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Title
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Journal
American Journal of Agricultural Economics P and P, 91(5)

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Publication Date
2009

Patterns of Pass-through of Commodity Price Shocks to Retail Prices

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The prices of corn and wheat started in the year 2000 at $1.92 and $2.17 per bushel, respectively. Eight years later, corn stood at $7.38 and wheat at $11.95 per bushel. In May of 2009, corn dropped to $3.96 and wheat to $4.77 per bushel. Gasoline prices followed the same pattern during the same period. The national average was $1.21 per gallon in 2000, increased to $4.11 per gallon in July of 2008, and dropped back down to $2.08 per gallon in May 2009. Other commodities followed similar patterns. Fuel, wheat, and corn are all important elements for the manufacture and delivery of foodstuffs. The effect of these high prices on food prices depends on the pass-through of these raw commodity prices to the prices of foods purchased and consumed by consumers. Since grain and fuel are only a fraction of the value of the consumed food products, the change

in prices is expected to be significantly less than the change in these commodity prices.

In this article we examine the pass-through of corn, wheat, and gasoline prices to the supermarket prices of cereals and chicken. We estimate these pass-through rates and compare our estimates to a rough estimate of the level of pass-through that can be derived from the cost share of the commodity in the final product. We also examine how the estimate of pass-through varies with price measurement. Because sales are a pervasive way of reducing prices, we expect analyses that use shelf prices to differ systematically from those that use transaction prices. We will show this in two ways: through a comparison of pass-through estimates from shelf and transaction prices and through an analysis of the frequency of sales as a function of commodity prices.

Farm to shelf markups have always concerned farmers who typically receive a very small share of the shelf price. Gardner (1975) set out a six equation model to explain the relation of prices at these levels. Heien (1980) introduced dynamics to the markup model and using retail and wholesale prices for 22 food items estimated the pass-through equations. He found no asymmetric effect—price increases and decreases have the same effect. More recently, researchers have been able to use consumer level data derived from supermarkets or from home scanners to investigate price variation and pass-through (Nakamura 2008; Rojas, Andino, and Purcell 2008). These data differ from earlier data in that they include promotions. Hosken and Reiffen (2004) show that retail promotions account for 20 to 50 percent of the annual variation in prices, so capturing these sales is an important part of the data. Pesendorfer (2002) analyzes the frequencies of sales as method of price discrimination; Berck et al. (2008) find little empirical

evidence supporting most theories of sales; and finally, Hendel and Nevo (2006a, 2006b) and Gicheva, Hastings, and Villas-Boas (2008) study the effect of sales on consumer behavior and demand substitution. Two recent papers use the transaction price data to examine pass-through. Kim and Cotterill (2008) set out two structural models, collusion and Nash-Bertrand, and estimate the pass-through of milk prices to cheese prices. They also estimate a nonstructural model and find that the empirical pass-through lies between the collusion and Nash-Betrand models. Leibtag et al. (2007) examine the pass-through for coffee. Their estimation shows a penny for penny pass-through in the long run and significantly less than that within a calendar quarter. Coffee and cheese are both good goods to study pass-through because of the relatively high percentage of value occupied by the raw commodity in the final product. Coffee is also subject to dramatic price swings that greatly increase the accuracy of estimation.

In this article we begin an investigation of the pass-through to transaction food prices of the changes in the prices of major food commodities at both farm and wholesale level. We have selected two commodities that are derived from grains, fresh chicken, and ready-to-eat cereals (cereals hereafter). Both storability and commodity content are related to pass-through. Storability allows retailers to segment the market between those who buy only for current consumption and those that will buy and store (Pesendorfer 2002; Hendel and Nevo 2006a, 2006b). Of these two products chicken presents a more competitive market, has the higher grain content, and is less storable. Cereal, on the other hand, is a highly concentrated industry, with differentiated products, high price-cost margins, and large promotion to sale ratios, presenting cooperative competition (Nevo

2001) that increases the likelihood of idiosyncratic behavior.

Data

The data are on prices at three levels along the vertical distribution chain: downstream retail (chicken and cereal), intermediate processing (feed and flour), and upstream commodities (corn and wheat).

