The Impact of Higher Prices of Nonfarm-Inputs to Food Processing And Distribution on Food Prices and Quantities*

by

C. M. Gempesaw II
Assistant Professor of Food and Resource Economics
University of Delaware

J. W. Dunn
Associate Professor of Agricultural Economics
The Pennsylvania State University

Introduction

Over the last three decades, a smaller portion of the consumer's food dollar has been for nonfarm inputs and a larger share for farm inputs. As may be seen in Table 1, 40 percent of gross purchases by the food manufacturing industry were spent on agricultural products. By 1972, the share of agricultural product purchases had declined to less than 29 percent. In contrast, purchases of nonfarm inputs increased in relative importance, growing from 60 percent in 1947 to over 70 percent in 1972.

Among the nonfarm inputs purchased, containers and packaging purchases had the largest percentage increase, doubling its share from 4 percent to 8 percent. In current dollar terms, purchases of containers and packaging grew by 9.6 percent annually. With overall inflation averaging 2.6 percent during the same time period, purchases of this nonfarm input increased at an annual rate of almost 7 percent in real terms. This change is consistent with the intensive use of product differentiation to gain brand loyalty and premium prices over this period. One of the most prevalent methods of product differentiation has been the design of attractive packaging (Scherer). Also, retail food products are processed further than they were 40 years ago. As incomes and the number of women employed outside the home have risen, more food preparation has been done in the factory and less in the home.

The increasing use of nonfarm inputs relative to farm products has occurred despite larger increases in nonfarm-input prices than in farm prices (Table 2). During the 1950-84 period, farm product prices rose by an annual rate of 2.7 percent, while nonfarm-input prices increased by 5.5 percent annually. Packaging and containers, along with hired labor wages, had the largest annual price increases among the nonfarm inputs. However, during the 1970-84 period, as a result of the quadrupling of energy prices, transportation services had the largest price increase among the nonfarm inputs. For this time period, nonfarm-input prices rose by 8.4 percent annually, while farm product prices only rose by 6.3 percent per annum. These figures illustrate the

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Table 1. Gross Purchases by the Food and Tobacco Manufacturing Industries from Other Industries, 1947-72

Industries	1947 $ Billion	%	1972 $ Billion	%
Labor and capital utilization	8.6	20.4	49.0	22.7
Agriculture	16.8	40.0	62.2	28.8
Livestock	10.6	25.4	44.7	20.7
Crops	6.2	14.6	17.5	8.1
Semifinished food stuff	8.5	20.3	38.8	17.9
Containers and Packaging	1.7	4.0	17.0	7.9
Transportation Services	1.2	2.8	6.2	2.9
All Other Industries	5.3	12.5	43.1	19.8
TOTAL	42.1	100.0	216.3	100.0

SOURCE: Connor, et al. (1985) and U.S. Department of Commerce, U.S. Input-Output Table.

Table 2. Average Annual Increase in Farm and Nonfarm-Input Prices Used in the Food Processing and Distribution Industry

Input	% Annual Increase 1950-84	1970-84
Agricultural Products	2.7	6.3
Livestock	2.7	5.7
Field Crops	2.8	7.2
Hired Labor	5.6	8.2
Packaging and Containers	6.1	8.1
Transportation Services*	4.5	9.2
Intermediate Goods and Services	4.9	8.5
All Nonfarm Inputs**	5.5	8.4

SOURCE: Statistical Abstract and Agricultural Statistics, various issues.

* CPI for transportation
** Nonfood producer price index

increasing importance of nonfarm inputs to the food marketing industry despite larger price increases for nonfarm inputs compared to farm inputs.

The growing share of nonfarm inputs and the food-price inflation of the 1970s sparked an interest in the effect of changes in nonfarm-input prices on food prices. Studies by Heien (1983), Lamm, and Lee are examples. These studies have generally found that nonfarm-input price increases contributed significantly to food-price inflation. Gardner showed how marketing margins change when the farm output, marketing supply, and retail demand functions change. Among his numerous results, he concluded that an increase (decrease) in the supply of marketing inputs will decrease (increase) the retail-farm price ratio or lower (raise) marketing margins. Lamm and Westcott analyzed the effects of nonfarm-input prices on retail food prices using Popkin's stage-of-processing approach and found that both higher farm-output prices and nonfarm-input prices contribute to higher relative food prices. Dunn and Heien also examined the effect of nonfarm-input prices on the derived demand for farm output and concluded that higher nonfarm-input prices have a significant depressing effect on farm output demand.

