Empirical Results

This section describes data requirements, reports estimates of *M* and *S* for the at-home beef, pork, poultry, eggs, dairy, fresh fruit, and fresh vegetable markets, interprets differences between the series, and presents empirical evidence that support the new estimates.

The new retail-farm price estimates (*M*) given by equation 2 can be written in an equivalent form that is convenient for computation. Since equaiton 3 implies $E = P_r Q$, and farm receipts are $FR = P_f F$, equation 2 can be rewritten as

$$M = (E - FR)/Q. \qquad (5)$$

Equation 5 states that the new retail-farm price spread is the ratio of an industry's marketing bill to composite consumer demand.[8] We use equation 5 to compute empirical estimates of the revised retail-farm price estimates.

Note that we are computing estimates of market-specific price spreads, so that necessarily they apply to at-home price spreads.[9] Hence the variables *E*, *FR*, and *Q* in equation 5 refer to *at-home* consumer expenditures, farm receipts (i.e., receipts generated from *at-home* food sales), and *at-home* consumer demand, respectively.[10]

Table 1 reports the annual estimates of the *M* and *S* series over the 1980-97 sample for the seven composite markets. *M* is computed from equations 3 and 5, and *S* refers to the currently reported ERS estimates that can be thought of as adjusted versions of equation 1. Both estimates are expressed in index form.

Figures 1-7 present scatter plots of logs of input-output quantity ratios (Q/F) against logs of output-input price ratios (P_r/P_f).[11] Except for the beef market (figure 1), the positive-sloped regression lines shown in figures 2-7 provide evidence of input substitution. The negative-sloped regression line for beef (figure 1) may suggest structural change in the form of plant improvements that lead to the utilization of inputs in different proportions. Hence figures 1-7 suggest the new estimates could be justified on the basis of structural change for beef and input substitution in the other six markets.

Figures 8-14 present time plots of the *M* and *S* estimates over the sample period. These plots reveal some very general patterns across the seven markets. In particular, they illustrate that while *M* and *S* follow similar upward trends, *M* appears to be more volatile than *S* in every market. Moreover, there appear to be clear intervals over which *M* systematically differs from *S*. For example, figures 8 (beef), 9 (pork), and 14 (fresh vegetables) reveal extended periods over which the revised series (*M*) lies systematically above the existing series (*S*). This means that $F/Q < \theta$ or that proportionately more marketing-service-intensive products were purchased in these markets than the current ERS estimates suggest. On the other hand, figure 13 (fresh fruit) reveals that, over most of the sample, *S* systematically exceeds *M*, or $F/Q > \theta$. In this case, the new estimates suggest that consumers purchased more farm-intensive fresh fruit products than the current ERS estimates suggest.

Because *F/Q* for a composite market depends on consumer expenditure patterns for a market's diverse elementary products (i.e., equation 4 above), one would expect *M* to be more volatile than *S*. With the exception of eggs, Figures 8-14 show the relationship between the new estimates (*M*) for a composite market and its component expenditures. Overall, the figures

[8]The data and the data sources used to construct the variables of equation 5 are described in detail in the Appendix.

[9]The reason is that we can identify the main farm ingredient. For at-home purchases in these markets, consumers are purchasing a fairly well defined food bundle comprised of the farm ingredient and marketing services. In contrast, it is difficult to conceptualize, for example, a retail-farm price margin for away-from-home beef because the bundle demanded is a meal consisting of a number of different foods produced from a number of different farm ingredients. Nevertheless, the consumption of away-from-home beef has a direct impact on the corresponding at-home beef margins because final beef consumption competes for the same farm supply.

[10]The computational problem is obtaining estimates of farm receipts generated from at-home food sales. The results are based on estimates of farm receipts adjusted by a longrun point estimate of the proportion of farm receipts generated from at-home food sales for each industry (see Appendix E). However, this proportion may have declined over the sample period. In an attempt to capture the changing proportion, we adjusted the industry-specific point estimates by the observed declining proportion of food sales spent on at-home consumption (Putnam and Allshouse, 1999). This did not noticeably alter the empirical results reported here.

[11]The scatter points plotted in these figures are the OLS residuals of $ln(F/Q)$ regressed against a constant and time trend (T) (on the y-axis) against the residuals of $ln(P_r/P_f)$ regressed against a constant and T (x-axis). In other words, the scatter points represent logs of price and quantity ratios with both the mean and trend removed. By the law of iterated projections (e.g., Sargent, 1987), the slope coefficients associated with these scatter points reported in figures 1-7 equal the OLS estimate of β_2 in the model $ln(F/Q) = \beta_0 + \beta_1 T + \beta_2 ln(P_r/P_f)$.

