The Impact of Changing Retail Services on the Grocery Store Producer Price Index

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Maintaining accurate and consistent inflation estimates over time is a priority for governments since these measures are used to adjust contracts, wages, and other employee and consumer benefits as well as provide a general measure of the macroeconomy. Since the set and number of priced items in an index can change over time, quality adjustment methods are used to adjust the observed price changes in an index to more accurately measure the true market price change. Methods used to quality adjust price indices can improve the accuracy of inflation estimates to more closely match actual inflation as experienced by market participants.

There are many causes for inaccurate measurement of pure price change in an index. These causes can be divided into three general categories. Mismeasurement due to the changing nature of the items in the sample over time, mismeasurement due to temporary missing prices or permanently unavailable/discontinued items, and mismeasurement due to the sample not being representative of the actual universe of items that it is supposed to represent. My focus here is on the first of these three concerns. A large amount of research has focused on quality adjustment issues in the Consumer Price Index (CPI). This focus is primarily due to the use of the CPI by the U.S. government in setting the indexation formulas for income tax brackets and government benefit payments[1]. However many of the issues discussed in relation to the CPI apply to other indices, as well.

This article focuses on these issues as they relate to the U.S. Producer Price Index (PPI)[2] for retail food stores. Within the retail trade sector, food stores make up 15.4% of the revenue generated in the sector[3] and nearly 97% of food store revenue is generated by grocery stores[4]. This paper outlines methods of quality adjustment and applies a direct adjustment technique to

the PPI for grocery stores. This subset of the PPI is unique in that it is one of the first indices for retail goods to use the retail margin (retail price - wholesale price) as a measure of the price of the products sold in a store. This measure provides an estimate of the prices of the services provided by the retailers.

Section two of this article provides background on the model that forms the basis for the producer price index, while sections three and four discuss the index construction for retail food stores specifically. The fifth section discusses some specific applications of hedonic models to quality adjustment, while the section six applies the methodology to the retail food price index. Lastly, I conclude and suggest how expanded data collection would improve the accuracy of price index measures when products undergo changes in quality.

The Producer Price Index

The Producer Price Index (PPI) is designed to estimate a fixed-input output price index (FIOPI) model. The fixed-input output price index model assumes that there is perfect competition in a market, a fixed technology level, and profit maximization as the objective of all firms in the market. This implies that firms respond to changes in input and output prices by changing the mix of inputs used and outputs produced to maintain profit maximization. If we further assume that the type and quantity of *inputs* used in production is fixed, then the firm can only respond to price changes by altering the level of output it produces.

The revenue of the representative firm is then just a function of output prices (P), input quantities

(I) and the level of technology (T) used by the firms. The theoretical FIOPI Index is then $R(P_c, I_b, T_b) / R(P_b, I_b, T_b)$. In order to calculate this index measure it is necessary to have an estimate of the revenue function in each period. For the base period, $3\ P_b\ Q_b$ from a Laspeyres Index[5] will provide an accurate measure of revenue. However, for the current period the revenue function depends on the current level of output prices assuming that the current level of technology and quantities of inputs used has remained unchanged from the base period. In reality, the current period revenue is unobservable unless there has actually been no change in technology levels and no change in input quantities used. Since, in many cases these two factors do change from period to period, it would be necessary to measure input quantities and technology at each time period and factor out any changes to isolate the actual price change that has occurred.

One solution to this problem is to approximate the current period revenue function with the numerator of the Laspeyres Index, $3\ P_c\ Q_b$. This measure is only accurate if the quantity of output produced remains unchanged from the base period. Since in most cases this will not be true, the Laspeyres Index will only contain an *approximation* of the revenue function actually needed for the theoretical FIOPI measure. Using the Laspeyres Index as an approximation for the FIOPI adds the restrictive assumption that the quantity and mix of outputs does not change from the base period level. By adding this restriction, it will be the case that the Laspeyres approximation, $3\ P_c\ Q_b$, will always be less than or equal to the actual revenue function from the FIOPI.

In general, a firm has at least two options. It can produce base period quantities in the current

period or it can adjust the output quantity that it produces in order to maximize profits given the new set of prices it can sell its goods at. By restricting producers to only using option one we are removing their option of doing at least as well (profit-wise) with some other quantity (and therefore revenue) level. Therefore, this approximation restriction results in the Laspeyres Index measure acting as a lower bound to the ideal FIOPI measure.

