Methodology

In this study we compare two sets of estimates of retail-farm price margins. Both define retail-farm price margins as the difference between a market's average retail-price and its retail-equivalent farm price, and both have been justified on efficiency grounds (Reed and Clark 1997).

The first set is the current ERS estimates. The current estimates are based on fixed-factor proportions at the market level. In particular, if P_r and P_f denote a market's average retail and farm price and θ denotes a fixed farm-input–food-output coefficient, an estimate of a price spread for that particular market can be represented as

$$S = P_r - \theta P_f. \qquad (1)$$

Corresponding to equation 1 is a definition of the farm value share. Note that according to equation 1 the spread-to-retail price ratio $S / P_r = [1 - K]$ where the farm share, K, is $\theta (P_f / P_r)$. Hence implicit in the current estimates is a farm share that does not reflect changes in consumer demand for marketing services in the products that they purchase.[3]

The second set of estimates, denoted here as the new estimates, relax the restriction of a fixed input-output coefficient. If Q denotes composite consumer demand for a particular industry's output and F denotes the industry's demand for farm inputs, the new estimate is

$$M = P_r - (F/Q) P_f. \qquad (2)$$

Equation 2 implies $M/P_r = [1 - K]$ where the farm share, K, is defined naturally as $(P_f F_f / P_r Q)$. Implicit in the new estimates is a farm share that directly reflects changes in consumer demand for marketing services in the products that they purchase.

Fixing the farm-to-output ratio leads to problems in evaluating equation 1. For markets like beef or pork, the farm input is generally considered to be a fairly homogeneous commodity. In these markets, the problem lies in choosing a particular elementary retail product price that represents the average industry price P_r. By choosing a particular per unit product price (instead of an average price index) one implicitly restricts the array of final consumer products associated with a market to be identical. For other markets, like fresh fruits and vegetables, in which the farm commodity is heterogeneous, the problem becomes one of defining an average per unit farm price.

More generally, the problem with fixing a market's input-output ratio to a parameter, θ, is that it restricts the description of diversity. In particular, for a given fixed industry technology (no technological change) a fixed θ implies that when relative input prices change, the marginal cost of each fixed-proportions-producing firm shifts in the same way as every other firm in the industry. This means, for example, that if energy prices rise relative to farm prices, each identical firm utilizes inputs in the same fixed proportion and makes the same relative contribution to industry supply as it did before the price change.

On the other hand, the input-output ratio F/Q in equation 2 automatically allows for both technological change and differential supply responses among firms with different technologies. In particular, (F/Q) can automatically account for the effect of technological change at the firm or plant level that leads to the utilization of inputs in different proportions. The production process might be altered, for example, with improvements in plant production. However, if technology is fixed (which is the usual case) but varies across the firms of an industry, changes in relative factor prices will alter F/Q (Wohlgenant, 1989; Wohlgenant and Haidacher, 1989).

To see this, suppose again that energy prices rise relative to farm prices, and that the firms in an industry produce an identical product, but are bestowed with different technologies.[4] In this case, the marginal costs of firms with energy-intensive technologies will rise more than the marginal costs of firms with farm-intensive technologies. This means that after the relative increase in the energy price, energy-intensive firms contribute proportionately less and farm-intensive firms contribute proportionately more, to industry output. At the industry level then, F/Q rises. Hence, even if each firm produces the same product in fixed pro-

[3]It is important to note that while equation 1 forms the basis of the ERS estimates, ERS adjusts this basic formula when publishing its estimates. For example, for some markets ERS (infrequently) revises its estimates of θ. Furthermore, the basic estimates are updated based on current information on consumer expenditures.

[4]These technologies can be characterized as fixed-proportions technologies as long as the input-output coefficients vary across firms.

portions, input substitution occurs through the allocation of different production technologies across the industry. Note that in response to the increase in relative energy prices, equation 2 suggests that the increase in F/Q dampens the increase in retail-farm price margins.

One way to detect input substitution is to find empirical evidence of *diminishing returns* to the farm input. In this case, diminishing returns implies that with all factors held constant except the farm factor, the marginal productivity of the farm factor would decline as production increases. That is, as output (Q) rises, F/Q rises. However, competitive producers would be willing to pay less for a less-productive farm factor, so that a rising farm output ratio should be accompanied by a rising retail-to-farm price ratio (P_r /P_f). A positive correlation between F/Q and P_r /P_f provides evidence of input substitution, and evidence in support of the revised retail-farm price margins proposed in equation 2.

