*Journal of Agribusiness* 20,1 (Spring 2002):85–102


# The Impact of Intermediate Input Price Changes on Food Prices: An Analysis of "From-the-Ground-Up" Effects

**Chinkook Lee**

The impact of intermediate input price increases on food prices is analyzed assuming the producers can pass through increased production costs to final consumers. Five scenarios of input price increases are empirically examined. Findings indicate that the meat processing sector has a strong dependence on intermediate inputs (livestock), and an increase in livestock prices would have a greater impact on processed meat prices than would any other intermediate input price increases. Price increases in the service sector would result in overall price increases in food prices comparable to increases in intermediate agricultural commodities. Further, price increases in nondurable goods have more influence on food price increases than durable goods.

***Key Words:*** food price, input-output analysis, intermediate input, pass-through effects

The primary objective of this study is to assess the impact of intermediate input price increases on food production costs, and thereby on food output prices when the increased costs are passed through to final consumers. A major concern is the effect of changes in raw farm product prices on food prices, as well as the impact of changes in the cost of other intermediate inputs used in food processing and distribution. Intermediate inputs—inputs bought by one industry from other industries to produce its own outputs—are distinguished from primary inputs in that the value of intermediate inputs indicates value added by some other industries.

Input price increases arise from several sources, including general inflation, weather-related supply problems (particularly in the case of farm products), and/or energy-related crisis spirals. National monetary and fiscal policies can also create excess demand, resulting in higher prices (including higher interest rates and wages) for items purchased by food producers. Likewise, economic growth can increase

---

Chinkook Lee is an agricultural economist with the Economic Research Service, U.S. Department of Agriculture. The opinions and conclusions expressed in this article are those of the author's and do not necessarily reflect the opinions of the Economic Research Service or the U.S. Department of Agriculture. The author appreciates helpful comments and suggestions by Gerald Schluter and Kenneth Hanson, both at ERS/USDA. Constructive comments offered by anonymous reviewers are also gratefully acknowledged. However, any remaining errors are the responsibility of the author.

demand for capital relative to labor in the nonfarm sector, thereby raising the opportunity cost of capital for food production. General inflation pressure, which is usually measured by changes in the Consumer Price Index for All Urban Consumers (CPI-U), in an economy characterized by excess demand, may be associated with an increase in the demand for food. In contrast, higher marketing costs engendered by higher wages and other input costs in the marketing sector reduce both the demand for food at the retail level and the farm-value proportion of the food dollar. These opposing forces suggest the net impact of inflation in the national economy on prices received by food producers will be small compared to the impact on prices paid, as long as the input price increases are not passed through to the final consumer.

Because the costs paid by consumers for food represent prices of final products, the effects of price increases for intermediate inputs on food prices have received little scrutiny in the formal analysis of food prices. More attention has been given to the effects of cost increases in primary inputs in food production, despite the fact that intermediate inputs account for more than 70%–80% of the cost of food production.

In 1992, for example, according to the benchmark input-output accounts for the U.S. economy (table 1) [U.S. Department of Commerce/Bureau of Economic Analysis (USDC/BEA), 1998], intermediate inputs related to processed meat production (the meat-packing sector) accounted for 86¢ per $1 output price received, of which 73.6¢ represented intermediate input of livestock. As seen from table 1, the food and kindred products industry as a whole, which requires a great deal of intermediate inputs of farm products for production, uses more intermediate inputs (70¢) than the average reported for total U.S. industries (43¢). Therefore, the impact of intermediate input price increases on food prices is more significant than on nonfood prices, if the cost of intermediate input price increases can be passed on to the final consumer. An examination of the cost structure of 12 sectors of the food and kindred products industry over time—the secondary objective of this analysis—helps to achieve the primary objective identified above.

## Theoretical Approach

To develop and empirically investigate the hypothesis that what happens to intermediate input prices will have an effect on food output prices, this analysis first considers a short-run food market situation. In a short-run competitive market, food producers are price takers in both output and input markets since, individually, they are but one of many sellers of their output and but one of many buyers of their input. Further, their production practices are already established with their existing plant sizes.

From a practical point of view within the competitive food industry, this short-run analysis is important when one considers the continuous influence of intermediate inputs, particularly raw farm products. Farm products are not easily substitutable in most food production processes, and changes in farm product prices will eventually have an effect on food prices, consequently signaling consumers to anticipate food price increases.

**Table 1. Average Cost Share of Intermediate Inputs and Value-Added, by Industry Sector, 1992**

| Industry Sector | (A) Agricultural and Food Products | (B) Services | (C) Energy | (D) Nondurable Manufactured Goods | (E) Durable Manufactured Goods | (F) Imported Goods | (G) Total Intermediate Goods | (H) Value-Added |
|---|---|---|---|---|---|---|---|---|
| Meat Packing | 0.7355 | 0.0689 | 0.0079 | 0.0240 | 0.0009 | 0.0272 | 0.8644 | 0.1356 |
| Poultry and Egg Processing | 0.6070 | 0.0819 | 0.0137 | 0.0345 | 0.0016 | 0.0062 | 0.7449 | 0.2551 |
| Dairy Plants | 0.5525 | 0.1193 | 0.0141 | 0.0618 | 0.0121 | 0.0146 | 0.7744 | 0.2256 |
| Canning and Preserving | 0.1699 | 0.1862 | 0.0183 | 0.0717 | 0.0811 | 0.0637 | 0.5909 | 0.4091 |
| Flour Milling | 0.3776 | 0.3130 | 0.0240 | 0.0570 | 0.0110 | 0.0218 | 0.8044 | 0.1956 |
| Bakery Products | 0.2068 | 0.1615 | 0.0178 | 0.0689 | 0.0111 | 0.0234 | 0.4895 | 0.5105 |
| Sugar Processing | 0.5340 | 0.1701 | 0.0350 | 0.0292 | 0.0037 | 0.0408 | 0.8128 | 0.1872 |
| Oil Milling | 0.5864 | 0.1775 | 0.0235 | 0.0218 | 0.0109 | 0.0464 | 0.8665 | 0.1335 |
| Confectionery | 0.2068 | 0.1615 | 0.0178 | 0.0689 | 0.0111 | 0.0234 | 0.4895 | 0.5105 |
| Beverage | 0.1310 | 0.1700 | 0.0102 | 0.0529 | 0.1381 | 0.0454 | 0.5476 | 0.4524 |
| Fish and Seafood | 0.1245 | 0.1767 | 0.0183 | 0.0270 | 0.0289 | 0.4010 | 0.7764 | 0.2236 |
| Miscellaneous Food | 0.1433 | 0.2667 | 0.0162 | 0.1142 | 0.0244 | 0.0377 | 0.6025 | 0.3975 |
| Food and Kindred Products | 0.3862 | 0.1735 | 0.0041 | 0.0556 | 0.0364 | 0.0405 | 0.6963 | 0.3037 |
| Eating and Drinking Places | 0.2117 | 0.2032 | 0.0281 | 0.0163 | 0.0140 | 0.0471 | 0.5204 | 0.4796 |
| U.S. Industry Total | 0.0333 | 0.2382 | 0.0226 | 0.0306 | 0.0695 | 0.0392 | 0.4334 | 0.5666 |