PPIs for the Retail Sector

The Laspeyres Index measure, as an approximation of the FIOPI, has been applied to the retail sector in order to measure price changes over time. Ideally, one would like to form an index of all goods and services provided by all establishments in a given market. In order to understand the process by which an actual index is formed, it is helpful to follow the process in one specific sector. Within the retail trade sector, food stores make up 15.4% of generated revenue generated and nearly 97% of that revenue is generated by grocery stores (SIC 5411/ NAICS 4451). Food stores provide both food products and distribution services to consumers and are therefore a good sector to focus on in terms of quality differences.

The price index for this sector would ideally measure the output of all grocery stores in a given market (country, region, city, etc.) and track how prices change over time. In the case of grocery stores, as is true with many retailers, the output produced can be approximated by the difference between the price the grocery store sells an item for and the price it paid for the good from a distributor or manufacturer (margin). Since the FIOPI model assumes firms are price takers and in perfectly competitive markets, this price margin will approximate the value-added of the

retailer. This price margin would then include the costs of the services provided by the retailer. By tracking this price margin over time one can construct a price index for the sector.

Since it is not feasible to collect prices for all items in all grocery stores, this index is created by selecting items from a sample of stores to represent all items in all stores. This sampling procedure is done in two stages. First stores are selected to be included in the sample and then items within each of these stores are selected to have their prices tracked over time. From the nearly 133,000 grocery stores (supermarkets and convenience stores) in SIC 5411 (1996 UI File), stores were selected based on information from scanner data collected by Information Resources Incorporated (IRI) and The Chain Store Guide directory listings[6]. For companies with more than one store an official at the establishment headquarters would select stores to represent the different pricing zones[7] that the company operated in. In total, 338 stores were selected for sector 5411 with 282 supermarkets and 56 convenience stores sampled.

Each selected store is assigned to one of eight regions[8] across the United States and a number of price quotes is assigned based on the store's relative share of sales revenue generated. The items to be priced at each store came from Product Assignment Sheets (PAS) which lists items selected based on their share of revenue generated by grocery stores in each of eight regions across the US. Each store is asked to price from one to eleven items based on the size of the store's revenues.

Retail Food Price Index Construction

Once the sample of stores and prices are collected, the price index is constructed using the standard BLS procedure. The Laspeyres Index measure is transformed into a weighted price relative measure by multiplying the numerator by (P_b / P_b). Thus, the numerator of the Laspeyres Index can be rewritten as 3 $\{(P_c / P_b)\ P_b Q_b\}$. This is a weighted sum of the price relatives for all goods in the sample. The preference for calculating the numerator in this form is purely from an ease of calculation standpoint[9].

The price relative for each item is formed by taking the price margin for the good in the current month and dividing it by the price margin of the good from the base month. Each of these price relatives is then weighted and summed to create an index for each of the eleven sub-departments in a supermarket and two indices for convenience stores (those that sell gasoline and those that do not). The term $P_b Q_b$, the revenue generated by an item in the sample, is measured by using an item weight for each priced good.

The weight for each item is made up of three parts. First a weight is assigned for each item based on its share of revenue in grocery stores. Then a sampling weight is applied to increase the weight of smaller stores that represent a larger number of establishments in the universe and a smaller weight for larger stores that represent a smaller number of similar-sized stores. Finally, this product is divided by the number of quotes per store.

Item Weight = TVOS * SF / #Q (1)

where

TVOS = Total Value of Shipments for the sampled store.

SF = Sampling Factor (for varying store sizes)

#Q = number of price quotes per store

The weighted price relatives are then summed to form a cell aggregate (CA) measure for each of the eleven departments.

$CA = \Sigma_i$ (Price Relative * Item Weight) (2)

If the set of items in a cell never changed, then this cell aggregate could just be divided by the denominator of the Laspeyres index, 3 (P_b Q_b), (and multiplied by 100) and the index would be complete. However, since the exact sample of goods priced may change from one month to the next due to the addition or discontinuation of respondents, a method is needed to distinguish true price changes from sample structure changes.

The solution to this problem is to use the previous month's price relative measure weighted by the *current* month's item weights and multiply this fraction by a similar measure for the previous three months. The current period price index measure for a particular department is then

$PI_t = (CA_t / CA_{t-1})* (CA_{t-1} / CA_{t-2})*(CA_{t-2} / CA_{t-3})*(CA_{t-3} / CA_{t-4})* PI_{t-4}$ (3)

where

$PI_{t-4} = (CA_t / CA_{t-1}) PI_{t-5}$

There is no need to chain back beyond four periods because no changes are made to an index measure beyond four month of its release period[10].

In order to get the price index measure for all goods in all grocery stores, the eleven sub-department indices are then weighted by their relative shares and summed to get the PPI measure for grocery stores.

$PI_s = \Sigma_d (PI_t * \text{Dept. Weight})$ (4)

The indices for each of the eleven departments are constructed using the above method with the monthly retail margin data for the year 2000 and are shown in table 1. This index uses all prices for which store characteristics are available in order to be able to make valid comparisons between this unadjusted index and the quality adjusted index (see section 6)[11].