Of these previous studies, only Dunn and Heien allowed any commodity interactions. They either dealt with a simple aggregate commodity or they dealt with each commodity individually. However, there are actually many potential interactions between commodities. Certainly the consumer considers the prices of several food items when planning a menu. Similarly, substantial interactions may exist at the farm level. For example, Gempesaw and Dunn found statistically significant relationships among livestock products and among crop products in their study of the structure of northeastern agriculture. Although the interactions are undoubtedly less at the marketing level, some potential substitutability and complementarity may exist. It should be noted that Dunn and Heien tested for these interactions but found none.

Objectives

This study has two objectives. First, a model for measuring the economic impact of changes in nonfarm-input prices on food supply and demand is to be developed. This model is to divide into a farm sector, a marketing sector, and a consumer sector and will include several commodity groups simultaneously. The second objective is to use this model to estimate the consequences of changes in the prices of the nonfarm inputs used in food processing and distribution on the quantities and prices of food products at the farm, marketing, and consumer level.

Methodology

The model divides food markets into three parts: the farm sector, the consumer sector, and the marketing sector. The marketing sector includes those agents who store, transfer, and otherwise transform raw farm products into finished retail products. It is assumed that the difference between retail prices and the value of the farm ingredients in those retail products is the price of these marketing services. The interrelationship between the three sectors means that a change in conditions in one sector affects the other sectors. An additional characteristic included is the interrelationship between different categories of food and farm products. This interrelationship occurs to some degree at all levels, but primarily at the consumer level where different food products may be substitutes or complements, and at the farm level where different farm products may be related in their production, such as milk and feed grains.

There are two types of models used in this study. The first model is for a single product but is multi-sectoral, meaning it deals with only one food product but includes the interaction among the farm, marketing, and consumer sectors. This approach is called the single commodity model. The second model is multi-product and multisectoral and includes not only the three sectoral interactions but also the relationship among all food products. This approach is called the multiple commodity model. The multiple and single commodity

models follow the basic equilibrium model developed by Dunn for a single commodity. A modification of that model is used in this study to include multi-commodity interactions.

The farm supply sector is divided into two parts, food and feed. The farm supply of food products is of the form

$$(1) \quad \ln Q_i = \sum_{j=1}^{6} \gamma_{ij} \ln F_j,$$

where Q_i is the farm quantity of meat animals, dairy products, poultry and eggs, fruits and vegetables, and other food products for $i = 1, \ldots, 5$ respectively and F_j is the farm price of the preceding products for $j = 1, \ldots, 5$ and for feed grains if $j = 6$.

The supply of feed grains is given by

$$(2) \quad \ln Q_6 = \sum_{j=1}^{6} \gamma_{6j} \ln F_j$$

and the demand for feed grains by

$$(3) \quad \ln Q_6 = \sum_{j=1}^{6} \beta_{6j} \ln F_j,$$

where Q_6 is the quantity of feed grains and the F_j's are defined as before. Estimates of γ_{ij} and β_{6j} come from Gempesaw (1985).

The marketing sector buys farm and nonfarm inputs and sells retail products. Its demand equations for farm inputs are of the form

$$(4) \quad \ln Q_i = \sum_{j=1}^{5} \beta_{ij} \ln F_j + \sum_{k=1}^{4} \alpha_{ik} \ln W_k + \sum_{j=1}^{5} \theta_{ij} \ln X_j + \phi_i \ln K$$

for $i = 1, \ldots 5$

and the demand equations for nonfarm inputs are of the form

$$(5) \quad \ln N_l = \sum_{j=1}^{5} \eta_{lj} \ln F_j + \sum_{k=1}^{4} \mu_{lk} \ln W_k + \sum_{j=1}^{5} \varepsilon_{lj} \ln X_j + \Gamma_l \ln K$$

for $l = 1, \ldots 4$

where Q_i and F_i are defined as before, X_j is the retail quantity of food product j to be produced, with $j = 1, \ldots, 5$ defined as at the farm level, W_k is the price of the nonfarm inputs labor, packaging, transportation, and other inputs for $k = 1, \ldots, 4$ respectively, N_l is the quantity of these same nonfarm inputs, and K is the capital in the marketing sector. Marginal cost pricing would provide a supply of retail products of the farm

$$(6) \quad P_i = \sum_{j=1}^{5} \tau_{ij} \ln F_j + \sum_{k=1}^{4} \mu_{ik} \ln W_k + \sum_{j=1}^{5} \pi_{ij} \ln X_j.$$

Estimates for the parameters of the marketing sector are found in Dunn and Heien. Lastly, retail demand is of the form

$$(7) \quad \ln Q_i = \sum_{j=1}^{5} \lambda_{ij} \ln P_j.$$

Estimates for the parameters of the demand sector are found in Heien (1982).