*Source:* USDC/BEA, "The 1992 Benchmark Input-Output Accounts for the U.S. Economy," 1998.

The theme of a recent group of studies published in the *American Journal of Agricultural Economics* was retail food price forecasting (Clauson, 1997; Jountz, 1997; Urbanchuk, 1997; and Young et al., 1997). Each of these studies emphasizes the importance of farm products and their price volatility in affecting food prices. In a related study, Reed et al. (1997) examine three different techniques for analyzing cost shocks to the CPI to forecast food prices.

In the long run, to reach a new equilibrium when there are changes in relative prices, substitution of inputs will occur. The production process and technical coefficients may change over time. When intermediate input prices rise, they will likely experience substitution effects on the input mix, and therefore variable proportions over time. In the short run, however, firms will carry out production responses to meet demand by using existing plants, and there is always one combination of intermediate inputs the firm considers best (most efficient). Consequently, once a production process is adopted, it incorporates a certain fixed amount of inputs. Thus, at least for a short-run analysis, it is reasonable to assume fixed technical coefficients.

A second theoretical perspective is now considered: When an intermediate input price increase occurs, firms can pass through the effects of this price increase onto their output prices in order to maintain their profit margins. The pass-through method is based on the observation that in a perfectly competitive market with constant returns to scale, average cost equals marginal cost, which in turn equals the output price. Thus, any increase in intermediate input costs will add to the industry's average and marginal costs, and therefore to the output price by the amount of the affected intermediate input's share of operating cost. The higher intermediate input cost is thereby "passed through" to ultimately be paid by the industry's consumers.

Recent studies examining the pass-through effect have included analysis of changes in prices due to exchange rate fluctuations and changes in food prices due to increases in the minimum wage (see, e.g., Aaronson, 2001; Besley and Rosen, 1999; Lee, Schluter, and O'Roark, 2001; and Poterba, 1996).

Gron and Swenson (1996) found less than a full pass-through in automobile industry prices relative to exchange rate movements because multinational automobile producers transfer their production process across national borders to deal with exchange rate fluctuations. Yang (1997) analyzed exchange rate pass-through on changes in industrywide costs. He concluded pass-through is generally smaller when products are highly substitutable, implying that product differentiation plays a key role in exchange rate pass-through.

Using an input-output (I/O) framework, Lee and Wills (1989) evaluated dollar depreciation pass-through effects on agricultural prices and income, and determined that full or partial pass-through depends on the agricultural market structure and the exchange rate regime.

In an analysis of consumer and wholesale prices, Popkin (1974) developed a model requiring prices be written by "stage of processing" as functions of current and lagged intermediate input prices. Based on his principal argument, there are many theories of price determination, but none can be demonstrated superior to the others. Consequently, any price determination models based on the central thesis of many different theories may serve as empirical approximations. For example, Popkin states, "The study of price indexes by stage-of-process can be viewed as an approximation to the type of study that could be conducted in an I/O framework if time-series data were available for I/O industries" (p. 486).

For purposes of this study, an I/O model is used to analyze a pass-through to output prices of all costs incurred due to an intermediate input price increase, just as firms in a perfectly competitive market equate their price to average and marginal cost. Leontief's I/O model is a special production scheme in the sense that fixed proportions exist in all production processes. This special fixed-proportion production function allows no substitution among the inputs. Specifically, it is assumed that in any given period of time, with existing production capacities in each sector, there is always one combination of resources to which firms are committed.

## Structure of Intermediate Inputs in the U.S. Food and Kindred Products Industry

An examination of the effects of an intermediate input price increase on food prices is best contemplated within the context of the continuous structural changes in the intermediate inputs within the U.S. food and kindred products industry. For purposes of this examination, the food and kindred products industry is disaggregated into 12 I/O sectors, based on (*a*) roughly three-digit codes as developed under the 1987 Standard Industrial Classification (SIC) industry coding system, and (*b*) the USDC/BEA (1979, 1991, 1994, 1998) published I/O account tables for the U.S. economy. The usefulness of the I/O technique for analysis of the food and kindred products industry (SIC 20) has been described well by Schluter, Lee, and LeBlanc (1998):

> . . . the I/O perspective of food cost/price views all the sectors [here, all 491 sectors defined in the national I/O table] of the economy as part of the food system. This view can be descriptively useful because in a highly developed economy, such as the U.S. economy, most sectors serve both as markets for other sectors' outputs and as suppliers of other sectors' inputs (p. 1136).

Furthermore, since, from the demand perspective, eating and drinking places (SIC 58) are closely related to the food and kindred products industry, the eating and drinking places industry (in aggregate) is also included in this analysis. The food and kindred products industry is comprised of establishments that manufacture or process food and beverages for human consumption, including certain related products such as manufactured ice, chewing gum, vegetable and animal oils, and prepared feeds for animals and fowl. Eating and drinking places consist of retail establishments selling prepared food and drink for consumption on the premises, including fast food restaurants.