Quality Adjustment with Hedonic Models

A number of quality adjustment methods have been developed in order to improve price measurement. The direct method of quality adjustment attempts to use an estimate of the change in value (or at least cost) of a product when its characteristics change. When the actual value of a quality change is not explicitly observed a hedonic (characteristic based) approach can be used. Triplett (1986) outlines three ways in which a hedonic regression can be used to construct a more accurate price index. First, it can be used to make an explicit quality adjustment if you calculate an implicit price for each characteristic of a

product and add or subtract from the observed new price any amount of the change due to a specific priced characteristic that changed[12]. Secondly, one could use a time dummy in the characteristics regression as a measure of the amount of price change that is not attributable to the identified characteristics and use that measure as an estimate of the pure price change. Finally, one could construct an index directly from the coefficients of the characteristics in the regression, in other words a 'characteristics price index' that could be used to deflate the unadjusted index.

Building off of ideas set forth in Court (1939), Griliches (1961) used this third method to derive implicit prices for the various characteristics of goods bought and sold in a market. He applies this theory to the automobile industry as an illustration. Assume that the price of a good, p_{it} , (i= quality characteristic, t=time period) is a function of different quality characteristics x_{it} and some random disturbance term $,_{it}$. Then the price of a good can be expressed as:

$p_{it} = f(x_{1t} , x_{2t} ,....x_{it} , ,_{it})$ (5)

These quality characteristics (x_{it}) can be expressed either as a numerical value[13] (in) or simply as indicator (dummy) variables. To estimate this function, one must make additional assumptions about the functional form to be estimated. Griliches (1961) uses a semilogarithmic form: $\text{Log}\ (p_{it}) = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + ... + \alpha_i x_{it} + ,_{it}$, although other forms may be more appropriate in other situations.

The coefficients for each identified characteristic can be used to form a predicted price,

$p\hat{}_{it}$, for the good based on the characteristics that are observed. These predicted prices can be used to form a 'quality change price index' that will deflate the observed price index, the net result being a final price index that more accurately measures the true price change. If we were to apply this procedure to the Laspeyres index, for example, we would have the observed price index as

$\{\Gamma (p_{i1}Q_b)/ \Gamma (p_{i0} Q_b)\}$ and the quality change index as $\{\Gamma (p\hat{}_{i1}Q_b)/ \Gamma (p\hat{}_{i0} Q_b)\}$. The 'true price index' could then be calculated by deflating the observed price index by the quality change index:

$$\text{Quality Adjusted Price Index} = \{\Gamma (p_{i1}Q_b)/ \Gamma (p_{i0} Q_b)\} / \{\Gamma (p\hat{}_{i1}Q_b)/ \Gamma (p\hat{}_{i0} Q_b)\} \quad (6)$$

Pakes (1997) explains that this measurement would provide an upper bound to the ideal price index for base period utility. Therefore, incorporating this type of adjustment into index formulations would be beneficial.

Quality Adjustment in the Retail Food Store Index

One of the unique qualities of the retail sector is that suppliers bundle together the physical products they sell with services that enhance the value of the products that are sold. Betancourt and Gautschi (1988) delineate five general categories of retail services that are often provided. They are location accessibility, product assortment (breadth and depth), assurance of product delivery (time and form), information (prices, advertising), and

ambiance. In creating a retail sector price index that tracks prices on the retail level, it is important that the prices that are recorded accurately measure the price level for retailers. In order to focus on the value added by the retailer, BLS collects the retail price margin (the difference between the wholesale price and the retail price) for each good in the index. Leibtag (2002) used these price margins, expressed as a fraction of the retail price and characteristics of the stores and products in the sample, to measure the fraction of the price margin[14] that can be explained by the variation in store and product characteristics. That study uses the margin expressed as a fraction of the retail price in order to be able to compare many different products with varying price margin levels[15] that are sold at food stores in the sample.

Using that measure, I find that 72% of the variation in the retail price margin of a good can be explained by differences in product [16] and store type characteristics. Given the somewhat detailed data that is available about each product and the store it is priced from, I am able to identify the characteristics of a product's store that are most important in determining the variation in price margins. This measure, however, is not as helpful in the current study in which a quality adjustment of the price margin measures themselves is needed to adjust the index. In this case a model of the margins as a function of the store and product characteristics is necessary. In order to avoid the problem of variation in absolute margin levels between different products in the data, I use a dummy variable for the department[17] from which each product is sold[18].