The retail price data set comes from scanner data on two product categories from 184 retail grocery stores in California. The data were collected weekly and cover the years 2003-2005. We have weekly product level (UPC-level) data for all items within the two product categories analyzed (fresh chicken and ready-to-eat family cereal). The original scanner data include the total: unit quantity sold of each UPC, gross revenue, revenue net of sale discounts, and weight of the UPC sold for the chicken products (weights consists of pounds of meat, and price is measured in dollars per pound). Mean price for a box of cereal in our sample is $4.22, and the mean price net of promotional discounts is $3.78 with a standard deviation of $1.07. The average promotion is 51.7 cents which represent a 12.2 percent discount from the regular price. The large average promotional discount is driven by frequent buy-one, get-one-free sale. Approximately 32 percent of the UPC observations in our data set are on promotion every week. These sales make the gross price, which is the shelf price, different from the net price, which is the actual transaction price and includes the sales. For the chicken category the main product differentiation is by cut of meat: boneless-skinless, breast, leg, thigh, drumsticks, etc. There are not many brand varieties, and organic or free-range varieties were not prevalent at this retail chain during this time period. Price is measured

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in dollars per pound, and quantity sold is measured in pounds. For fresh chicken 32 percent of the observations in the data set are on promotion. The average gross price per pound across products is $3.37 with a standard deviation of $1.76, and the average net price per pound is $3.10 with a standard deviation of $1.75. The average markdown is 27 percent of price with a standard deviation of 15 percent. Hence, the average markdown as a percentage of price is lower for chicken than for cereal.

The data on cereal and chicken include many UPC codes for each commodity. The prices of these different UPC code items are aggregated using fixed quantity weights into a price index. In this manner we constructed an index for net price (NPI) and gross price (GPI) for chicken and cereal for each store and week. Also, we created an index of the frequency of sales. The percent of each month that each UPC was on sale is its sale frequency. Again, we used a fixed quantity weight index of the UPCs to construct our frequency index by month and store.

There is considerable variation in price from store to store, despite the fact that all these stores belong to the same chain. Also, chain management has stated that the stores take independent price decisions. The common trend estimated as the first principal component accounted for 69 percent of the variability, still leaving 31 percent of the variability from other and presumably less common sources. This result is very similar to the average correlation among the 184 series for the NPI, which is equal to 67.4 percent.

Data on corn price are the futures prices from Chicago Board of Trade (CBOT), while data on feed are monthly data from the producer price indices (PPI).

Either corn or wheat or both are present in nearly all the cereals in our sample.

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Corn may be present in many forms, including as grain and as sweetener. The corn content of a box of cereal was about 4 cents if the cereal were solely corn based. This is almost 1 percent of the value of the product. Flour would be a higher percentage of value. The flour price is the PPI, while the wheat price is the CBOT futures price.

During the time of this study, there was a strike in some of the stores, and this is accounted for by a strike dummy. The tendency to have sales at holidays was accounted for by a holiday dummy. Transport costs were proxied with the gasoline price. Additionally, there were store and seasonal fixed effects and regional time trends. Table 1 gives the definition of each variable, its source, and its maximum and minimum value.

Empirical Strategy

To estimate the pass-through on cereal and chicken, we regress our three measures of retail price activity (NPI, GPI, and frequency index separately) on the input price in question while controlling for store-level fixed-effects, month dummies, holiday dummies, and regional time trends. The reduced form specification is given by:

(1) $\quad \log(y_{jrt}) = g_j + m_t + a\log(y_{jrt-1}) + y\,Strk_{jt} + d_r t + Holi_t q + \log(Input_t)b + e_{jrt}$,

where $\log(y_{jrt})$ represents the three dependent variables in logs in store *j* in time period *t* and in region *r*: (i) The index of "regular" shelf-prices or GPI, (ii) an index of prices "net of promotional discounts" or NPI, and (iii) the mean time frequency index. The intermediate, or commodity prices, are the inputs, and $\log(Input_t)$ is used. Each regression included store level fixed effects g_j and seasonal fixed effect m_t. To control

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for regional effects, there were regional trends $d_r t$ ($r = 1$ if store j is in South California and 0 if North California). Dummies for the Thanksgiving, Christmas, New Year's Day, and the Fourth of July $Holi_t$ are included for the week in which that day is held. Finally, $Strk_{jt}$ corresponds to dummies for the periods and stores under strike in southern California.

The fixed effects take into account all the variation in the store and store customers that are invariant in time such as location, squared feet of store, number of employees, etc. The seasonal fixed effect takes into account the changes that are common for all stores in a given month; the regional trends capture the differences in the regional prices tendencies common for stores in a given region.

The parameter b measures the contemporaneous effect on retail price activity of the changes in commodity prices, controlling for seasonal, event, and regional effects.

To account for possible slow adjustment of price we add a lagged dependent variable. Now, the parameter of interest is the long run elasticity or dynamic multipliers given by:

$$(2) \qquad z(P_{y_t}; P_{input_t}) = \frac{\hat{b}_{input}}{1 - \hat{a}}.$$

The standard errors of the dynamic multipliers are calculated using the Delta method.

Before running the pass-through regressions, the system was checked for stationarity with the test of Levin, Lin, and Chu (2002). The null hypothesis of unit roots was rejected. Since this system is a panel with a lagged dependent variable and fixed effects, the ordinary difference in difference estimator would not be consistent.