Table 1 shows the average cost share of intermediate inputs and primary factors (value-added) of production for 12 sectors in the food and kindred products industry in 1992. In an I/O analysis, all inputs other than primary factor inputs are labeled as intermediate, and therefore farm products are defined as a part of intermediate inputs.

The last three rows of table 1 also show average shares of costs by the entire food and kindred products industry, the eating and drinking places industry, and the U.S. as a whole. Intermediate input purchases from other sectors are presented in six cost groupings (columns A–F) to better summarize the intermediate input structure of the sector's production.

In 1992, for example, the meat-packing sector's unit value (i.e., $1) consisted of 2.7¢ for imported inputs, 0.8¢ for energy use, 73.6¢ for domestic farm and processed food products, 2.4¢ for nondurable manufactured goods, and 6.9¢ for services. The total intermediate input cost was 86.4¢, and returns to wage earners and residual income (value-added) were 13.6¢. Residual income (column H) includes income such as profit, interest, depreciation allowances, etc.

Column G of table 1 shows total intermediate input use was highest in oil milling (87¢ per dollar), meat packing (86¢), sugar processing (81¢), and flour milling (80¢), and was smallest in bakery products (49¢) and confectioneries (49¢). In general, agricultural and food products and services comprise a heavy portion of the intermediate inputs for all 12 food and kindred products sectors. On average, food and kindred products used 70¢ per dollar for intermediate inputs, while the allotment for eating and drinking places was far less, at 52¢. In contrast, labor cost (wages and salaries) at 34¢ of 48¢ value-added (column H) was far higher for eating and drinking places compared with 14¢ of 30¢ value-added on average for the food and kindred products industry. Because it is a labor-intensive industry, eating and drinking places' higher share for compensation to wage earners is expected. On average, U.S. industries used 43¢ for intermediate inputs in 1992; i.e., food and kindred products sectors were much more dependent upon intermediate inputs than their counterparts in manufacturing sectors.

From table 1, column F, we observe a wide disparity across sectors in their use of imported inputs: the fish and seafood sector had the highest cost share in 1992 (40¢), the canning and preserving sector was second (6.4¢), and the poultry sector spent almost nothing (0.6¢) on imported inputs. Column A shows 1992 purchases of domestic farm and food products. These are usually larger values, as expected, because farm products are key intermediate inputs for food production. From column D, we observe that the miscellaneous food and the canning and preserving sectors used 11¢ and 7¢, respectively, of nondurable manufactured inputs, indicating these two sectors use more packaging than other sectors in the food and kindred products industry. The oil milling, miscellaneous food, seafood, and flour milling sectors are relatively heavy users of trade and transportation and other services, as shown in column B. Column G sums up columns A–F, yielding total intermediate input costs.

In summary, the food and kindred products industry uses more domestically produced farm and processed food as inputs (38.6¢ in 1992) compared to the eating and drinking places industry (21.1¢) and U.S. industry as a whole (3.3¢). On the other hand, the food and kindred products industry uses more nondurable manufactured inputs (5.6¢) than durable manufactured inputs (3.6¢), while U.S. industry on average uses more durable manufactured inputs (7¢) than nondurable manufactured inputs (3.1¢). Overall, both the food and kindred products industry and the eating and drinking places industry use more intermediate inputs (69.6¢ and 52¢, respectively) than the U.S. industry average (43.3¢). Finally, a lower value-added cost share is reported in 1992 for the food and kindred products industry (30.4¢) relative to the eating and drinking places industry (48¢) and the U.S. industry average (56.7¢).

Similar statistics for 1972 and 1982 are provided in appendix tables A1 and A2. These tables reflect the changing pattern of intermediate input cost structures over the two decades from 1972 to 1992. For example, in 1972, the meat-packing sector used 1.5¢ for imported inputs (table A1, column F), compared with 1.5¢ in 1982 (table A2) and 2.7¢ in 1992 (text table 1). Correspondingly, the fish and seafood sector spent only 17.9¢ in 1972 for imported inputs, but then increased spending to 33.4¢ in 1982, and to 40¢ in 1992. For the food and kindred products industry as a whole, the imported inputs grew over time from 2.8¢ in 1972 to 4.1¢ in 1992.

Estimation of the import components of inputs is based on the method employed by Lee and Wills (1989). The energy cost shares per dollar of food price received by producer moved up and down during the two decades. For example, energy use by the sugar processing sector, which used the most energy among the 12 sectors, was 1.6¢ in 1972, went up to 5.6¢ in 1982, and declined to 3.5¢ in 1992.

The inputs of domestically produced farm and processed foods for the food and kindred products industry as a whole declined slightly from 43.5¢ in 1972, to 36.1¢ in 1982, and to 38.6¢ in 1992, but the industry's input of services increased from 14.2¢ in 1972, to 16.8¢ in 1982, and to 17.4¢ in 1992.

Overall, the costs of total intermediate inputs for the food and kindred products industry fluctuated slightly from 71.4¢ in 1972, to 73.8¢ in 1982, and to 69.6¢ in 1992. Of interest to this study is the changing pattern of the shares of intermediate input costs in the industry over time, which is also associated with changes in production practices over time.

## The I/O Model

The Leontief I/O model, which is used in this analysis, is an empirical representation of the U.S. production economy. It is a system that determines total output requirements under a given set of final demands for goods and services. Therefore, the demand for final goods and services determines the demand for intermediate goods and the supply of various products. In the Leontief system, we can also treat prices as variables and calculate equilibrium prices as we do for equilibrium output levels. In such a case, unit cost of production consists of the fixed cost share of intermediate inputs and fixed direct primary factor costs. Thus, the unit value (price) of an output consists of the unit values of its commodity and service inputs, each weighted by the contribution to the output of the commodity, plus the value of the labor and capital inputs per dollar of output.

