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LINKAGES BETWEEN PRICES OF AGRICULTURAL
COMMODITIES AND PROCESSED FINAL PRODUCTS

Most agricultural commodities are not consumed in their original form. Rather agribusinesses add form utility to these agricultural commodities by processing and consumers buy the processed products. In fact, most agricultural commodities go through a sequence of processes. The processed product produced at one stage is used as a raw material in the next process. The processing continues until a product is produced for which consumer demand exists. Processed products are referred to as intermediate and/or final products, while agricultural commodities are referred to as primary commodities.

The demand for most agricultural commodities is derived from the demand for processed products. Therefore, a commodity's price is dependent upon the demand for the final products produced from the commodity, the supply of the commodity, and the processors' margin.

Whether a particular product is considered to be a final product or an intermediate product depends upon the scope of the analysis. A product is considered to be a final product if its demand is known or assumed to be known. On the other hand, if the demand for a product is derived from another product, the product is considered to be an intermediate product. A product can be considered an intermediate product is one analysis and then be considered a final product in another analysis.

This paper presents an introductory discussion of the linkages between the price of the primary commodity and the products produced from the primary commodity. First, a case is discussed where the primary commodity is processed into an intermediate product and then into a final product. As in this case, at each successive stage of processing, the transformation results in only one product. This case is referred to as the single product case. In the second case the primary commodity is processed into two products simultaneously in a fixed proportion. This case is the joint product case.

THE SINGLE PRODUCT CASE

A good example of the single product case involves red hard winter wheat. Hard red winter wheat is milled into whole wheat flour, and the flour is then baked (processed) into loaves of whole wheat bread. The final product is assumed to be bread. Further assumed that there is no final demand for flour i.e. consumers do not directly purchase flour. The demand for flour is derived from the final demand for bread. Similarly, the demand for wheat is derived from the derived demand for flour.

Further assumptions concerning technical coefficients and processing costs for transforming the commodity into the final product must be made. Also, assumptions must be made about the supply and demand conditions for the retail and derived products. Assume that:

(1) The milling of one bushel of wheat yields 57 pounds of whole wheat flour with no other by-products. The derived demand for wheat is entirely a function of the derived demand for whole wheat flour.

(2) The baking of a pound of flour yields one loaf of bread. Therefore, a single bushel of wheat yields 57 loaves of bread.

(3) The milling cost per bushel is $1.50 per bushel or 2.63 cents per pound, and is independent of the quantity of wheat milled. This assumption implied that the fixed costs are zero and that the average and marginal costs of milling are identical and constant.

(4) The baking costs per pound of flour is fixed at 72.77 cents and is independent of the total number of loaves baked. Again this assumption implies that the average and marginal costs are identical and constant, and fixed costs equal zero.

(5) The supply curve for wheat and the demand curve for bread are known and linear.

(6) Wheat and flour are demanded exclusively for producing flour and bread, respectively. This assumption implies the absence of any other competing demands for the wheat or flour.

