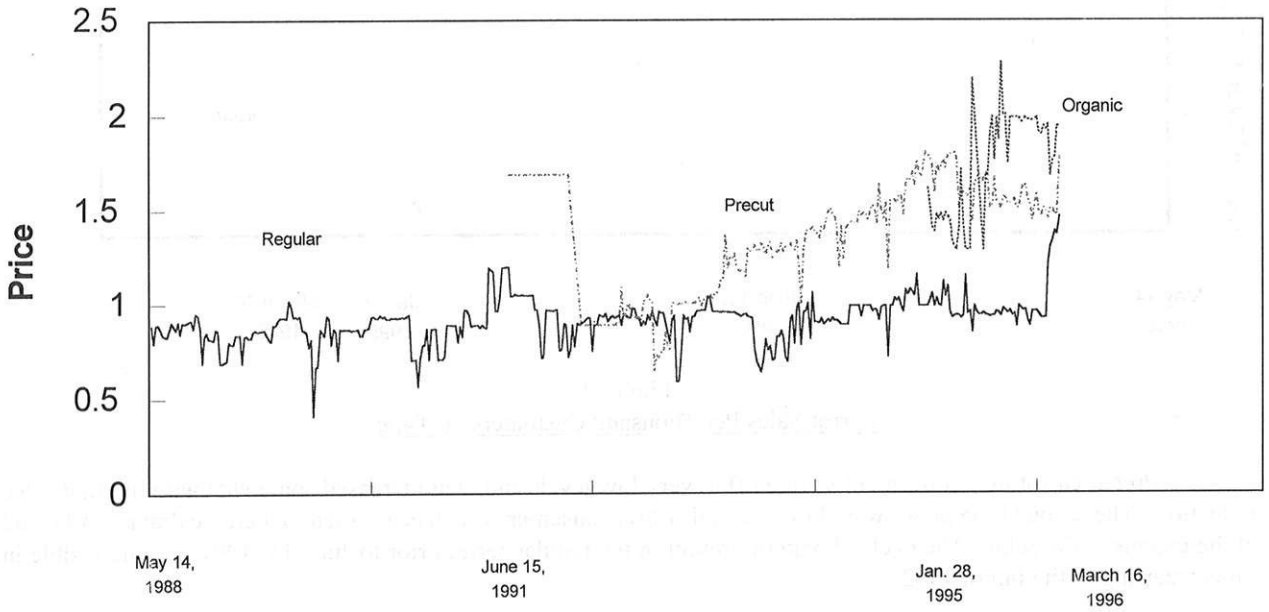

Figure 1
Average Carrot Prices by Type

Regular carrot prices remained relatively stable over the entire period, with weekly prices fluctuating around a horizontal line (see Figure 1). Both precut and organic prices were initially set at high levels for a few weeks and then were lowered. After being at relatively low levels for a few weeks, the prices of each increased.

A seasonal pattern is visible in regular carrot sales per thousand customers (see Figure 2). Prior to the introduction of precut, regular item movement seemed to fluctuate around a horizontal line. Soon after the time precut became available, the chain started to implement changes in its bar code scheme for fresh vegetables and departmental designations, which resulted in an erratic and unreliable record of sales noticeable in the weeks following July, 1991. Substitution of precut for regular carrots is quite apparent, and regular item movement declined to the point where it

is comparable to organic's. It should be noted that inspection of newspaper, television, and radio advertising for January, the seasonal high, revealed that only regular carrots were promoted, and this occurred in only four weeks, which were in different years.