Mathematically, in equilibrium, the price of product $i$ in the $n$-sector economy can be written as:

$$p_i = p_1 a_{1i} + p_2 a_{2i} + \dots + p_n a_{ni} + p_l Li + p_i r,$$

where the first $n$ terms on the right-hand side indicate the cost of inputs purchased from other producing sectors. The term $p_l Li$ indicates per unit cost of labor input, and $p_i r$ denotes the per unit amount of profit if the profit rate is $r$; together, these terms become per unit value added ($v_i$) in sector $i$. Since there are $n$ sectors in the economy, there are $n$ such equations. Denoting **P** as the price vector including $n$ commodity prices, and **V** as the value-added vector, then

$$\begin{pmatrix} p_1 \\ p_2 \\ \vdots \\ p_n \end{pmatrix} = \begin{pmatrix} a_{11} & a_{21} & \cdots & a_{n1} \\ a_{12} & a_{22} & \cdots & a_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n} & a_{2n} & \cdots & a_{nn} \end{pmatrix} \times \begin{pmatrix} p_1 \\ p_2 \\ \vdots \\ p_n \end{pmatrix} + \begin{pmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{pmatrix}.$$

The $\{n \times n\}$ matrix above is actually the transpose of matrix **A**, the technical coefficients matrix, because rows and columns of matrix **A** are interchanged here. Therefore, the above system may also be represented by:

$$\text{(1)} \qquad \mathbf{P} = \mathbf{A}' * \mathbf{P} + \mathbf{V},$$

where **P** is a vector of sector output prices ($P_j$'s), **V** is the vector of value-added or returns to residual and wage incomes, and **A** is the matrix of input-output technical coefficients representing sector purchasing per dollar of output. Thus, given the wage rate and profit rate, a set of equilibrium prices can be obtained as follows:

$$\text{(2)} \qquad \mathbf{P} = [\mathbf{I} - \mathbf{A}']^{-1} * \mathbf{V},$$

where **I** denotes an identity matrix, and all other terms are as previously defined.

Assuming each foreign good is not a perfect substitute for the corresponding domestic good (Armington assumption), because prices are not already set by international trade, equation (2) can be used to calculate the impact of alternative policies on the price vector. For example, to estimate the burden of each intermediate input price increase on food prices, we must know the impact of each intermediate price increase on the price of each output. If some industries use inflated commodities as intermediate inputs, then the burden is further shifted to consumers of those outputs. Under constant returns to scale and perfect competition, all increases in costs are passed through to final consumers as food price increases.

To estimate these intermediate input price increases, we post-multiply matrix **A**′ in equation (2) by another matrix, **T**, to obtain:

$$\text{(3)} \qquad \mathbf{P} = [\mathbf{I} - \mathbf{A}' * \mathbf{T}]^{-1} * \mathbf{V},$$

where **T** is a diagonal matrix containing $1 + t_i$ (where $i = 1, 2, ..., n$) and $i$ represents the intermediate input price increase rate for the $i$th sector (regardless of where it is used), as below. Here, **P** is the vector of new prices necessary to maintain the same profit margin after the intermediate input price increase.

We can use equation (3) to calculate the new sector output prices after the intermediate input price increase has fully passed through to sector

$$\mathbf{T} = \begin{pmatrix} 1+t_1 & 0 & \dots & 0 \\ 0 & 1+t_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & 1+t_n \end{pmatrix}$$

output. Once again, the calculation obviously assumes there is no upsurge in unit costs other than those due to an intermediate input price increase. Thus, the expected new output prices due to an increase in intermediate input prices are based on the assumption that the producers can pass through the higher input costs caused by increases in intermediate inputs. In a competitive market, food and kindred product prices will equate to average cost and marginal cost in the market, such that output prices rise to cover higher input costs.

Equation (3) can also be used in this instance to determine the extent to which a producer's profit margin may diminish if it absorbs the price of labor inputs. Again, the above equation states that commodity output prices are equal to unit factor costs (direct and indirect) and output prices move hand in hand with factor costs. The expression $[\mathbf{I} - \mathbf{A}' * \mathbf{T}]^{-1}$ in equation (3) shows by how much the particular price $p_i$ in the vector **P** would go up (or down) for every dollar added to (or subtracted from) the intermediate input price increases.

The prices derived through equation (3) are sector output prices at point of production. Thus they are expressed in producers' prices. In order to express these amounts in terms of purchasers' prices, the I/O tables adopt the convention of "margin." This procedure is characterized by unbundling (i.e., recording the value of the trade and transportation margins separately, rather than incorporating them in the value of the merchandise) and forward shifting (showing the margins as being used directly by the user of the merchandise). The producer's prices represent the basic value at the production point, and adding various margins brings the good from the producer's to the user's cost. Therefore, in order to express the producers' prices in terms of the purchasers' prices, we establish a link between these prices through the bridge matrix containing "margins." The bridge table (derived from unpublished USDC/BEA bridge tables titled "Bridges Between Producer's Prices and Purchaser's Prices") is based on the transportation and wholesale and retail trade margins.

Specifically, let **B** be an $\{80 \times 3\}$ bridge matrix. That is, each row entry will show percentage sectoral distributions of the output price (first column), transportation margin (second column), and trade margin (third column). Then,

$$\text{(4)} \qquad \mathbf{P_r 92} = \mathbf{Dp} * \mathbf{B}[1{:}80,1] + \mathbf{Dp}[62,1] * \mathbf{B}[1{:}80,2] + \mathbf{Dp}[63,1] * \mathbf{B}[1{:}80,3],$$

where $\mathbf{P_r 92}$ is a vector of purchasers' prices, and **Dp** is an $\{80 \times 80\}$ diagonal matrix of producers' prices derived from equation (3). $\mathbf{B}[1{:}80,1]$ is a column vector (the