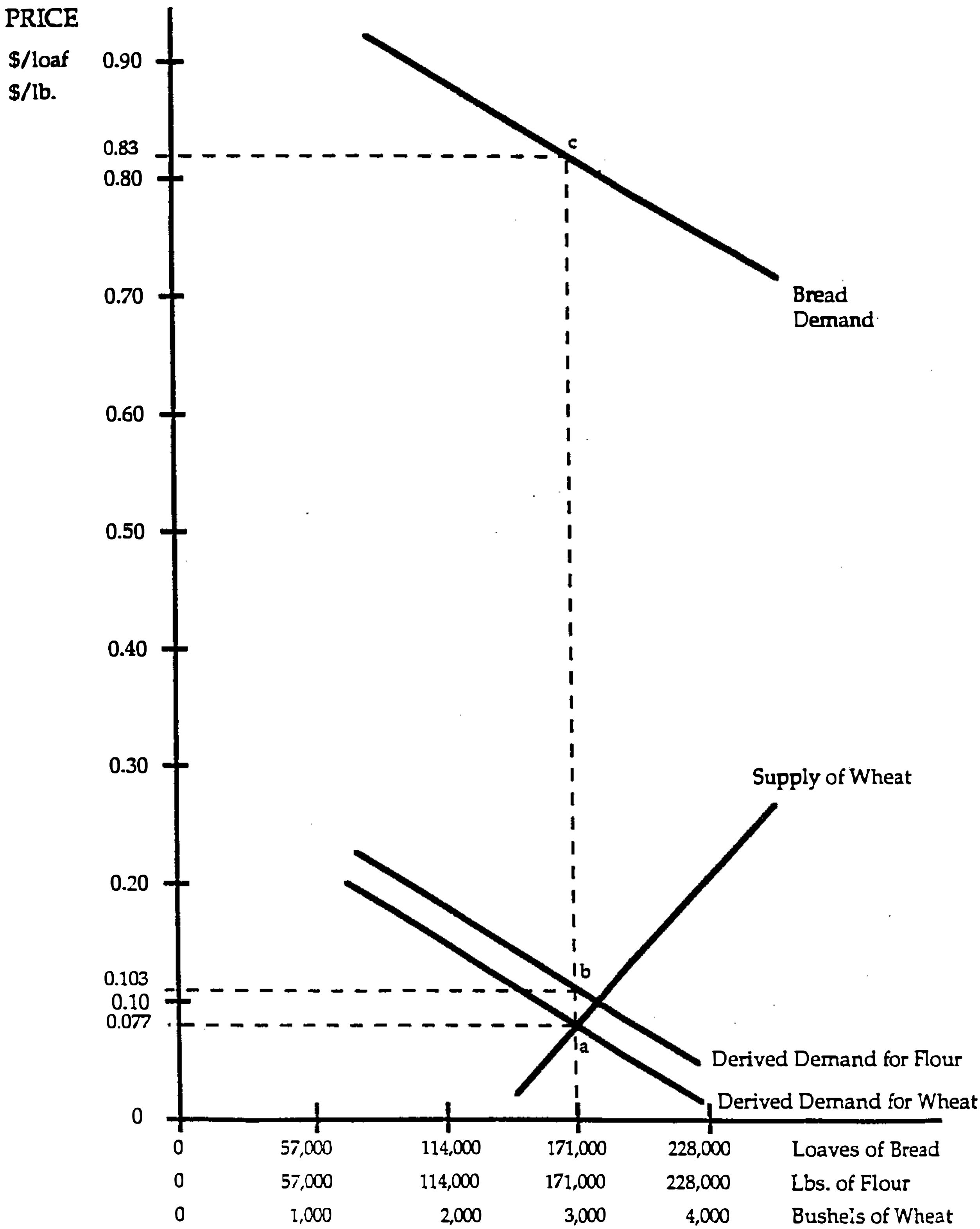
(7) Wheat, flour, and bread are not traded between other regions. The possibility of export or import of these products does not exist.

More complex models of retail and derived demand may relax one or more of these restrictive assumptions.

Given the demand for bread, the derived demand for flour is obtained by deducting the cost of other inputs from the price of bread. Since the baking costs of a loaf of bread is 72.7 cents and is independent of the output level, the derived demand for flour is parallel to the demand for bread (Figure 1). If the cost of the flour is excluded, the vertical distance between the bread demand schedule and the derived demand schedule for flour equals the baker's cost of producing a loaf of bread.

Similarly, the derived demand for wheat is obtained by

Figure 1: Price Relationship and Degree of Processing



deducting the milling cost from the flour demand curve. Since the milling cost is assumed to be constant and independent of the output level, the derived demand for wheat is parallel to the derived demand for flour. The milling cost is 2.63 cents per pound of flour, therefore the difference between the price of flour and the price of wheat will also be 2.63 cents per pound.