The semilog functional form is used for these regressions with the log of the price margin as the dependent variable and store and product characteristics as independent variables following standard practice in the literature[19]. Following Pakes (2001) the functional form of the regression uses higher order terms for the store characteristic variables to approximate the non-linear relationship between the characteristics and the price margin[20]:

$$Ln(M_{ijt}) = \alpha_0 + \beta_1(SC_j) + \beta_2 (INV_j) + \beta_3(INV_j^2) + \beta_4(INV_j^3) + \beta_5(SKU_j) + \beta_6(SKU_j^2) + \beta_7(SKU_j^3) + \beta_8(HRS_j) + \beta_9(HRS_j^2) + \beta_{10}(HRS_j^3) + \beta_{11}(HRS_j^4) + \beta_{12}(HRS_j^5) + \beta_{13}(FTE_j) + \beta_{14}(FTE_j^2) + \beta_{15}(FTE_j^3) + \beta_{16}(CHK_j) + \beta_{17}(CHK_j^2) + \beta_{18}(YSLR_j) + \beta_{19}(YSLR_j^2) + \beta_{20}(YSLR_j^3) + \beta_{21}(YSLR_j^4) + \beta_{22}(BN_{ij}) + \beta_{23}(SA_j) + \beta_{24}(SA_j^2) + \beta_{25}(INC_j) + \Sigma^S_{s=1}\{ \delta_s(ST_s)\} + \Sigma^T_{t=1}\{\eta_t(M_t)\} +)\} + \Gamma^D_{d=1}\{(_d(D_d)\} + \varepsilon_{ijt}$$

(7) (i=item, j=store, t=time)

Where

M_{ijt} ~ retail price margin

SC_j ~ a dummy variable for stores located in a shopping center (Accessibility)

INV_j ~ inventory/stockroom space per store in thousands of square feet (Assurance)

SKU_j ~ number of stock-keeping units (in thousands) per store (Assortment)

HRS_j ~ hours of operation per store (Assurance)

FTE_j ~ number of full-time equivalent employees per store (Information)

CHK_j ~ number of checkouts per store (Assurance)

$YSLR_j$ ~ years since the last renovation of the store (Ambiance)

BN_{ij} ~ a dummy variable=1 if the item is a brand name good and =0 for store/generic label

SA_j ~ store area per store in thousands of square feet

INC_j ~ median household income (in thousands of dollars) in zip code of the store

ST_s ~ a set of dummy variables to control for the type of store (Assortment)

M_t ~ a set of month dummy variables

D_d ~ a set of dummy variables to control for the department from which the product was sold

The results from this regression are summarized in table 2. All of the store characteristic variables are significant in the regression, implying that these characteristics can explain some of the variation in price margins across different products from different stores. The net effect of each of the store characteristic variables that will be used to quality adjust the index is presented in table 3[21]. A one unit increase in most of the characteristics causes a slight[22] increase in the price margin of a product with hours of operation and whether the store is in a shopping center having the largest impacts. The only exception to this result is that an increase in the number of employees has a very small (-0.0007%), but significant, *negative* impact on the price margin. This could mean that, controlling for other characteristics of a store, the number of employees is not a good measure of information services provided by the retailer or that the lack of detail in terms of the *type* of worker causes this negative measure. It could be the case that a measure of all full-time equivalent employees that have some *service* aspect to their job would be a better measure and provide a positive impact on the price margin (similar to the other characteristics in regression)[23].

Given this information, a quality adjustment to the index would be necessary anytime the characteristics of the product or store it was priced from change. A characteristics based pricing model allows store characteristics or qualities to be measured and factored into explaining part of the retail price margin. By using the implicit values for the retailer-provided services (see table 3), one can adjust the changes in the price index to more accurately measure true changes to the price of retail goods over time. The quality

adjustment is unique here because it is an adjustment for characteristics not directly purchased but rather implicitly bundled retail services that a consumer receives as part of the shopping experience.

If the retailer increases the services provided in its store then a change in the price one pays for a good may, at least partially, be based on this added service. For example, if a supermarket were to extend operating hours from twelve to twenty-four hours a day then an increase in prices charged for items in the store may be partially due to the added service provided- namely, the convenience that consumers can now shop anytime during the day. These types of changes will impact the price index and can be controlled for with information detailing the characteristics of the stores and products that they sell.

The store characteristics identified to have a measurable impact on the variation in price margins are hours of operation, whether the store is in a shopping center or not, years since the store was last renovated, the store inventory/stockroom space (measured in square feet), the number of stock-keeping units, the number of employees, and the number of checkout lines in the store. In terms of quality adjustment, these characteristics listed can be thought of as approximate measures of retail services provided.