The system of equations is in elasticity form, since all variables are in logarithms. Of the variables listed, only the W_k's and K are exogenous. Therefore the system may be solved for reduced form elasticities with respect to changes in these variables.

In this study, the farm production structure is assumed to be separable in six farm

product categories: meat animals, dairy products, poultry and eggs, fruits and vegetables, feed grains, and other farm products which are mostly comprised of food grains. Feed grains are excluded in the marketing and consumer sectors because they are intermediate input to farming. Nonfarm inputs to the marketing sector considered here are hired labor, packaging and containers, transport, and other nonfarm inputs.

Hired Labor Effects

In 1984, one-third of total consumer expenditures for food products was accounted for by direct labor costs in the food marketing sector. This is the largest single component of the total food marketing bill (Dunham). The effects of higher wage rates on the supply and demand for food products at the farm and retail sectors and the marketing bill are shown in Table 3 for both the multiple and single commodity models.

As an a priori hypothesis, one would expect higher wage rates to increase the marketing bill and retail prices and to lower farm prices for food products (Tomek and Robinson). Higher wage rates are also expected to have a negative effect on the quantity of food products at all levels. In the single commodity model, these were the results generally found except for the farm price for poultry and eggs and the marketing bill and retail price of other products. The largest response in the marketing bill to a one percent increase in labor cost was from meat animal products (1.277) with fruits and vegetables having the smallest positive response (0.052). The same pattern was also found in the retail price responses.

When all products were considered simultaneously, with interactions possible at all levels, the values for all and the signs for some elasticities changed. These changes were most substantial at the farm level, where interactions among products allowed feed grain prices to fall, resulting in a positive impact on the farm-level prices of poultry and eggs (1.298) and meat animals (.010). Commodity interactions apparently put more pressure on the marketing sector to hold down its costs, with smaller increases estimated for the marketing bill for all livestock products. These smaller increases in the marketing bill led to smaller decreases in retail consumption of meats (-.376) and dairy products (-.111). Except for fruits and vegetables, the retail prices of all the other commodities increased due to higher labor cost. The highest response was found in poultry and egg retail prices (0.882). This may imply that poultry processors can pass higher labor costs to consumers more readily than can meat, dairy, and other food product processors.

It is interesting to note that the two products of the farm sector which suffered most from an increase in labor costs were feed grains (-.277) and other food products (-1.441). Other than dairy, these two product groups include most of the farm products with substantial government programs. These results suggest that these product groups also bear the brunt of higher labor costs in the marketing sector, perhaps making such programs necessary.

Packaging Price Effects

In 1984, eight cents of every dollar spent on food went to packaging cost (Dunham). The use of packaging is important both for the preservation of food products and for product differentiation. The differentiation of food products allows individual companies to compete on the basis of product characteristics as well as price and to achieve profitability levels generally not found in undifferentiated food products. As an example, the profits of poultry firms have been aided substantially by the sale of branded frozen nuggets, patties, pieces, and breast strips.

One would expect packaging costs to have an impact similar to labor costs, i.e., higher retail prices and marketing bills, lower farm prices, and smaller quantities. The exception might be in firms which are unable to pass on these costs effectively, opting instead to decrease packaging and perhaps differentiation. For the single commodity model results as shown in Table 4, only meat animals did not have a negative response in farm prices (0.077) and quantity (0.012). Dairy, poultry

Table 3. Elasticities of Response of Various Food Prices And Quantities to Changes in Labor Costs to the Marketing Sector

	Food Products											
	Meat Animals		Dairy Products		Poultry and Eggs		Feed Grains*		Fruits and Vegetables		Other Products	
	MC**	SC	MC	SC	MC	SC	MC	SC	MC	SC	MC	SC
Farm Quantity	-.008	-.010	.004	-.025	.147	.037	-.123		-.122	-.037	-.071	-.039
Farm Price	.010	-.067	-.011	-.198	1.298	.329	-.277		-.065	-.122	-.316	-1.441
Marketing Bill	1.094	1.277	.318	.733	.237	.722			.087	.052	.355	-.016
Retail Quantity	-.376	-.418	-.111	-.277	-.303	-.266			-.037	-.005	-.056	.072
Retail Price	.567	.624	.161	.288	.882	.483			.049	.008	.257	-.224

* There is no retail demand for feed grains. The results pertain only to the farm level. Also, there is no single commodity model for feed grains.