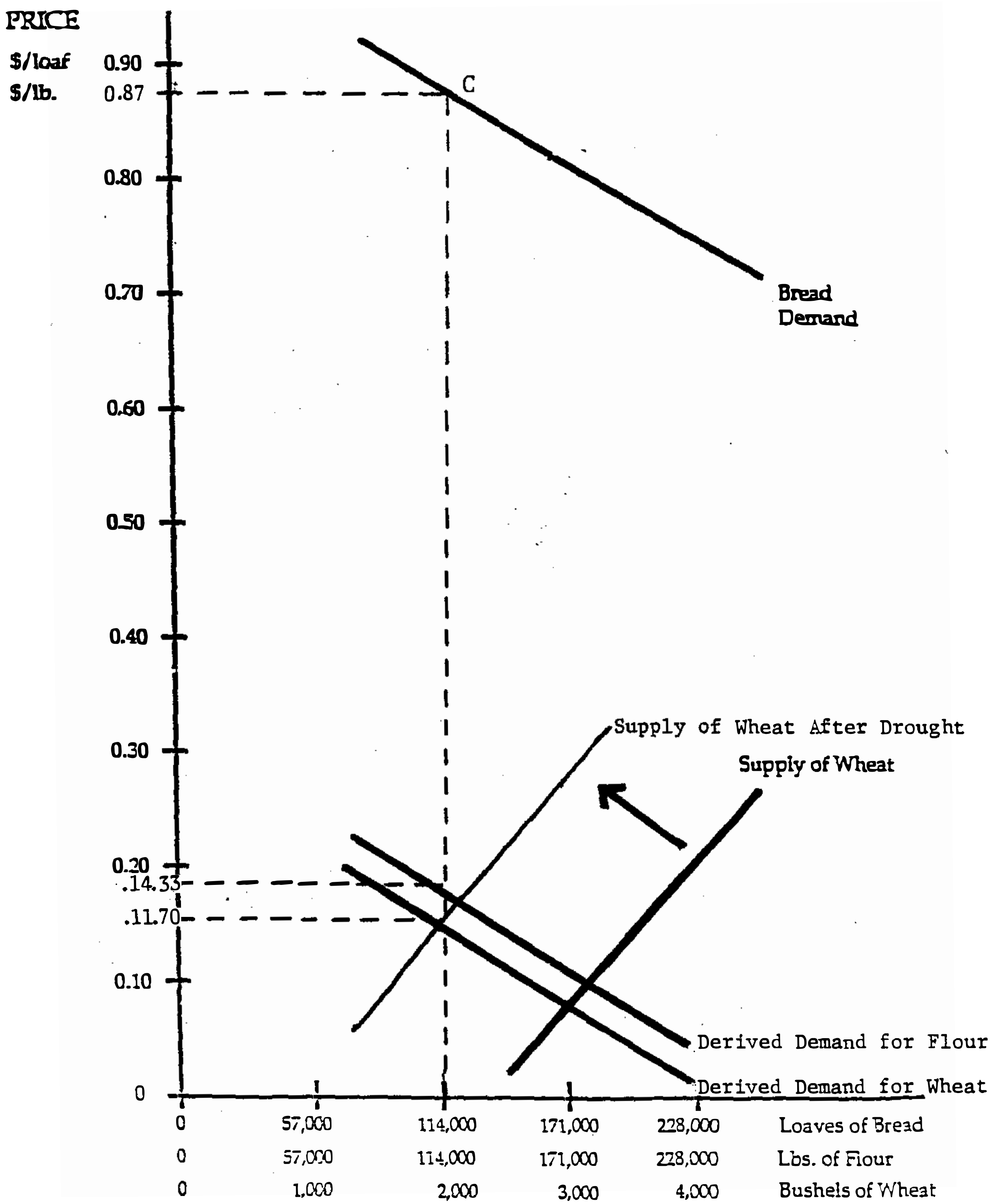
The intersection of the supply and derived demand schedules for wheat determines wheat market equilibrium. In Figure 1 the wheat market equilibrium occurs at point "a" where 171,000 pounds of flour equivalent are sold at 7.70 cents per pound. The flour yield per bushel of wheat is assumed to be 57 pounds. Therefore, the price per bushel of wheat is equal to $4.39 (7.70 cents per pound multiplied by 57 pounds).

The millers will purchase 3,000 bushel of wheat and sell 171,000 pounds of flour. The miller receives a flour price per pound equal to the per pound cost of the wheat (7.70 cents) plus processing costs (2.63 cents). In this example, the miller receives a price of 10.33 cents per pound.

Bakers, in turn, transform this flour into 171,000 loaves of bread. The price per loaf equals the flour price per pound plus the baking costs. The bread would be sold for 83.00 cents per loaf or 10.33 cents plus 72.77 cents.

Assume a drought causes the supply schedule to shift to the left (Figure 2). At any given price level less wheat will be supplied. The equilibrium prices for wheat, flour and bread will increase. If the new equilibrium quantity of wheat turns out to be 2,000 bushels, wheat prices would increase to 11.70

Figure 2: Decrease in the Supply of Wheat and Its Impact on Price Relationships



cents per pound of flour equivalent or $6.67 per bushel. At this higher wheat price, the flour price would increase to 14.33 cents per pound, and the bread price would increase to 87.00 cents per loaf.