In this data set no explicit changes to store characteristics were reported to have occurred in 2000, however as stores do undergo changes (usually enhancements to the services provided) in the future it will be important to know what impact those changes have on the

index. In order to approximate the upper and lower bound of the impact on the index of changes to store characteristics, two adjusted indices for the July 2000 index are constructed to compare to the unadjusted index. In both cases the hypothetical change is in terms of the store type- a store expanding from a conventional supermarket to a superstore. This is an often observed change in store format, a trend towards larger grocery stores which provide added services to their customers. In the first experiment, just one store in the sample changes format while in the second experiment (the opposite extreme) *all* conventional supermarkets become superstores. The quality adjustment in both cases is done at the product level based on the specific store from which the product was priced. The store characteristics of the changing stores are adjusted to match the average characteristics of all superstores in the sample. This change is then used to deflate the observed price of the products from each changing store in the given month (July 2000).

The results of these experiments are shown in tables 4 and 5. Table 4 shows that a change in format for one store in the sample causes a slight decrease in the overall index (from 116.91 to 116.85). This small change is not surprising given that only one store in the sample changed[24]. In table 5 the more broad experiment is shown in which all the conventional supermarkets expand to become superstores. In this case the adjusted index is almost 2 index points lower (116.91 vs. 115.17) than the unadjusted index. Given that the index rarely changes by more than two points from month to month this is a rather large upward bias in the unadjusted index. If store characteristics are changing over time and no adjustment is made for these changes, then an upward bias will exist in the index[25].

These experiments show that changes to the characteristics of a store, if not adjusted for in a price index, can bias the index upward. The magnitude of the bias will depend on both the nature of the change in characteristics (quality) as well as the number of stores that undergo a change at any given point in time. If these changes are widespread, even if only a few occur each month, the index would have an increasingly upward bias as these unadjusted characteristic changes occur each month.

Conclusion

Proper measurement of price change is crucial for constructing an accurate price index. Direct quality adjustment of a price index through the use of a characteristics based price margin model can correct the upward bias implicitly contained in an unadjusted index. In this study I find that the Producer Price Index for food stores would be biased upward between 0.06 and 1.74 index points[26] if a change in store characteristics was not adjusted for in the index calculation. This bias would be larger if store characteristics were to change over time without any adjustment made for them. Given the ever-expanding services available in grocery stores and the recent increase in nontraditional retailers selling a greater share of consumer food products[27], this is likely to occur. An up-to-date measure of store and product characteristics will be needed to construct an unbiased (or at least less biased) index. The use of PPI indices in labor contracts and cost estimate adjustments makes accurate measures of producer price inflation crucial. For example,

since food service companies use the PPI to adjust their cost estimates, the upward bias in the PPI causes prices to rise artificially in response to a higher than actual inflation estimate.

The more information that is available in terms of store and product characteristics, the more accurate an adjustment that can be made. The potential bias that would occur without these adjustments underlies the importance of proper data collection and frequent updates of any changing characteristics in order to construct a more accurate measure of price change in an industry, sector, or market where the price that is observed encompasses more than the physical product that is sold. This adjustment method can and should be applied to retail and service sector indices whenever possible.

References

Armknecht, P. and F. Maitland-Smith, "Price Imputation and Other Techniques for ealing with Missing Observations, Seasonality and Quality Change in Price ndices", *Working Paper of the International Monetary Fund,* June 1999.

Baker, D.(ed.), *Getting Prices Right: The Debate over the CPI,* Economic Policy Institute, E Sharpe Publishers, Armonk, NY, 1998.

Betancourt, R. and D. Gautschi, "The Economics of Retail Firms", *Managerial and ecision Economics,* 1988.

Bratanova, L., "National Practices in Quality Adjustments for Specific Items", *Statistical Journal of the United Nations,* 1998.

Court, A., "Hedonic Price Indexes with Automotive Examples", *The Dynamics of Automobile Demand,* 1939.

Diewert, W.E., "Exact and Superlative Index Numbers", *Journal of Econometrics,* 1976.

Fisher, I., *The Making of Index Numbers,* Sentry Press, New York, NY (Third Edition), 1927.

Feenstra, R., "Exact Hedonic Price Indexes", *The Review of Economics and Statistics,* November 1995.

Feenstra, R., and M. Shapiro, "High Frequency Substitution and the Measurement of Price Indexes", Presented at *CRIW Conference- Scanner Data and Price Indexes*, November 2000.

Gleason, S., and D. Hosken, "Econometrics in FTC versus Staples /Office Depot", *FTC*

Working Paper, 1999.

Gousen, S., K. Monk, and I. Gerduk, *Producer Price Measurement: Concepts and Methods,* US Department of Labor - Bureau of Labor Statistics, 1986.