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Therefore, we estimated pass-through using the Generalized Method of Moments (GMM) Arellano-Bond (1991) estimator. We used four lags of the exogenous variable and the exogenous variables as instruments.

Results: GPI and NPI

Table 2 shows the coefficients, and table 3 shows the dynamic multipliers. The first set of columns in table 2 are the cereal results, the second set the chicken results. Within the sets the results for GPI are presented before those for NPI and with those categories first regressions on commodities and then on intermediate goods. The reported standard errors are GMM robust standard errors. All of the coefficients were significantly different from zero.

If the technology at all levels of processing was Leontief and the market organization was strictly competitive, then pass-through would be dollar for dollar. Let r be the input requirement, approximately 1 for grain in cereal and 2.6 for grain in chicken, then the elasticity of NPI with respect to commodity price should be $r \times P / \text{NPI}$, where P is commodity price. Vukina (2009) provides data showing that feed costs were 15.13 cents per lb, inclusive of corn costs of 10.2 cents per lb of chicken on December 30, 2005. For chicken this estimate of pass-through elasticity would be under 3 percent for corn and 4 percent for feed. The estimated pass-through for chicken using NPI is 17 percent for corn and 30 percent for feed. The sign on other potential cost shares is negative: gasoline is reported but the same results obtain with labor. Labor was not included because the available series do not match our chain very well.

The Leontief-competitive pass-through for cereal also would be less than

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3 percent. However, the estimated results for pass-through rates to NPI are quite different from either the Leontief-competitive model or from those for chicken. The pass-through elasticity for corn is negative and for wheat it is positive for cereal. Added together (since both corn and wheat trend together), they come to 15 percent, well above the naïve level. For flour the elasticity is above 1, yet flour is not even the majority cost share of cereal on the shelf. Gasoline again has the wrong sign.

Comparing the NPI and GPI estimates, for cereal the GPI estimates of pass-through are bigger and statistically significantly so. For chicken it is the NPI estimates that are greater, also statistically significantly so. Therefore, it is important to use NPI, as the existence of sales does change the estimates of pass-through.

Results: Frequencies

We ran the same set of regressions with the frequency of sales as the dependent variable, and results for coefficients and dynamic multiplier are presented in tables 4 and 5. In this case we expect that increases in input prices cause decreases in the percentage of time on sale. For chicken we found that the mean frequency does not show statistically significant changes when corn price changes, whereas the long run elasticity for feed is significant and above 1. Additionally, the frequency of sales decreases when the gas price goes up.

For cereal we found that wheat has an unexpected positive coefficient, and corn has a coefficient of -2.13. Together they add -1.11, indicating a great response of the frequency of sales when commodity prices change. On the other hand the long-run flour elasticity has the wrong sign.

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Conclusion

The aims of this article are to re-estimate the cost pass-through accounting for sales and to provide dynamic multipliers for grain commodity price increases to supermarket shelf prices. First, the estimated dynamic elasticities are not as small as one might expect from a naïve model. The elasticity of cereal price with respect to flour is over 1, and the elasticity of chicken price with respect to chicken feed was 30 percent. These estimates would imply a very large price increase in cereal and chicken over the last several years. Second, the elasticity estimates are definitely different when one includes sales but not always in the expected manner. There are fewer sales when commodity prices go up. From this we would conclude that net prices should be used for pass-through analysis.

One explanation for the large elasticities is imperfect competition and particularly the chicken-chicken feed elasticity is in the range of what Kim and Cotterill (2008) found. Another explanation is that a longer time series is needed for this estimation, and with a longer time series we would also be able to produce sensible estimates of the pass-through on labor and gasoline.

To deal with omitted variables and price stickiness, we included a lagged dependent variable, using the Arellano-Bond (1991) dynamic panel estimator. For chicken the results show that using standard information on regular shelf price leads to an underestimation of the true pass-through coefficient. For cereal using standard shelf prices leads to an overestimation of the pass-through coefficient reflecting the importance of storability faced by consumers and retailers and industry characteristics in the sale dynamics.

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Table 1. Data Sources

Name	Description	Source	Frequency	Min	Max
Flour (index number)	Milled flour	PPI sub-series 311211311211	M	112.20	119.90
Feed (index number)	Chicken Feed	PPI sub-series 93111912	M	74.40	103.50
Wheat ($/bu)	Cash	CBOT	W	2.54	4.22
Corn ($/bu)	Cash	CBOT	W	1.80	3.30
NPI-Cereal ($/box)	Net price ready to eat cereal	184 store scanner data	W	1.24	4.03
GPI-Cereal ($/box)	Gross price ready to eat cereal	184 store scanner data	W	1.40	4.29
NPI-Chicken($/lb)	Net price fresh chicken	184 store scanner data	W	.12	4.00
GPI-Chicken ($/lb)	Gross price fresh chicken	184 store scanner data	W	.13	4.14

Note: All data are for 2003 to 2005. The PPI is the producer price index of the Bureau of

Labor Statistics. The CBOT is the Chicago Board of Trade.