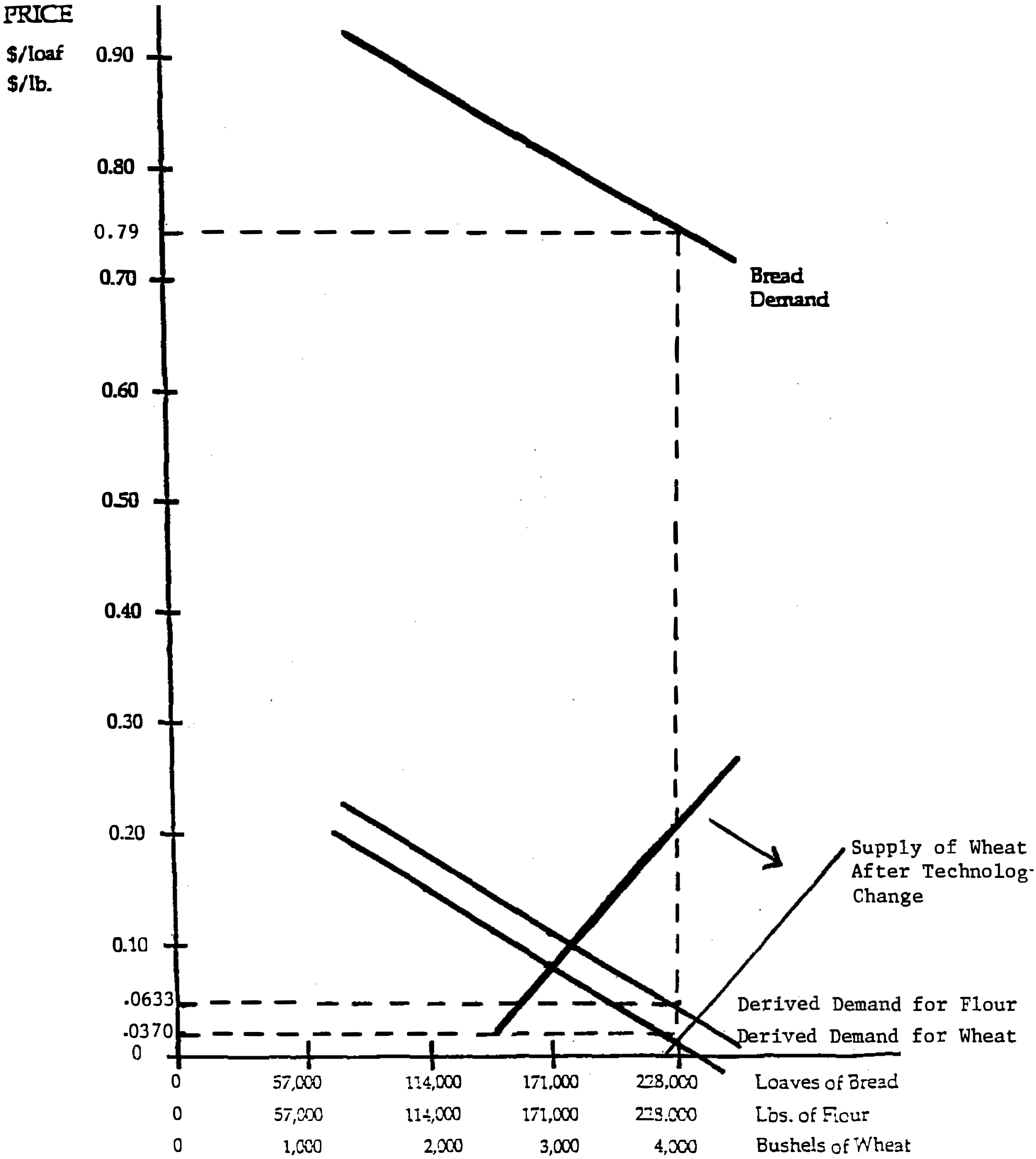
Assume a new high producing wheat variety causes the supply schedule to shift to the right (Figure 3). This increase in supply will cause the equilibrium prices to fall for wheat and flour as well as for bread. If the new equilibrium quantity of wheat turns out to be 4,000 bushels, the price of wheat would drop to $2.11 per bushel. The equilibrium prices of flour and bread would decline to 6.33 cents and 79.00 cents, respectively.

As the primary product is processed, its share of total costs declines. In the previous analysis, wheat's share of total costs was much higher for flour than for bread. In response to some percentage change in the base commodity, the percentage change in the price of a processed product will be much smaller. Furthermore, the higher the degree of processing, the lower the percentage change in the processed product's price relative to the primary product's price. As a result, the higher the degree of processing, the weaker will be the correlation between the base commodity price and the price of a processed product. For an analysis of actual wheat price relationships among farmgate, processor, and consumer prices, the reader is referred to a recent article by Babula and Bessler

FURTHER ANALYSIS OF PRICE RELATIONSHIPS FOR CASE I

So far, we have analysed the price relationships between wheat, flour, and bread under the assumptions that: (a) wheat