Griliches, Z., "Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change", *Price Indexes and Quality Change,* 1971.

Industry Synopsis SIC 54 - Food Stores, Bureau of Labor Statistics, 1998.

Hausman, J. and E. Leibtag "CPI Bias from Supercenters: Does the BLS Know that Wal-Mart Exists?", NBER Working Paper No. 10712, National Bureau of Economic Research, Inc., Cambridge, MA, August 2004.

Leibtag, E., "Determinants of Retail Price Margins and Quality Adjustment of Price Indices in Retail Food Stores", Dissertation, University of Maryland, June 2002.

Liegey, P., N. Shepler, "Adjusting VCR Prices for Quality Change: A Study using Hedonic Methods", *Monthly Labor Review,* September, 1999.

Kokoski, M., "Quality Adjustment of Price Indexes: Anatomy of Price Change", *Monthly Labor Review,* December 1993.

Nordhaus, W., "Quality Change in Price Indexes", *Journal of Economic Perspectives,* Winter 1998.

Pakes, A., "Hedonics and Price Indices", *Mimeo,* March, 1997.

Pakes, A., "A Reconsideration of Hedonic Price Indices with an Application to PC's", *American Economic Review v93, n5,* December, 2003.

Silver, M., "An Evaluation of the Use of Hedonic Regressions for Basic Components of Consumer Price Indices", *Review of Income and Wealth,* March, 1999.

Silver, M., and S. Heravi, "Quality Adjustment, Sample Rotation and CPI Practice: An

Experiment", *Papers* of the Ottawa Group - International Working Group on Price Indices Sixth Meeting, April 2001.

Stanley, L. and J. Tschirhart, "Hedonic Prices for a Nondurable Good: The Case of Breakfast Cereals" *The Review of Economics and Statistics,* 1991.

Triplett, J., "The Economic Interpretation of Hedonic Models", *Survey of Current Business,* January 1986.

Triplett, J. and McDonald, R., "Assessing the Quality Error in Output Measures: The Case of Refrigerators", *Review of Income and Wealth,* June1977.

White, A., "Outlet Types and the Canadian Consumer Price Index", *Canadian Journal of Economics,* May 2000.

Table 1. Retail Food Store Price Index by Department, 2000

(Index Base is December 1999 = 100)

Dept	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Meat	97.16	115.32	106.85	115.62	104.33	101.21	105.56	101.93	110.96	109.79	113.98	114.15
Produce	112.91	118.47	120.06	123.14	130.36	128.28	137.78	136.41	124.81	129.71	135.36	134.52
Bakery	114.75	111.39	124.94	124.43	108.16	127.97	122.33	123.62	126.40	91.02	124.86	88.73
Dairy	96.27	95.63	90.65	96.75	99.06	94.76	111.21	100.03	100.77	100.87	98.49	100.59
Deli	98.68	96.56	96.63	98.96	98.51	99.03	100.20	98.64	98.40	99.48	100.09	100.11
Frozen Foods	102.44	115.89	113.50	111.25	116.18	115.66	110.27	108.86	106.19	126.43	120.51	123.22
Edible Grocery	102.41	108.57	120.94	118.53	116.95	111.16	130.06	129.22	114.32	109.44	102.51	105.30
Nonedible Grocery	98.59	99.93	106.17	103.14	107.65	108.63	113.91	103.30	113.07	108.11	101.56	105.88
Health and Beauty	101.33	102.22	104.75	104.41	101.28	102.27	97.82	98.77	99.33	101.59	93.69	96.54
General Merch.	100.85	107.49	108.38	104.52	106.90	104.11	94.54	96.35	104.77	100.36	105.81	103.83
Other	99.20	98.79	99.24	101.81	105.95	102.40	106.39	103.44	109.34	109.34	109.34	109.66
Total	**102.33**	**108.03**	**111.62**	**112.53**	**111.00**	**109.75**	**116.91**	**114.19**	**111.99**	**109.11**	**109.53**	**108.53**