Table 2. Arellano-Bond Regressions for log(GPI) and log(NPI) for Cereal and Chicken

	Cereal				Chicken			
	GPI		NPI		GPI		NPI	
Log(y(t-1))	0.728	0.684	0.298	0.288	0.374	0.368	0.117	0.108
	(0.014)*	(0.014)*	(0.007)*	(0.007)*	(0.019)*	(0.019)*	(0.012)*	(0.012)*
Log (Flour/PPI)		0.526		0.821				
		(0.020)*		(0.034)*				
Log (ChicFeed/PPI)						0.131		0.27
						(0.011)*		(0.020)*
Log(Wheat/PPI)	0.099		0.163					
	(0.005)*		(0.005)*					
Log(Corn/PPI)	-0.037		-0.049		0.082		0.152	
	(0.003)*		(0.005)*		(0.010)*		(0.016)*	
Log(Gas/PPI)	0.057	0.048	-0.047	-0.057	-0.131	-0.142	-0.202	-0.222
	(0.005)*	(0.005)*	(0.007)*	(0.006)*	(0.012)*	(0.012)*	(0.018)*	(0.018)*

Table 2 continued.

	Cereal				Chicken			
	GPI		NPI		GPI		NPI	
Constant	-0.838	-0.878	-3.01	-2.829	-3.152	-3.119	-4.753	-4.652
	(0.049)*	(0.048)*	(0.053)*	(0.044)*	(0.101)*	(0.099)*	(0.108)*	(0.102)*
Observations	28152	28152	28152	28152	28149	28149	28149	28149
Store FE	184	184	184	184	184	184	184	184

Note: Dependent variables are log(GPI) and log(NPI) for cereal and chicken respectively. All regressions include regional

trends and month, holidays, and strike and regional dummies.

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*Robust standard errors are in parentheses and significant at the 1 percent level.

Table 3. Dynamic Multipliers for GPI and NPI

	Cereal				Chicken			
	GPI		NPI		GPI		NPI	
Log(Flour/PPI)	1.665		1.153					
	(0.040)*		(0.044)*					
Log(ChicFeed/PPI)					0.207		0.303	
					(0.018)*		(0.022)*	
Log(Wheat/PPI)	0.364		0.232					
	(0.008)*		(0.006)*					
Log(Corn/PPI)	-0.135		-0.07		0.131		0.172	
	(0.009)*		(0.008)*		(0.016)*		(0.018)*	
Log(Gas/PPI)	0.21	0.153	-0.067	-0.081	-0.208	-0.224	-0.229	-0.249
	(0.017)*	(0.014)*	(0.010)*	(0.009)*	(0.019)*	(0.019)*	(0.019)*	(0.020)*

Note: Delta method standard errors are in parentheses.

*Significant at 1 percent.

Table 4. Arellano-Bond Regressions for Cereal and Chicken Sale Frequency Index

	Cereal		Chicken	
Log(y(t-1)	0.103	0.039	-0.195	-0.183
	(0.020)*	(0.018)**	(0.024)*	(0.023)*
Log(Flour/PPI)		1.183		
		(0.100)*		
Log(ChicFeed/PPI)				-1.528
				(0.215)*
Log(Wheat/PPI)	0.917			
	(0.031)*			
Log(Corn/PPI)	-1.913		-0.241	
	(0.044)*		(-0.163)	
Log(Gas/PPI)	-0.276	0.286	-0.446	-0.409
	(0.020)*	(0.016)*	(0.101)*	(0.065)*
Observations	2775	2775	2775	2775
Store FE	184	184	184	184

Note: Dependent variable: log(frequency). All regressions include regional trends and month, holidays, and strike and regional dummies. Robust standard errors are in parentheses

*Significant at 1 percent.

**Significant at 5 percent.

Table 5. Dynamic Multipliers for the Frequency Index

	Cereal		Chicken	
Log(Flour/PPI)		1.231		
		(0.094)*		
Log(ChicFeed/PPI)				-1.292
				(0.180)*
Log(Wheat/PPI)	1.023			
	(0.044)*			
Log(Corn/PPI)	-2.133		-0.202	
	(0.076)*		(0.135)	
Log(Gas/PPI)	-0.308	0.297	-0.373	-0.346
	(0.027)*	(0.013)*	(0.081)*	(0.053)*

Note: Delta method standard errors are in parentheses.

*Significant at 1 percent.