Figure 3: Increase in the Supply of Wheat and Its Impact on Price Relationships



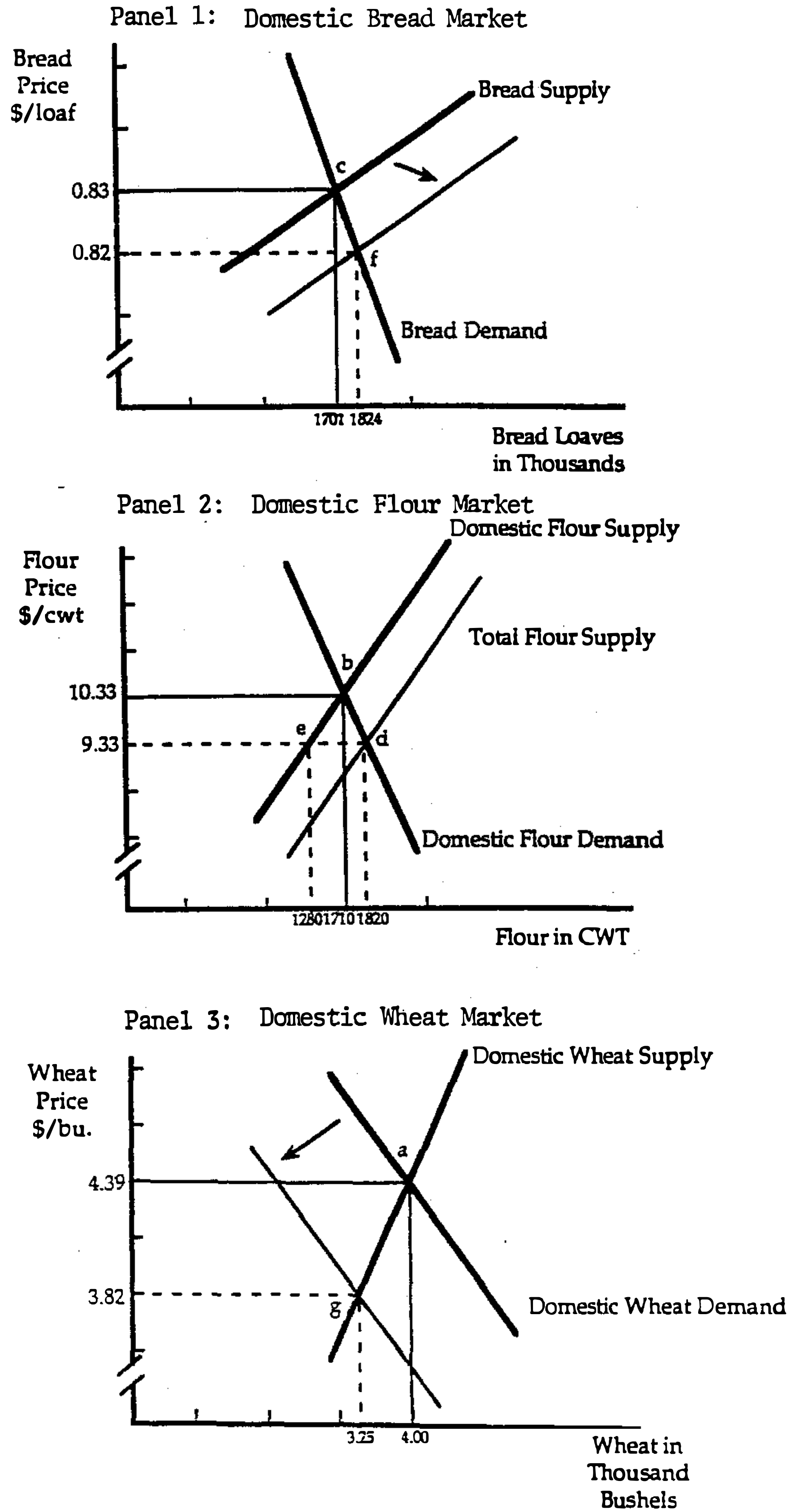
and flour are exclusively demanded for producing flour and bread, respectively, and (b) none of these products are traded with the people outside the specified market. If one or both of these assumptions are relaxed, the one-to-one correspondence between the demand schedules for the final product, the intermediate product, and the primary commodity would cease to exist.

Assume that there is a demand for wheat not connected to domestic flour production. If the price of wheat is low relative to the prices of feedgrains, it may be economically rational to incorporate wheat into livestock feed rations. As a result, the demand for wheat is the sum of the demand derived from flour and non-flour demand. It is essential a case of three interrelated markets, as shown in Figure 4.

Represented in Panel 1 are the supply and demand conditions for the bread market. The demand curve for bread is known. The supply of bread depends on the supply of flour, and the other costs of producing a loaf of bread. The initial bread market equilibrium is at point "c" where the supply and demand curves for bread intersect. At this point the price of a loaf of bread is 83.00 cents and 171,000 loafs of bread are produced.

Flour is again assumed to be used exclusively for producing bread (Panel 2). Flour demand is derived from bread demand by subtracting the margin associated with baking. The supply of flour is determined by the supply of wheat and its cost of milling. In the absence of any alternative uses of flour, the initial flour market equilibrium is at point "b", where flour supply intersects flour demand. At that point the price of flour is $10.33 per cwt, and 1,710 cwt of flour is produced,

Figure 4: Price Relationship Between Wheat, Flour and Bread.



which is exactly equal to the flour needed to produce the required 171,000 loaves of bread.

Presented in Panel 3 is the wheat market. The demand for wheat, is the sum of the demand derived from flour demand and the demand not related to flour production. Given the supply of wheat, the initial wheat equilibrium is at point "a", where the wheat supply and wheat demand schedules intersect. At this point the wheat price is $4.39 per bushel and 4,000 bushels are sold.