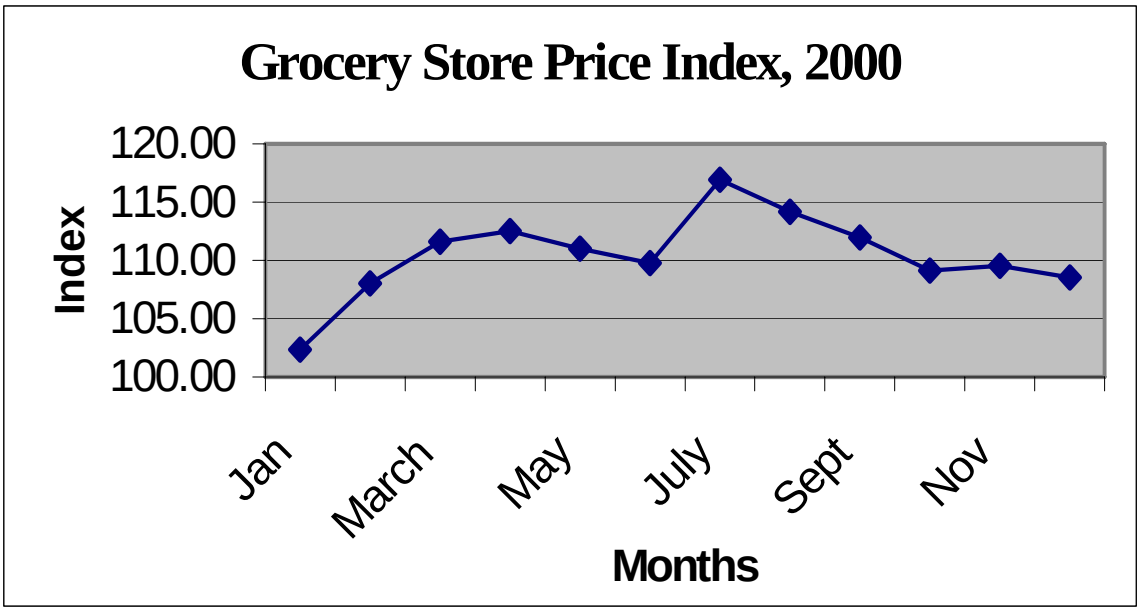

Figure 1. Monthly index for total grocery stores, 2000

Table 2. Weighted Regression of Log of Price Margin on Store Characteristics (t-statistic)

Dependent Variable	Log of the Price Margin
Characteristics	
Inventory Space*	**0.0734 (9.93)**
Inventory Space^2*	**-0.0015 (-7.49)**
Inventory Space^3*	**0.000003 (7.14)**
Stock-Keeping Units^	**0.0063 (4.88)**
Stock-Keeping Units^2^	**-0.0001 (-4.66)**
Stock-Keeping Units^3^	**0.0000001 (4.70)**
Hours of Operation	**-80.4124(-10.53)**
Hours of Operation^2	**10.8200 (11.28)**
Hours of Operation^3	**-0.7020 (-11.94)**
Hours of Operation^4	**0.0221 (12.52)**
Hours of Operation^5	**-0.0003 (-13.04)**
Number of Employees	**-0.0072 (-3.91)**
Number of Employees^2	**0.0001 (4.01)**
Number of Employees^3	**-0.0000002 (-4.07)**
Shopping Center	**0.1002 (3.81)**
Number of Checkouts	**0.0546 (3.44)**
Number of Checkouts^2	**-0.0018 (-3.86)**
Years Since Last Renovation	**-0.1933 (-3.42)**
Years Since Last Renovation^2	**0.0496 (4.51)**

Years Since Last Renovation^3	**-0.0044 (-5.54)**
Years Since Last Renovation^4	**0.00001 (6.43)**
Brand Name	**0.1174 (3.54)**
Income#	**0.0032 (3.70)**
Store Area*	**-0.0225 (-6.55)**
Store Area^2*	**0.0001 (4.55)**
Store Type	
Small Grocery	**0.6609 (4.46)**
Superstore	0.0245 (0.62)
Combination Store	0.0900 (1.83)
Warehouse Store	-0.0971 (-1.66)
Conventional Supermarket	Reference
Month Dummies**	NJS
Department Dummies**	JS
Intercept	**229.7210 (9.69)**
R-squared	0.22
Sample Size	8566

^In thousands of units.

In thousands of dollars per zip code of store.

* In thousands of square feet.

**JS = Jointly significant at the 5% level, NJS = Not jointly significant at the 5% level.

Table 3. Total Effect of Store Characteristics on Price Margin

Dependent Variable	Log of the Price Margin
Characteristics	
Inventory Space*	**0.0329**
Stock-Keeping Units^	**0.0029**
Hours of Operation	**0.2790**
Number of Employees	**-0.0007**
Shopping Center	**0.1002**
Number of Checkouts	**0.0099**
Years Since Last Renovation	**0.0328**
Brand Name	**0.1174**
Income#	**0.0032**
Store Area*	**-0.0093**
Department Dummies**	JS
R-squared	0.22
Sample Size	8566

^In thousands of units.

In thousands of dollars per zip code of store.

* In thousands of square feet.