** MC - multiple commodity model results.
SC - single commodity model results.

Table 4. Elasticities of Response of Various Food Prices And Quantities to Changes in Packaging Costs to the Marketing Sector

	Food Products											
	Meat Animals		Dairy Products		Poultry and Eggs		Feed Grains*		Fruits and Vegetables		Other Products	
	MC**	SC	MC	SC	MC	SC	MC	SC	MC	SC	MC	SC
Farm Quantity	-.101	.012	-.034	-.002	.016	-.024	.069		-.161	-.043	.031	-.026
Farm Price	.235	.077	.042	-.016	-.270	-.213	-.019		.034	-.140	-.879	-.978
Marketing Bill	.002	-.063	.038	-.007	-.494	-.575			.168	.138	.250	-.301
Retail Quantity	-.082	-.003	-.017	.004	.233	.195			-.083	-.042	.003	-.037
Retail Price	.115	.005	.040	-.004	-.358	-.355			.134	.068	.085	.114

* There is no retail demand for feed grains. The results pertain only to the farm level. Also, there is no single commodity model for feed grains.

** MC - multiple commodity model results.
SC - single commodity model results.

and eggs, fruits and vegetables and other products had lower farm prices due to higher packaging costs with especially large negative impacts on other products (-.978) and poultry and eggs (0.213). The effects of higher packaging costs on the marketing bill of the different food products were mixed. The marketing bill of dairy (0.007), fruits and vegetables (0.138), and other products (0.301) had positive responses while those of meat (-.063) and poultry and eggs (-.575) had negative responses.

When all products were considered simultaneously, the results of commodity interactions differed somewhat from the single commodity models. In the multiple commodity model, the farm prices of meat animals (0.235), dairy products (0.042), and fruits and vegetables (0.034) rose in response to higher packaging prices. Except for poultry and eggs (-.358), all retail prices increased given higher packaging prices. In this instance, the demand impacts offset the supply impacts by decreasing output for those products which decreased in price. The marketing bill for poultry and eggs declined (-.494), while meat (0.002) and dairy (0.038) rose slightly and fruits and vegetables (0.168) and other products (0.250) increased substantially.

At the farm level, the most negative impacts of higher packaging prices were for other products (-.978) and poultry and eggs (-.270). In general, these types of products have more product differentiation than dairy or meat products, making the farm level producers of such products most vulnerable to changes in packaging costs.

Transportation Cost Effects

With the regional specialization of agricultural production and the differences between the distribution of population and farm production, a substantial interregional trade in food products occurs in the U.S. This trade requires physical transport of farm and processed products. In 1984, transport costs accounted for approximately 5 percent of retail food expenditures (Dunham). The results of a change in transport costs on food prices and quantities are shown in Table 5. Higher transport costs are expected to increase the marketing bill, decreasing quantities and farm prices, while increasing retail prices. In the single commodity model, this occurred for all food products except for meat animals, which had a lower retail price (-.231) and marketing bill (-.384).

As with the impacts of higher labor and packaging costs, when all food products were considered simultaneously, the commodity interactions changed the results. As an example, interactions allowed a greater decrease in the farm prices for poultry and eggs (-.700), dairy (-.340) and meat (-.105). Meat products seemed especially vulnerable to transport price effects, with higher transport prices apparently placing substantial pressures on packer's margins, thereby resulting in lower prices at all levels. Margins increased for all other products, with the farmer bearing the burden in dairy and poultry and eggs, and the consumer bearing the burden in fruits and vegetables and other products. The marketing bills of poultry and eggs, dairy products, and fruits and vegetables had the largest positive responses to higher transportation costs (.634, .474, and .413 respectively).

Other-Input Price Effects

The other-input category includes utilities, advertising, taxes, rent, and other expenses, and accounts for 26 percent of total consumer expenditures for food in 1984 (Dunham). The effects in the single and multiple commodity models due to changes in other-input prices are shown in Table 6.

As with the effects of labor, packaging, and transport costs, higher other-input prices are expected to decrease consumer demand and farm prices, and increase retail prices and the marketing bill. The single commodity model's results show that these expectations were true for meat products. Except for the positive responses in farm prices, dairy, fruits and vegetables, and other products had an increase in the marketing bill and retail prices, along with a decrease in retail quantities.