So far this example is identical to the previous analysis except that we have used separate panels to represent each of the three markets. Note that the equilibrium prices of wheat, flour and bread are still result in the milling and baking margins being equal to their per unit cost of processing.

Now, let us, relax the assumption (b). Assume that a neighboring region has a lower equilibrium flour price. The transfer costs to our region are low enough so that it is profitable to import flour from that region. For the remainder of this discussion, the initial region will be referred to as the domestic production region, while the neighboring region will be referred to as the exporting region.

To simplify the analysis we will assume that the quantity of flour exported to the domestic production region is a constant. This situation could exist if the domestic region has an import quota, and the domestic region was relatively inefficient in wheat and flour production. The total flour supply in the domestic region would equal the domestic flour supply plus the imported flour.

The total supply schedule for flour is shifted to the right of the domestic supply schedule. Additional flour is available at all price levels. The shift to the right will cause the flour price to decrease. The lower flour prices will lower the cost of production for bread, and thereby, shift the bread supply curve to the right. As a result, the price of bread will be lower and bread sales will increase. In our figure the equilibrium bread price drops from 83 to 82 cents per loaf, with the total consumption of bread increasing from 171,000 to 182,000 loafs, and flour price is reduced to $9.33 per cwt.

The flour price has decreased to 9.33 cents per lb. If the domestic wheat price stays at $4.29 per bushel, the millers' margin will be reduced to $0.93 per bushel.[1] With a milling cost of $1.50 per bushel, this would imply a loss to the millers of 57 cents per bushel.

[1]The value of the flour produced from a bushel of wheat = 0.0933 x 57 = $5.32. The miller's margin = value of flour produced from a bushel of wheat minus the cost of a bushel of wheat or $5.32 - $4.39 = $0.93.

Since the milling of flour is no longer profitable, domestic millers will curtail both flour production and wheat purchases. As a result, the domestic wheat demand schedule will shift to the left, resulting in a lower equilibrium wheat price. The decrease in the wheat price relative to the flour price will continue until the milling margin is again equal to the milling cost per bushel ($1.50).

If flour milling costs for the entire domestic flour industry are higher than neighboring regions, it is quite possible that all flour demand will be met by imported flour. This result requires a more elastic export supply schedule than that used in the current analysis. If this happens, the flour milling industry will cease to exist in the domestic region and local demand for wheat for milling into flour will cease to exist. Wheat from this region must be exported to other regions or wheat production will be curtailed in the domestic region.

To summarize, cheaper imports of flour will affect all three markets. The new equilibrium for wheat, flour, and bread will be at points g, d, and f, respectively. The flour price will decrease from $10.33 to $9.33 per cwt. Total sales of flour will increase from 1,710 to 1,820 cwt, but domestic flour production will decrease from 1,710 to 1,280 cwt. Domestic wheat prices drop from $4.39 to $3.82 per bushel.

Similarly, short-run adjustments in miller and baker margins will occur if flour is exported from the domestic region. Assume a neighboring region has a higher flour price than the domestic region. If the domestic region places an export quota on the flour industry, the quantity exported from the domestic region will equal the export quota at any economic relevant price.

The exports of flour to the neighboring region will result in an upward shift of the flour demand curve and an increase in the flour price. In the short-run the increase in the flour price will increase the milling margin. The profits from flour milling will increase..

However, this profit opportunity will be short-lived. Due to the increased demand for flour, the derived demand for wheat will increase and the demand schedule will shift to the right.

Producers will receive a higher price for their wheat and millers' margin will soon decrease to the level of the flour milling cost.

Higher flour prices at all levels of output will cause the input costs of producing bread to increase. The bread supply curve will shift to the left. Initially, bakers will experience losses if the price of bread does not increase and bakers maintain their previous production levels. Eventually, the domestic price of bread will increase and the quantity supplied will decrease.

JOINT PRODUCTS CASE

In the case of joint products, processing the primary commodity, will cause two or more products to be produced in a more or less fixed proportion. An increase in the production of one product simultaneously increases the production of the other joint products.