**JS = Jointly significant at the 5% level.

Table 4. Standard and Quality Adjusted Index Comparison for a One-Store Change in Store Type from Conventional Supermarket to Superstore

Department	July Index	July Quality Adjusted Index
Meat	105.56	**105.47**
Produce	137.78	137.78
Bakery	122.33	122.33
Dairy	111.21	111.21
Deli	100.20	100.20
Frozen Foods	110.27	**110.24**
Edible Grocery	130.06	130.06
Non-Edible Grocery	113.91	113.91
Health and Beauty	97.82	**97.75**
General Merchandise	94.54	**93.77**
Other	106.39	106.39
Total	116.91	**116.85**

Table 5. Standard and Quality Adjusted Index Comparison for a Change in Store Type from Conventional Supermarket to Superstore for all Conventional Supermarkets

Department	July Index	July Quality Adjusted Index
Meat	105.56	**104.07**
Produce	137.78	**136.80**
Bakery	122.33	**119.62**
Dairy	111.21	**110.63**
Deli	100.20	**99.21**
Frozen Foods	110.27	**107.92**
Edible Grocery	130.06	**128.55**
Non-Edible Grocery	113.91	**109.37**
Health and Beauty	97.82	**96.87**
General Merchandise	94.54	**92.86**
Other	106.39	**105.99**
Total	116.91	**115.17**

Footnotes

[1] See Baker (1998).

[2] The Producer Price Index (PPI) constructed by the Bureau of Labor Statistics, measures the average change of selling prices over time received by producers of goods and services.

[3] 1997 Census of Retail Trade SIC 5411/NAICS 4451 is comprised of both supermarkets (95% of sales) and convenience stores (5% of sales).

[4] Within the supermarket category 77% of sales are from chain stores while 23% of sales are from independent stores.

[5] The Laspeyres Index is a price index that uses the base period quantity of goods sold or consumed as weights for the price changes measured over time. It can be expressed as $\{\Gamma (p_c Q_b)/ \Gamma (p_b Q_b)\}$ for all goods measured in a given price index.

[6] The Chain Store Guide contains information about supermarkets and convenience stores at the company level.

[7] Companies that own a set of chain stores often operate with more than one set of prices for different subsets of stores within the chain. These different sets of prices are known as pricing zones and usually are determined by the level of competition in a specific area. For companies selected that had more than one pricing zone for their stores, price quotes were divided amongst representative stores, one for each pricing zone. Chain stores were assigned 5, 7, or 11 quotes that were then divided among the selected stores, with the store representing the larger pricing zones getting a larger number of quotes.

[8] California, West, Mid-South, Great Lakes, Northeast, Plains, South Central, Southeast.

[9] Producer Price Measurement Concepts and Methods p.111.

[10] In the initial period of index calculation, b+1, the index is simply $(CA_{b+1} /\Sigma (P_b Q_b))*100$.

[11] The index constructed in this paper follows the same trend as the index constructed by BLS, but the

magnitude of the index here differs based on the slight differences between the two samples.

[12] See Triplett and McDonald (1977) for an application to refrigerators.

[13] Griliches (1961), for example, measures horsepower of the car in this way.

[14] Expressed as a fraction of the retail (or net) price that it is sold for.

[15] Anywhere from $0.01 to $54.40.

[16] Department that it is sold from or whether the product was a brand name or private label item.

[17] Meat, Produce, Bakery, Dairy, Deli, Frozen Foods, Edible Grocery, Non-Edible Grocery, Health and Beauty, General Merchandise, Other.

[18] I have also experimented with regressions run for each department separately and found similar results for the larger departments in the stores. The smaller departments often do not have enough individual observations to estimate the regression accurately.

[19] See Griliches (1971) for example.

[20] Other functional forms including linear, quadratic, cubic, uniform higher order terms, completely log, and step functions for the variables of interest did not perform as well in explaining the variation in price margins. The final functional form as show in Table 2 uses higher order terms for each independent variable with the maximum number of terms used for each variable based on significance. See Leibtag (2002) for additional discussion of these alternatives.

[21] This net effect of a characteristic is calculated using the coefficient for each term and evaluating its effect at the mean value for that characteristic in the data. Similar measures were calculated at the minimum and maximum values and did not significantly change the results.

[22] Ranging from a 0.0029% increase to a 0.2790% increase.

[23] Alternatively, Pakes (2001) notes that a negative sign on any one term in a characteristics regression may not be problematic because the individual coefficients are not necessarily accurate measures of the marginal valuation of each characteristic, but rather are only useful when used together with all relevant characteristics.

[24] Representing only about 1.5% of the sample.

[25] The same experiments were run using prices from other months with similar results found.

[26] On a scale based on 100 as the starting point and with an average monthly change of 2.59 index points per month for the year 2000.

[27] See Hausman and Leibtag (2004) for a discussion of these issues and their impact on the CPI.