**Table 2. Intermediate Input Cost Shares, by Industry Sector, 1992**

| | Sector's Share of: | | | |
|---|---|---|---|---|
| Industry Sector | Producer Prices | Transportation | Trade | Total Value |
| Meat Packing | 0.6735 | 0.0285 | 0.2980 | 1 |
| Poultry and Egg Processing | 0.7013 | 0.0041 | 0.2946 | 1 |
| Dairy Plants | 0.6876 | 0.0093 | 0.3030 | 1 |
| Canning and Preserving | 0.6359 | 0.0273 | 0.3368 | 1 |
| Flour Milling | 0.6005 | 0.0199 | 0.3795 | 1 |
| Sugar Processing | 0.6075 | 0.0291 | 0.3634 | 1 |
| Oil Milling | 0.6728 | 0.0495 | 0.2777 | 1 |
| Confectionery | 0.6631 | 0.0120 | 0.3249 | 1 |
| Bakery Products | 0.6881 | 0.0389 | 0.2731 | 1 |
| Beverage | 0.5703 | 0.0147 | 0.4150 | 1 |
| Fish and Seafood | 0.5930 | 0.0113 | 0.3957 | 1 |
| Miscellaneous Food | 0.6698 | 0.0111 | 0.3191 | 1 |
| Eating and Drinking Places | 1.0000 | 0.0000 | 0.0000 | 1 |

*Source:* USDC/BEA, "The 1992 Benchmark Input-Output Accounts for the U.S. Economy," 1998.

first column of the matrix **B**), showing the percentage distribution of the output prices. **Dp**[62,1] and **Dp**[63,1] are {80 × 80} diagonal matrices of the producers' prices of transportation and wholesale and retail trade, and **B**[1:80,2] and **B**[1:80,3] are vectors showing the percentage or share of the transportation and trade margins, respectively. The percentage distribution of output prices, and transportation and trade margins for the food and kindred products industry are shown in table 2.

Equations (3) and (4) are characterized by three interesting attributes. First, they represent a simultaneous structure. Simultaneity in consumption (purchasers' prices) is an important aspect of food price determination. Second, the intermediate input-level prices affect retail food prices, implying intermediate input price increases (diagonal elements of the matrix **T**) are the appropriate right-hand-side variables. Therefore (third), the causality relationship is postulated as unidirectional from intermediate inputs to retail-level prices.

The practical significance for our study of this treatment of retail prices is that if an intermediate input price increase affects transportation, wholesale, and retail trade less than food processing (either **Dp** > **Dp**[62,1] or **Dp** > **Dp**[63,1], or both), then the estimated effect of an increase in the intermediate input price on food prices is softened from what we observe at the food processor level.

## Empirical Results

In a recent analysis of pass-through effects, Lee, Schluter, and O'Roark (2001) concluded that increases in the minimum wage would have a minimal effect on food prices. Since labor is a primary factor, not an intermediate input, the question naturally arising is: How much would an intermediate input price increase affect food prices if producers want to maintain the same profit as before the input price increase?

To answer this question, this analysis examines five scenarios of input price increases, each of which eventually affects food prices.[1] The five scenarios are: *What would happen to food prices if . . .*

1. energy sector prices increase by 10%?
2. agricultural output prices increase by 10%?
3. durable manufactured good prices increase by 10%?
4. nondurable manufactured good prices increase by 10%?
5. service industry prices increase by10%?

The results for these scenarios are presented in table 3, with producers' price results reported on the left-hand side (section A) and results for purchasers on the right-hand side (section B). The percentage changes from the unit base year price to the new price for the particular scenarios are shown in the first five columns of section A. The first column (scenario 1), for example, shows the percentage changes in sector output prices in the food and kindred products industry and the eating and drinking places industry with a 10% increase in energy sector prices. For purposes of this analysis, the energy sector is defined as a combination of refined petroleum, electricity, and natural gas services. Percentage changes in food prices range from 0.93% (the highest) in sugar processing to 0.40% (the lowest) in the beverage industry. These differences occur for two reasons. First, as indicated by the intermediate input cost shares of output price shown in table 1 for 1992, the share of intermediate inputs of energy (refined petroleum product, electricity, and natural gas combined) was largest for sugar processing (3.5¢). Second, there are "indirect" uses of energy by each of the sectors, as they produce their own goods in the production process. Refined sugar requires a great deal of electricity and natural gas. From the last two rows of table 3, the scenario 1 column shows average food and kindred product output prices increase more (0.75%) when there is a 10% increase in energy prices than prices in eating and drinking places (0.53%).

Scenario 2 in table 3(A) reveals that when agricultural, processed food, and nonfood other agricultural product prices are increased by 10%, the meat-packing sector price must be increased by 16.1% to maintain the original value-added in the sector. Prices for the poultry processing and dairy products sectors are required to increase more than 10% (13% and 10.4%, respectively), and the smallest price increase would be for the beverage sector (2%). Overall prices for the eating and drinking

[1] These scenarios are based on intermediate inputs as described in columns A–E of cost-share tables 1, A1, and A2. As noted by Schluter, Lee, and LeBlanc, ". . . food spending for domestically produced food represents the retail market value of food purchased by or for domestic consumers" (1998, p. 1135). Therefore, examination of the imported intermediate input (described by column F of the three cost-share tables) price increase on food prices is excluded from this empirical study.