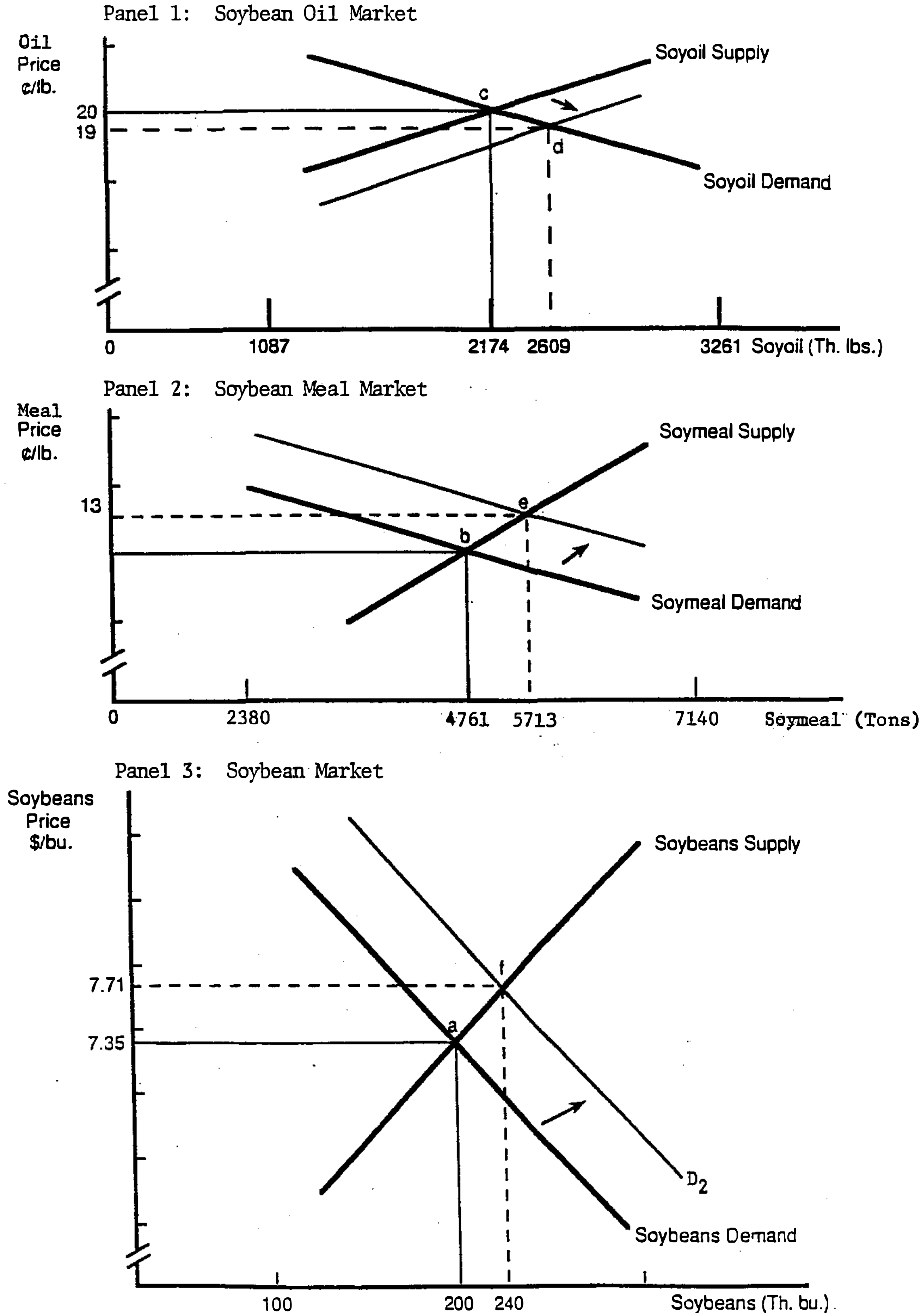
The soybean complex provides a good illustration of such a price relationship between soybeans (a primary commodity) and soybean oil and soybean meal (two joint products). On average, the crushing of soybeans yields 18.12 percent soybean oil and 79.35 percent of soybean meal. In an actual situation, the proportion of oil and meal depends upon the quality of the soybeans processed and the processing technique used. For the following example it is assumed that the crushing of a bushel of soybeans weighing 60 pounds yields 10.87 pounds of oil (18.12 percent) and 47.61 pounds of meal (79.35 percent).

Assume the demands for soybean oil and soybean meal are final demands. Shown in Firgure 5 are the supply and demand conditions for soybeans, soybean oil, and soybean meal. In the graphical presentation the quantity scales for oil, meal and soybeans are comparable in terms of soybean equivalence. Crushing 2,174 thousand pounds of oil produces 200 thousand bushels of soybeans. Therefore, 2,174 thousand pounds of oil are equivalent to 200 thousand bushels of soybeans. Similarly, 4,761 tons of meal are equivalent to 200 thousand bushels of soybeans. In their respective panels, the points representing 2,174 thousand pounds of oil, 4,761 tons of meal, and 200 thousand bushels of soybeans are at the same distance from the origin (Figure 5).