When commodity interactions were considered, different results were derived. For

Table 5. Elasticities of Response of Various Food Prices And Quantities to Changes in Transport Costs to the Marketing Sector

	Food Products											
	Meat Animals		Dairy Products		Poultry and Eggs		Feed Grains*		Fruits and Vegetables		Other Products	
	MC**	SC	MC	SC	MC	SC	MC	SC	MC	SC	MC	SC
Farm Quantity	.032	-.011	.034	-.017	-.086	-.024	.083		-.260	-.076	.033	-.014
Farm Price	-.105	-.069	-.340	-.136	-.700	-.213	-.291		.023	-.250	.004	-.520
Marketing Bill	-.634	-.384	.474	.199	.634	.351			.413	.263	.050	.147
Retail Quantity	.237	.155	-.070	-.037	-.026	-.005			-.181	-.083	.037	-.016
Retail Price	-.377	-.231	.085	.039	-.177	.088			.315	.134	.043	.050

* There is no retail demand for feed grains. The results pertain only to the farm level. Also, there is no single commodity model for feed grains.

** MC - multiple commodity model results.
SC - single commodity model results.

Table 6. Elasticities of Response of Various Food Prices And Quantities to Changes in the Costs of Other Inputs to the Marketing Sector

	Food Products											
	Meat Animals		Dairy Products		Poultry and Eggs		Feed Grains*		Fruits and Vegetables		Other Products	
	MC**	SC	MC	SC	MC	SC	MC	SC	MC	SC	MC	SC
Farm Quantity	.446	-.016	.122	.003	-.222	-.070	-.136		.681	.100	-.032	.040
Farm Price	-.806	-.101	-.304	.023	-.291	-.612	.323		-.067	.329	3.858	1.482
Marketing Bill	.023	.298	.864	.517	.196	.294			.213	.481	.542	.362
Retail Quantity	.275	-.069	-.259	-.269	-.061	.141			-.040	-.326	-.096	-.142
Retail Price	-.380	.104	.306	.281	-.100	-.257			.143	.443	1.026	.526

* There is no retail demand for feed grains. The results pertain only to the farm level. Also, there is no single commodity model for feed grains.

** MC - multiple commodity model results.
SC - single commodity model results.

example, the marketing bill for meat (0.023) increased slightly along with a substantial drop in farm prices (-.806) which might have caused an unexpected positive response in retail quantity (0.275) and negative response in retail price (-.380). Except for meat, increases in other-input cost had a depressing effect on consumer demand for all food products. The marketing bill for dairy (0.864) and other products (0.542) had the largest positive response to higher other-input prices. This was especially true for the other product category which includes cereal products. As an example, advertising cost is a major component in the total distribution costs of cereal products. Farm producers of meat (-.806), dairy (-.304), poultry and eggs (-.291), and fruits and vegetables (-.067) were worse off in terms of lower farm prices due to higher other-input prices.

Conclusion

Models were developed to estimate the effects of changes in prices of nonfarm inputs to the food processing and distribution sector. A model allowing commodity interactions at all levels was solved and the results were contrasted with the results of a more traditional, single commodity model. These models are all very aggregated, providing only general trends and magnitudes of the changes. They do, however, illustrate the importance of nonfarm inputs on all levels of the food industry. Furthermore, since the different food products interact at the farm, marketing, and consumer levels, these interactions may cause responses for particular products to nonfarm-input price changes which differ substantially from results of the single commodity model. This is especially true for meat, poultry and eggs, and dairy, all of which use feed grains, compete for other farm level inputs, and are closely related at the consumer level.

The poultry market was found to be very sensitive to nonfarm-input prices, with the exception of the other-input category. Meat prices were also very sensitive to nonfarm-input prices, with large quantity effects for transport and other-input prices. In contrast, the remaining products were more selectively affected, with dairy being affected most by other-inputs, fruits and vegetables by transport prices, feed grains by all nonfarm inputs except packaging, and other food products by other-input prices.

For all of these products, at least one category of nonfarm inputs to the marketing sector has major effects on the level of food prices and quantities. As a result, changes in these prices can have major impacts on the farm level, often offsetting the impacts of agricultural policy. These research results also imply that rising nonfarm-input costs have important consequences on the vertical integration of food processors and distributors. As an example, poultry and egg processors not only control the sources of farm broilers through production contracts but also own the refrigerated transportation needed to guarantee on-time quality shipments. It has been pointed out by Connor et al. that there is increasing evidence about the direction of food manufacturer diversification. Three important directions mentioned are vertical integration into packaging and containers, conglomerate diversification into other consumer products, and into wholesaling and retailing. Hence, the ability of firms to handle rising nonfarm-input is certainly influenced by the extent of their control over vital resources.

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