**Table 3. Effects of Increase in Output Prices Due to Intermediate Input Price Inflation: Results for Five Scenarios**

| | A. PRODUCERS' PRICES | | | | |
|---|---|---|---|---|---|
| Industry Sector | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 |
| | <- - - - - - - - - - - - - - - - - | | (% increases) | | - - - - - - - - - - - - - - - - -> |
| Meat Packing | 0.6421 | 16.1383 | 0.5781 | 1.6341 | 6.3497 |
| Poultry and Egg Processing | 0.8123 | 12.9700 | 0.4750 | 2.0550 | 5.9670 |
| Dairy Plants | 0.7536 | 10.4315 | 0.7329 | 2.1715 | 6.1552 |
| Canning and Preserving | 0.5275 | 3.2237 | 1.6391 | 1.7723 | 4.8318 |
| Flour Milling | 0.7491 | 4.2728 | 0.6696 | 1.8566 | 7.2657 |
| Bakery Products | 0.7347 | 8.4782 | 0.5326 | 1.6655 | 6.7161 |
| Sugar Processing | 0.9269 | 7.7722 | 0.4860 | 1.4607 | 5.6171 |
| Oil Milling | 0.7447 | 8.3143 | 0.5671 | 1.6885 | 6.7879 |
| Confectionery | 0.4798 | 3.3285 | 0.5326 | 1.6655 | 4.1957 |
| Beverage | 0.3991 | 1.9633 | 2.5311 | 1.4011 | 4.2413 |
| Fish and Seafood | 0.5073 | 2.4122 | 0.4866 | 0.8936 | 4.0235 |
| Miscellaneous Food | 0.4846 | 2.1711 | 0.7576 | 2.3689 | 4.9436 |
| Food and Kindred Products | 0.7536 | 10.4315 | 0.7329 | 2.1715 | 6.1552 |
| Eating and Drinking Places | 0.5351 | 3.9197 | 0.5358 | 0.8087 | 5.0293 |

*Definitions of Scenarios:*
- Scenario 1 = 10% increase in price of energy (refined petroleum products, electricity, and natural gas)
- Scenario 2 = 10% increase in price of farm, processed food, and nonfood agricultural products
- Scenario 3 = 10% increase in price of durable manufactured goods
- Scenario 4 = 10% increase in price of nondurable manufactured goods
- Scenario 5 = 10% increase in price of all service sectors

places industry would have to increase by 4%. The eating and drinking places industry is more affected by intermediate input price increases for processed food than raw farm product price increases. In contrast, meat sectors, such as meat-packing, poultry processing, and dairy sectors, are more affected by price increases in raw farm products.

Scenario 3 of table 3(A) predicts that when durable manufactured good prices are increased, the canning and preserving and the beverage sectors are the only sectors reflecting a price increase of more than 1% (1.6% and 2.5%, respectively). (As seen from table 1, these two sectors' average cost shares were 13.8¢ and 8.1¢, respectively, for durable manufactured goods used in production.) The remaining 10 sectors, as well as the overall food and kindred products industry and the eating and drinking places industry on average, all show less than 1% increases in prices. This finding suggests food sectors are not significantly affected by increases in durable manufactured input prices.

By contrast, scenario 4 in table 3(A) reveals that food sectors are more affected by price increases in nondurable manufactured goods. With the exception of the fish and seafood sector (showing an increase of 0.9%), the sectors in the food and kindred products industry required price increases ranging from 1.5% to 2.4%.

**Table 3. Extended**

| | B. PURCHASERS' PRICES | | | | |
|---|---|---|---|---|---|
| Industry Sector | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 |
| | <----------------- | | (% increases) | | -----------------> |
| Meat Packing | 0.5805 | 10.9082 | 0.5527 | 1.3014 | 5.6489 |
| Poultry and Egg Processing | 0.7152 | 9.1554 | 0.4993 | 1.6359 | 5.4162 |
| Dairy Plants | 0.6931 | 7.2551 | 0.6989 | 1.7193 | 5.5518 |
| Canning and Preserving | 0.6392 | 2.2347 | 1.3645 | 1.4901 | 4.7399 |
| Flour Milling | 0.6742 | 2.6666 | 0.6497 | 1.4046 | 6.0638 |
| Bakery Products | 0.6597 | 5.8763 | 0.5702 | 1.3556 | 5.9639 |
| Sugar Processing | 0.7418 | 4.7730 | 0.4939 | 1.1298 | 5.0549 |
| Oil Milling | 0.6594 | 5.6297 | 0.5490 | 1.3466 | 5.9856 |
| Confectionery | 0.5141 | 2.3018 | 0.5702 | 1.3556 | 4.2157 |
| Beverage | 0.6556 | 1.4185 | 1.8987 | 1.2978 | 4.4308 |
| Fish and Seafood | 0.4841 | 1.4938 | 0.4982 | 0.7800 | 4.0574 |
| Miscellaneous Food | 0.6037 | 1.6343 | 0.8075 | 1.9201 | 4.8056 |
| Food and Kindred Products | 0.2709 | 7.2551 | 0.6989 | 1.7193 | 5.5518 |
| Eating and Drinking Places | 0.5351 | 3.9197 | 0.5358 | 0.8087 | 5.0293 |

Because the main nondurable goods inputs are packaging materials such as paper bags and plastic, this result indicates that, overall, the food and kindred products industry uses more nondurable manufactured goods than durable manufactured goods. Hence, price increases in nondurable manufactured goods will affect food and kindred products output prices more.

Finally, based on results for scenario 5 in table 3(A), when the service industry prices are increased, flour milling, oil milling, and bakery products sector prices will increase the most (7.3%, 6.8%, and 6.7%, respectively), and the price increases of the remaining sectors will be between 4% and a little more than 6%.

A comparison of scenario 1 from section B of table 3 (the right-hand side) with its scenario 1 counterpart in section A suggests a 10% increase in energy prices causes purchasers' prices to rise less than producers' prices in the food and kindred products sectors. In general, the increase was less for purchasers' prices because these prices include a proportionate share of the effects of intermediate input price increases on the trade and transportation sectors—which are not greatly affected by price effects from intermediate input price increases.

For example, in scenario 1, while the transportation sector price increased 1.016% and the trade sector price increased 0.35%, the meat-packing price increased 0.64%. Using the weights from table 2, the 0.64% increase effect on meat-packing prices receives a weight of 0.6735, the 1.016% increase effect on transportation price receives a weight of only 0.0285, and the 0.35% increase effect on wholesale and retail prices receives a weight of 0.298. Therefore, even though the transportation sector price goes up more than 1% due to energy price increases, the transportation and trade sectors combined are affected less by increased energy prices, and consequently there is a lower effect on the purchasers' price of meat-packing output.