The demand for soybeans is derived from the demands for oil and meal, and crushing costs. In competitive market equilibrium the crushers margin will be equal to the unit crushing costs of the industry. Therefore, in a competitive market equilibrium, the relationship between the prices of soybean oil, soybean meal and soybeans are such that the soybean price per bushel is derived by deducting the crushing cost per bushel from the sum of the values of the oil and meal obtained from processing a bushel of soybeans. The value of a specific joint product per bushel equals the product's price times the product yield per bushel. For a specific level of soybean processing, oil and meal prices are obtained from their respective demand schedules.

The supply schedule for soybean oil is a function of the demand for soybean meal, supply of soybeans and the soybean processing costs. Similarly, the supply schedule for soybean meal is a function of the demand for soybean oil, supply of

Figure 5: Price Relationship between Soybeans, Soymeal, and Soyoil



soybeans and the soybean processing costs.

The demand curves for soybean oil and meal are known and exogenous. Also, it is assumed that the crushing cost is $18 per ton or 52 cents per bushel. This crushing cost is assumed to be a constant and independent of quantity of soybeans crushed. Assume the supply of soybeans to be known.

In a competitive market, a soybean processor will engage in soybean processing only if his margin is at least enough to cover the processing costs. On the other hand, if the margin is more than the crushing costs, it will be short lived. The competition among soybean crushers will decrease the margin to a level which is just enough to cover the crushing costs. In a competitive market equilibrium, the prices of soybeans, soybean oil and soybean meal and soybean processing costs will show a relationship as follows:

Price of Soybeans per Bushel	+	Processing Cost per Bushel	=	Value of Soybean Meal per Bushel	+	Value of Soybean Oil per Bushel

Due to the very nature of joint product there exists an interdependence between the demand and supply of the joint products. A shift in the demand schedule for one joint product will not only result in an increase in the price of that product, but will also cause a shift in the supply of the other joint products. Let us assume that the demand for soybean meal increases. This demand change will increase the price of soybean meal and increase in the value of the soybean meal contained in a bushel of soybeans. If there are no changes in the demand for soybean oil, supply of soybeans and crushing costs, the soybean processors will be willing to supply soybean oil at a lower price. This implies an outward shift in the soybean oil supply curve. Due to this interdependence between demand and supply of joint products, a shift to the right (left) in the demand for one product will be associated with a shift to the left (right) in the supply of the other product.

The market clearing prices in all three markets are determined simultaneously. In Figure 5, soybean, soybean oil, and soybean meal markets are assumed to be initially at equilibrium. These equilibria are represented by points a, b, and c, respectively. The soybean price is $7.35 per bushel and 200,000 bushels of soybeans are crushed to obtain 4,761 tons of meal and 2,174 thousand pounds of oil. The meal and oil prices are 12 and 20 cents per pound, respectively. In competitive equilibrium, as long as some soybeans are crushed, the crushers' margin will exactly equal their crushing costs--54 cents per bushel or $18.00 per ton.

To do a graphical analysis of the previous discussion, again assume the demand for meal increases or the demand schedule shifts to the right. Higher meal prices will initially result in a larger processing margin. The processors, however, in an effort to expand their processing, will bid the soybean prices up resulting in an outward shift in the soybean derived demand (to level D2. In the meantime, the higher price for soybeans will also increase the quantity of soybeans supplied along the supply curve.

With an increased quantity of soybeans processed, there will be an increased production of both soybean meal and soybean oil. As a result the supply curve of soybean oil will shift to the right, and soybean oil prices will decline along the soybean oil demand curve. Once the markets achieve a new equilibrium level, the opportunities for excessive profits from crushing will also be eliminated.

The panels in Figure 5, show that the new equilibria in the oil, meal and soybean markets will be at points d, e, and f, respectively. The new equilibrium prices are 19 cents per pound of oil, 13 cents per pound of meal, and $7.71 per bushel of soybeans. The crushers' margins will again be reduced to being just equal to the crushing cost.

If, for some reason, the crushing margin is less than the crushing costs, the processors will not engage in crushing. In real world, even in a highly competitive industry, cost vary from firm to firm. There are some firms which have costs slightly higher that industry average and there are others which have costs slightly below the industry average. When processing margins start decreasing, the most inefficient firms are first to experience negative crush margins. Nevertheless, in the short run, these firms may continue processing as long as the crushing margin is enough to pay for their variable costs. For a firm to continue processing, in the long run, however, the margin must be enough to pay for variable as well as fixed costs. If the processors margin is not enough to cover the per unit fixed as well as variable costs of processing a large portion of the production capacity will exit from the industry.

Conclusion

Agricultural commodities are often processed into one or more products. The demand for agricultural commodities is generally a derived demand rather than a final demand. Changes in processing costs and shifts in the final demand for processed products directly affect the price for the agricultural commodities.

Often the processing of agricultural products produces two or more joint products. In the case of joint products in addition to the interdependence between the prices of interdependence between the demand for one product and the supply of other products and base commodity there is also joint products.

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