Aside from diversity among firm technologies, diversity among final consumer food products also implies an F/Q ratio that responds to changes in relative factor prices.[5] To see this, suppose each identical firm in an industry produced the full array of diverse final consumer products associated with the particular food market. Suppose the energy-to-farm price ratio again increases. In this case, each efficient, identical, multi-product firm will want to produce its output using higher proportions of the relatively less expensive farm ingredients. Each firm does this by producing relatively more of its existing high-farm-content products. The market clears as the industry offers more of these "low-processed" products to consumers at a lower relative price. Hence in response to a decrease in the relative farm price F/Q increases as the market allocates transactions across different final consumer food products.

A key to evaluating equation 2 is computing an estimate of composite consumer demand (Q). The challenge is to construct an estimate that reflects consumers' preferences for the diverse elementary products that they actually purchase.

The method of deflation provides one such estimate (Usher, 1971). Deflation defines Q as market-level consumer expenditures (E) divided by a market average retail price index (P_r), or

$$Q = E/P_r. \tag{3}$$

Equation 3 indicates that Q is a value measure of composite demand expressed in base period dollars. Because E represents the sum of expenditures across different elementary products, a consistent estimate of equation 3 provides a measure of demand that reflects the value that consumers place on the diverse products that they actually purchase. An important question is whether equation 3 is a consistent estimate of consumer demand. This question relates to important issues of market definition. Recent theoretical work suggests that under fairly mild conditions, the "deflated" expenditure measure of Q represents a consistent estimate of composite, market-level consumer demand (Lewbel, 1996).[6]

To see the implications of equaiton 3 for market-level estimates of retail-farm price margins consider a correctly defined composite market that produces ($i = 1,\ldots,n$) different elementary products, so that consumer expenditures are

$$E = p_1 x_1 + p_2 x_2 + \ldots + p_n x_n$$

where p_i is the ith elementary price and x_i is the ith elementary quantity demanded. According to equation 3, the market-level output-input ratio is

$$Q/F = (E/P_r)/F = (p_1/P_r)(x_1/F_1) + (p_2/P_r)(x_2/F) + \ldots + (p_n/P_r)(x_n/F_1). \tag{4}$$

Equation 4 reveals that the output-input ratio, or equivalently the inverse used in equation 2, is a relative-price-weighted sum of the different output-input ratios associated with the different products of the market. In the theory of retail-farm price margins, food products are conceptualized as bundles of farm and marketing services, so that a high (low) output-input ratio denotes a product with a high (low) marketing service component. Equation 4 illustrates that a composite market with a high output-input ratio is one in which consumers purchase high-priced, marketing-service-intensive products. Equations 2 and 4 suggest that retail-farm price margins rise as consumers shift from prod-

[5]The following description is more formally stated in Wohlgenant (1999).

[6]Appendix D discusses the tests for each of the seven markets in this study. Based on these tests, we could not reject the notion that each market represents a composite.

ucts with high farm components to products with high marketing service components.

One advantage of appealing to an expenditure-based measure of composite demand is that it provides a clearly defined measure of *quality*. If equation 3 is a consistent estimate of composite demand, it can be decomposed into a *physical* measure of output and a corresponding measure of quality (Usher, 1971; Nelson, 1991). For example, if one chooses to measure the physical dimension of consumer beef demand in pounds, quality would represent the value that consumers place on the countless number of other attributes of beef products (e.g., texture, flavor, convenience, nutritional content). In this case quality is defined as composite beef demand (i.e., equation 3) divided by the pounds of beef purchased. Notice that while clearly defined, quality always depends on the single physical dimension chosen (Nelson, 1991).

The willingness of agricultural economists to use *commercial disappearance* (e.g., Huang, 2000) as the physical measure of food demand suggests that they are implicitly willing to measure quality in terms of all of the attributes of food except the farm ingredient.[7] In this study, we call the collection of these other attributes (e.g., flavor, convenience, processing) "marketing services" and measure it as *Q/F*. Hence our approach allows us to interpret the inverse of *F/Q* used in equaiton 2 as food quality. Equation 4 illustrates that consumers have considerable choice in their determination of food quality through the purchases of different elementary products. Moreover, the new estimates given by equation 2 indicate that for a given set of farm and retail prices, increases in food quality are reflected in increases in retail-farm price margins.

In this study, we compute new estimates of retail-farm price margins (*M*) and compare them to *S*. Differences trace to differences in accounting for the quality of composite output arising from technological change, heterogeneous responses of firms, and the diversity of elementary consumer food products.

[7]Commercial disappearance estimates pertain to farm ingredients as they are derived from farm-level supply-utilization tables (see Putnam and Allshouse, 1999).