In sum, from the "ground up" point of view, food prices are affected mostly by the intermediate input increase of agricultural, food, and other nonfood agricultural products, followed by price increases in service sectors. Food prices are also more affected by price increases in nondurable manufactured goods than those in durable manufactured goods. The empirical results also reveal that energy price increases are closer to the effect of price increases in durable manufactured goods. As shown by the last row of table 3, price increases in the service industry are more important than other intermediate input price increases for eating and drinking places.

## Summary and Conclusions

This study has examined the generalized concern of how intermediate input price increases could directly translate into increased prices in consumer food prices. Findings indicate the meat-packing sector has a strong dependence on intermediate inputs of agricultural commodities. Therefore, a price increase in an intermediate input (livestock) would have a greater impact on the processed meat prices for consumers than any other intermediate input price increase. Poultry processing and dairy plants also show some degree of dependence on raw farm products, but not as much as the meat-packing sector.

Another major element of the "ground up" forecasting procedure for consumer food price increases is the incorporation of the impact of price increases in intermediate inputs of nonfarm sectors on food production. Scenarios 3, 4, and 5 (table 3) examined these impacts, and findings show that, for most sectors, service sector price increases result in about the same overall price increase in food prices as compared to increases in agricultural commodity prices. Price increases in nondurable manufactured goods have more influence on food price increases than corresponding price increases in durable manufactured goods.

The methodology used in this study is a full pass-through approach; that is, the increase in intermediate input cost is fully passed on to the final consumer in the form of higher food prices. Therefore, the empirical results laid out here are probably best considered as short-run phenomena and as the upper bounds. Based on the findings of this analysis, the intermediate inputs observed to have the greatest effect on food prices are agricultural inputs, services, and nondurable manufactured inputs. Thus, an intermediate input price increase on food prices is of importance, particularly the intermediate inputs of domestic agricultural and food products. Energy and durable manufactured inputs would also affect food prices, but to a lesser degree. As the processed food industry grows to meet the demand for increased consumption of prepared foods, the demand for intermediate inputs of agricultural products will also grow, and so too will the importance of intermediate input price increases on food prices.

Several proposals are suggested for future research to refine the analysis undertaken here. First, the impact of price increases in imported intermediate inputs on food prices could be investigated. Note, however, from column F of table 1, the U.S. food industry imported minimal amounts of intermediate inputs from overseas. Thus, such research may not be as significant as domestic intermediate input price increases.

Second, a resectoring of the detailed breakdown of the food and kindred products industry more in line with retail (CPI) food sector prices would facilitate comparison with familiar retail food price indices. A research project with this focus could be a major undertaking, because I/O sector prices implicitly include all product prices in the base year, while CPI prices are representative sector commodity prices. However, when the USDC/BEA releases its new 1997 benchmark U.S. I/O tables, this project may be worthwhile to consider.

Third, marketing margins (farm-retail spreads) are widening, and therefore the farmer's share of retail food prices is declining. An analysis addressing not a "pass-through," but the effects on the value-added in food sectors, would be helpful in assessing how much food sectors are expected to lose if they can't "pass through" the cost increase to final consumers, and instead must absorb the higher costs themselves.

## References


Aaronson, D. (2001, February). "Price pass-through and the minimum wage." *Review of Economics and Statistics* 83(1), 158–169.

Besley, T., and H. Rosen. (1999). "Sales taxes and prices: An empirical analysis." *National Tax Journal* 52(2), 157–178.

Clauson, A. (1997). "Forecasting retail food prices under current conditions." *American Journal of Agricultural Economics* 76(5), 1669–1672.

Gron, A., and D. Swenson. (1996). "Incomplete exchange-rate pass-through and imperfect competition: The effect of local production." *American Economic Review* 86(2), 71–76.

Jountz, F. (1997). "Forecasting CPI prices: An assessment." *American Journal of Agricultural Economics* 76(5), 1681–1685.

Lee, C., G. Schluter, and B. O'Roark. (2001, Spring). "Minimum wage and food prices: An analysis of price pass-through effects." *International Food and Agribusiness Management Review* 3(1), 113–130.

Lee, C., and D. Wills. (1989). "Effects of dollar depreciation on agricultural prices and income." *Agribusiness: An International Journal* 5(1), 43–51.

Popkin, J. (1974). "Consumer and wholesale prices in a model of price behavior by stage of processing." *Review of Economics and Statistics* 56, 486–501.

Poterba, J. (1996). "Retail price reactions to changes in state and local sales taxes." *National Tax Journal* 11(4), 121–123.

Reed, A. J., K. Hanson, H. Elitzak, and G. Schluter. (1997, June). "Changing consumer food prices." Technical Bulletin No. 1862, USDA/Economic Research Service, Washington, DC.

Schluter, G., C. Lee, and M. LeBlanc. (1998). "The weakening relationship between farm and food prices." *American Journal of Agricultural Economics* 80(5), 1135–1139.

Urbanchuk, J. M. (1997). "Commodity markets, farm-retail spreads, and macroeconomic condition assumptions in food price forecasting." *American Journal of Agricultural Economics* 76(5), 1677–1680.

U.S. Department of Commerce, Bureau of Economic Analysis. (1979). "The detailed input-output structure of the U.S. economy, 1972." USDC/BEA, Washington, DC.

———. (1991). "The 1982 benchmark input-output accounts for the U.S. economy." USDC/BEA, Washington, DC.

———. (1994). "The 1987 benchmark input-output accounts for the U.S. economy." USDC/BEA, Washington, DC.

———. (1998). "The 1992 benchmark input-output accounts for the U.S. economy." USDC/BEA, Washington, DC.

Yang J. (1997, February). "Exchange rate pass-through in U.S. manufacturing industries." *Review of Economics and Statistics* 79(1), 95–104.

Young, R., L. Wilcox, B. Willott, G. Adams, and D. Brown. (1997). "Consumer food prices from the ground up." *American Journal of Agricultural Economics* 76(5), 1673–1676.