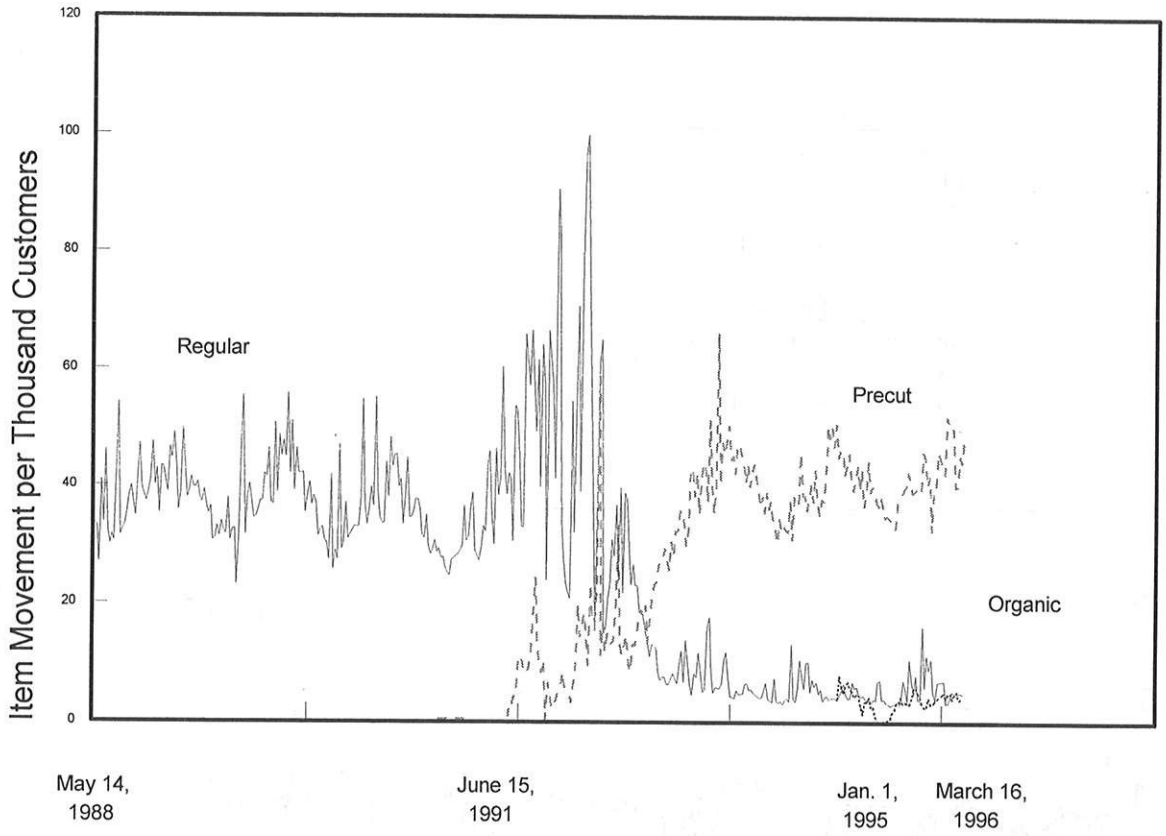

Figure 2
Carrot Sales Per Thousand Customers by Type

Precut carrot item movement started off at very low levels and then increased somewhat with the first price reduction. The second time prices were lowered (fall, 1991) consumer acceptance started to increase dramatically, and at the expense of regular. The cyclical pattern present in the regular series prior to June 15, 1991 became visible in precut starting in the fall of 1992.

Modeling a New Product Introduction

Two basic approaches to modeling a new product introduction combined with a cyclical pattern were explored. One was spectral analysis. However, the empirical results in the case of precut carrots were inferior in terms of overall fit and estimated parameters to those obtained from the spline function presented below.

The subperiod used in the analysis began with the week ending May 8, 1993. This was based on the date precut carrots were introduced, and on the erratic observations associated with the weeks during which the chain was switched its fresh produce bar codes and departmental designations. Consequently, the regression analysis coincides with the time the chain had the lowered the initial price, and sales were beginning to grow. (With respect to Figure 2, it is close to where the precut and regular curves cross.) This is May 8, 1993.

Choice of the functional form was motivated by an analysis of scatter plots. Notice that the cyclical pattern in precut item movement per thousand customers in Figure 2 is with respect to time. Plots with respect to the price of regular (Preg) and the price of precut (Ppre) (not shown) revealed no cyclical patterns. An implication is that the

estimation of the spline function with four knots is with respect to time, as opposed to either price.

Organic prices were not included for three reasons. First, organic carrots were introduced toward the end of the period. Second, they comprised a very small segment of the fresh carrot market. Third, the organic price correlation with precut item movement was very low. The last two points suggested that there was no omitted variable bias.

Several outliers are visible in Figure 2. These are not associated with holidays or special promotions. Rather than deleting these observations, dummy variables were used because the objective was to include as many observations as possible, but at the same time minimize the effects of these outliers on the overall fit. The approach is justified because outliers can induce serial correlation among the errors (Pindyck and Rubinfeld, 1997). Altogether, there were eight outliers. Each is identified in Table 3, along with the identification of the knots (described below). This methodology is also consistent with interest in the general pattern of consumer acceptance of the new product.

Spline functions provide flexibility to allow for cyclical patterns. They are piecewise polynomials. At the join points (knots) the derivative may be continuous or discontinuous (Smith 1979). Truncated polynomials are used to estimate the various segments, and alternative continuity restrictions can be imposed at the knots. Figure 2 identifies the knots. There are four, determined by the peaks and troughs observed in the precut series during the subperiod. The functional form can be specified to allow for sequential testing of the continuity restrictions.

Table 3
Dates of the Knots and Outliers

Knots		Outliers	
Date	Variable	Date	Variable
Jan. 29, 1994	K1	July 9, 1993	T1
July 9, 1994	K2	Sept. 11, 1993	T2
Jan. 21, 1995	K3	Nov. 27, 1993	T3
Aug. 8, 1995	K4	Dec. 11, 1993	T4
		Nov. 26, 1994	T5
		Dec. 24, 1994	T6
		Dec. 2, 1995	T7
		Jan. 6, 1996	T8

Choice of the functional form was motivated by the scatter plot, and it is also consistent with the typical relationship associated with new product introductions. The log of precut item movement per thousand customers (IM) is a function of precut and regular prices, and number of precut package types, and a second degree time polynomial for each of the segments of the cycles. NPRE is the number bar codes (types of precut packages vary by processor and size), and it fluctuated between six and nine, although for most weeks it was seven. Consequently, NPRE is the number of precut packages minus seven, so NPRE ranged between minus one and two to allow for the possibility that consumers may have developed an expectation with respect to variety in terms of precut package sizes available.