**Table A1. Average Cost Share of Intermediate Inputs and Value-Added, by Industry Sector, 1972**

| Industry Sector | (A) Agricultural and Food Products | (B) Services | (C) Energy | (D) Nondurable Manufactured Goods | (E) Durable Manufactured Goods | (F) Imported Goods | (G) Total Intermediate Goods | (H) Value-Added |
|---|---|---|---|---|---|---|---|---|
| Meat Packing | 0.7704 | 0.0617 | 0.0051 | 0.0101 | 0.0098 | 0.0152 | 0.8723 | 0.1277 |
| Poultry and Egg Processing | 0.6548 | 0.0933 | 0.0087 | 0.0224 | 0.0114 | 0.0045 | 0.7951 | 0.2049 |
| Dairy Plants | 0.5770 | 0.1041 | 0.0109 | 0.0488 | 0.0345 | 0.0123 | 0.7876 | 0.2124 |
| Canning and Preserving | 0.2361 | 0.2166 | 0.0111 | 0.0588 | 0.1433 | 0.0275 | 0.6934 | 0.3066 |
| Flour Milling | 0.5140 | 0.1617 | 0.0108 | 0.0439 | 0.0154 | 0.0210 | 0.7668 | 0.2332 |
| Bakery Products | 0.2583 | 0.1528 | 0.0069 | 0.0616 | 0.0333 | 0.0253 | 0.5382 | 0.4618 |
| Sugar Processing | 0.4696 | 0.1030 | 0.0164 | 0.0104 | 0.0194 | 0.1193 | 0.7381 | 0.2619 |
| Oil Milling | 0.6462 | 0.1194 | 0.0127 | 0.0177 | 0.0275 | 0.0239 | 0.8474 | 0.1526 |
| Confectionery | 0.2583 | 0.1528 | 0.0069 | 0.0616 | 0.0333 | 0.0253 | 0.5382 | 0.4618 |
| Beverage | 0.1524 | 0.1311 | 0.0073 | 0.0219 | 0.1390 | 0.0456 | 0.4973 | 0.5027 |
| Fish and Seafood | 0.0286 | 0.1860 | 0.0078 | 0.0451 | 0.3397 | 0.1791 | 0.7863 | 0.2137 |
| Miscellaneous Food | 0.1227 | 0.3649 | 0.0102 | 0.0601 | 0.0765 | 0.0376 | 0.6720 | 0.3280 |
| Food and Kindred Products | 0.4352 | 0.1422 | 0.0090 | 0.0548 | 0.0448 | 0.0277 | 0.7137 | 0.2863 |
| Eating and Drinking Places | 0.3087 | 0.1921 | 0.0128 | 0.0231 | 0.0131 | 0.0187 | 0.5685 | 0.4315 |
| U.S. Industry Total | 0.0543 | 0.1671 | 0.0239 | 0.0605 | 0.1043 | 0.0216 | 0.4317 | 0.5683 |

*Source:* USDC/BEA, "The Detailed Input-Output Structure of the U.S. Economy: 1972," 1979.

**Table A2. Average Cost Share of Intermediate Inputs and Value-Added, by Industry Sector, 1982**

| Industry Sector | (A) Agricultural and Food Products | (B) Services | (C) Energy | (D) Nondurable Manufactured Goods | (E) Durable Manufactured Goods | (F) Imported Goods | (G) Total Intermediate Goods | (H) Value-Added |
|---|---|---|---|---|---|---|---|---|
| Meat Packing | 0.7514 | 0.0867 | 0.0101 | 0.0225 | 0.0056 | 0.0148 | 0.8911 | 0.1089 |
| Poultry and Egg Processing | 0.6760 | 0.0647 | 0.0262 | 0.0334 | 0.0051 | 0.0048 | 0.8102 | 0.1898 |
| Dairy Plants | 0.6752 | 0.0866 | 0.0187 | 0.0586 | 0.0149 | 0.0106 | 0.8646 | 0.1354 |
| Canning and Preserving | 0.2158 | 0.1784 | 0.0275 | 0.0741 | 0.1188 | 0.0724 | 0.6870 | 0.3130 |
| Flour Milling | 0.3335 | 0.2029 | 0.0299 | 0.0531 | 0.0214 | 0.0124 | 0.6532 | 0.3468 |
| Bakery Products | 0.1897 | 0.1484 | 0.0204 | 0.0594 | 0.0138 | 0.0171 | 0.4488 | 0.5512 |
| Sugar Processing | 0.5297 | 0.1217 | 0.0564 | 0.0369 | 0.0050 | 0.0673 | 0.8170 | 0.1830 |
| Oil Milling | 0.6359 | 0.1463 | 0.0343 | 0.0371 | 0.0153 | 0.0427 | 0.9116 | 0.0884 |
| Confectionery | 0.1897 | 0.1484 | 0.0204 | 0.0594 | 0.0138 | 0.0171 | 0.4488 | 0.5512 |
| Beverage | 0.1417 | 0.1654 | 0.0171 | 0.0442 | 0.1875 | 0.0273 | 0.5832 | 0.4168 |
| Fish and Seafood | 0.0111 | 0.1488 | 0.0228 | 0.0497 | 0.1722 | 0.3337 | 0.7383 | 0.2617 |
| Miscellaneous Food | 0.1033 | 0.3707 | 0.0193 | 0.1620 | 0.0501 | 0.0382 | 0.7436 | 0.2564 |
| Food and Kindred Products | 0.3611 | 0.1683 | 0.0623 | 0.0623 | 0.0550 | 0.0292 | 0.7382 | 0.2618 |
| Eating and Drinking Places | 0.2663 | 0.2005 | 0.0279 | 0.0198 | 0.0121 | 0.0257 | 0.5523 | 0.4477 |
| U.S. Industry Total | 0.0461 | 0.2123 | 0.0408 | 0.0380 | 0.0720 | 0.0297 | 0.4389 | 0.5611 |

*Source:* USDC/BEA, "The 1982 Benchmark Input-Output Accounts for the U.S. Economy," 1991.