Fitting a second degree spline function entails incorporation of a set of dummy variables to allow for changes in the constant and changes in the first and second derivatives at the knots. Given the four knots, time, and time squared variables can be constructed. Dummy variables were set equal to zero until the time the respective knot is reached and then set equal to one thereafter. Time and time squared variables are calculated as each dummy variable multiplied by the difference between the observation number and the observation number for the knot. This procedure resulted in an initial regression that had time (T), time squared (TSQ), four knot segment intercept terms (D#), four knot segment time terms (DT#), four knot segment time squared variables (DTSQ#), and Preg, PPRE, and NPRE. Variables which had insignificant coefficients were deleted, and the re-estimated equation was compared to the initial estimates to make sure that there were no large changes in estimated coefficients, their standard errors, or measures of overall fit. The resulting equation is presented below (standard errors in parentheses, and * denotes significance at .05 level).

Interpretation of the time coefficients is as follows. Absence of D1, D2, and D3 variables (changes in the intercepts at the knots) suggests that at each of the first three knots the first partial derivative with respect to time was continuous, or the lnPRE function was smooth. However, at the fourth knot, there was a shift in the curve with respect to time. Only two squared terms had significant coefficients: TSQ and DTSQ2, which means that the second partial derivatives of lnPRE with respect to time are continuous at the first, third, and fourth knots.

$$\ln PRE = 3.439^* + .049T^* - .001TSQ^* + .121D4^* + .039DT2^* - .039DT3^* + .013DT4^*$$
$$(.131) \quad (.002) \quad (.0001) \quad (.038) \quad (.004) \quad (.008) \quad (.007)$$

$$+ .001DTSQ2^* + .118T1 - .189T2^* + .181T3^* - .207T4^* - .160T5^*$$
$$(.001) \quad (.074) \quad (.073) \quad (.073) \quad (.075) \quad (.073)$$

$$+ .192T6^* - .258T7^* - .563T8^* - .248Ppre^* - .226Preg^* - .011NPRE$$
$$(.075) \quad (.075) \quad (.074) \quad (.090) \quad (.077) \quad (.012)$$

$F = 57.839^*$, $R^2 = .89$, $DW = 1.58$

PRE's coefficient is negative and significant even though the simple correlation between precut's price and own item movement is positive. An interpretation is that the time variables in the spline function allow for the estimation of the new product introduction and cyclical effects, while the price variables can be used to estimate price responses. The negative coefficient for PREG is a complementary relationship because this variable and precut item movement per thousand customers change in the opposite direction. That is, they have a competing relationship. An interpretation is that consumers may have a budget allocation system in which a predetermined dollar amount is to be spent on carrots, either precut or regular, and as the price of regular increases, these consumers can purchase less of both, ceteris paribus.

Price elasticities are presented in Table 4. They are calculated for the average prices associated with the line segments found in Figure 2 given the significant knots. Thus, there are four subgroups, as noted in the table and overall elasticities. The own price elasticities become less inelastic over the first three segments, due to a rising precut price. For the last segment, the average precut price fell, leading to a small change in the elasticity. The interpretation is that food shoppers appear to have become somewhat more price sensitive over time as the chain raised precut prices. The cross-price elasticity does not change very much because the average price for each segment did not change very much, although there was price variability in within each subperiod.

Table 4
Estimated Elasticities

	Elasticity	
Line Segment	Precut	Regular
May 8, 1993-July 2, 1994	-.328	-.200
July 9, 1994-Jan. 14, 1995 -	.387	-.222
Jan. 21, 1995-Aug. 1, 1995	-.418	-.222
Aug. 8, 1995-Mar. 16, 1996	-.382	-.232
May 8, 1993-Mar. 16, 1996	-.368	-.216

Implications

Store level supermarket scan data provide insights regarding a chain's pricing behavior during the introduction of a new produce for which there is a close substitute and regarding consumers' purchases of a new type of convenience/health food. Experience properties of foods point to a need to get people to try products. The chain, with respect to precut carrots, accomplished this by initially selling them at a low price and then gradually raising it as sales increased.

Food shoppers responded positively. Not only did precut item movement grow, but consumers have substituted precut for regular carrots. The initial growth phase is consistent with the stylized product life cycle in which successful introductions are characterized by sales that increase at a decreasing rate up to the first knot in the spline function. The extent of substitution for regular carrots resulted in the cyclical pattern, observed in regular sales prior to precut's introduction, being found in precut item movement following the initial growth period.

Estimated own and cross elasticities indicate that along with the price increase, the demand gradually became less inelastic and that food shoppers appear to be somewhat more responsive with respect to carrots to precut prices (which are higher) than to regular prices. An interpretation is that food shoppers feel the convenience and preparation time saved are worth the existing price difference, but further increases in precut's price could have an adverse impact on precut sales.

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Endnotes

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