Table 1—Current (S) and new (M) estimates of retail-farm price spreads (1982-84=100)

	Beef		Pork		Poultry		Eggs	
	S	M	S	M	S	M	S	M
1980	91.10	68.60	87.00	88.45	91.50	87.89	89.00	79.69
1981	99.10	95.65	93.40	68.76	100.7	93.59	90.40	84.96
1982	100.9	90.48	97.50	55.88	101.3	108.8	97.40	99.87
1983	100.9	84.45	106.8	94.33	97.60	75.77	95.10	92.05
1984	98.30	125.1	95.60	149.8	101.1	115.4	107.4	108.1
1985	104.9	132.5	104.0	176.7	106.6	123.6	100.4	126.0
1986	105.5	141.1	109.4	168.8	113.3	107.0	106.0	131.6
1987	103.4	122.0	121.4	171.4	134.2	160.2	117.9	157.3
1988	105.7	89.54	133.7	192.6	132.9	102.5	124.9	173.5
1989	112.1	137.5	131.6	197.1	150.6	119.8	138.1	174.7
1990	116.7	146.6	145.7	214.6	161.1	169.4	153.2	157.1
1991	132.8	173.9	157.1	262.2	164.9	220.5	157.6	173.7
1992	127.3	173.5	154.5	302.6	163.0	214.4	163.2	189.4
1993	134.0	204.3	147.3	294.1	166.2	219.5	167.8	194.7
1994	142.4	235.1	161.2	331.9	172.6	233.2	169.4	207.6
1995	151.3	260.2	151.8	333.3	177.7	244.9	173.2	218.2
1996	150.6	275.2	159.6	323.4	182.6	229.9	191.4	208.1
1997	147.5	253.6	177.7	335.4	198.1	250.9	213.0	217.1

	Dairy		Fresh fruit		Fresh vegetables	
	S	M	S	M	S	M
1980	85.90	59.34	84.20	76.05	81.30	—
1981	93.20	64.65	88.60	83.57	89.80	—
1982	97.30	85.80	97.00	96.38	93.90	69.53
1983	99.50	79.02	99.90	94.53	97.90	56.54
1984	103.2	135.2	103.3	109.1	108.2	173.9
1985	110.5	121.2	121.9	120.1	108.9	280.1
1986	113.3	127.5	128.0	125.3	116.8	284.5
1987	117.5	131.8	145.7	141.5	127.7	388.9
1988	124.7	137.0	158.7	151.9	141.3	444.7
1989	130.8	178.0	176.0	162.5	153.2	463.2
1990	149.5	175.7	195.9	182.4	164.9	462.4
1991	157.4	186.6	212.6	207.8	176.8	603.2
1992	158.7	167.2	220.6	194.2	177.1	598.8
1993	162.9	183.5	224.0	205.3	189.7	516.2
1994	166.2	173.4	250.1	216.7	200.2	566.1
1995	170.3	186.8	268.7	235.9	225.5	574.6
1996	174.3	207.9	285.2	254.0	228.3	787.9
1997	189.3	219.4	295.0	251.1	233.6	721.1

Figure 1

Quantity vs price ratios, beef

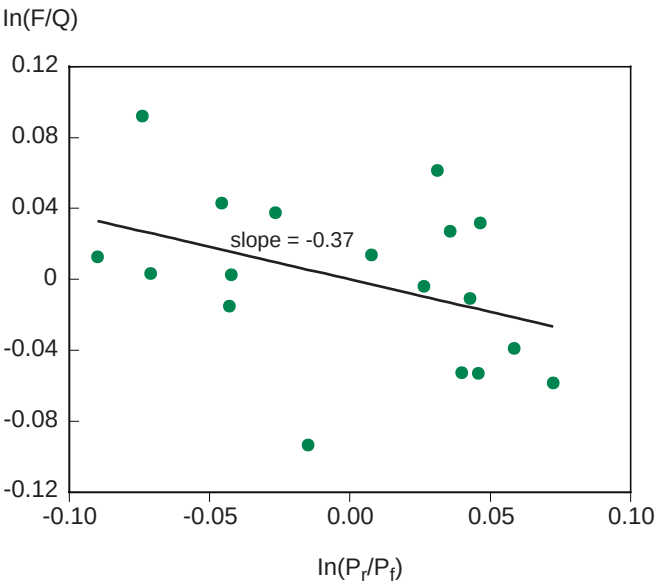


Figure 2

Quantity vs price ratios, pork

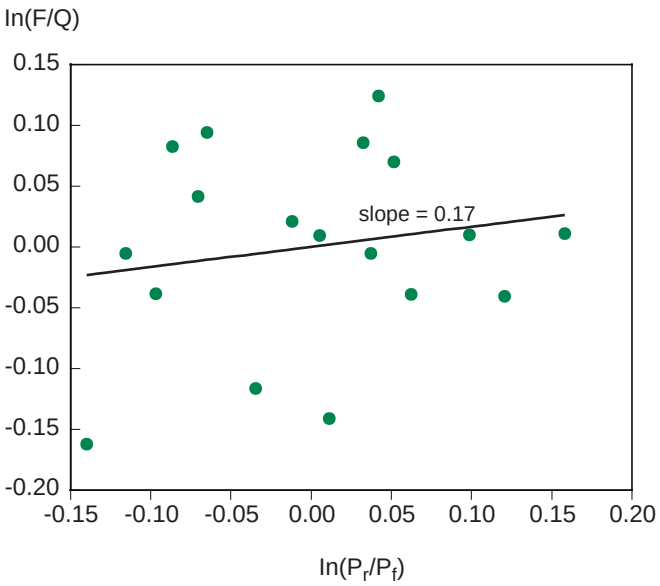


Figure 3

Quantity vs price ratios, poultry

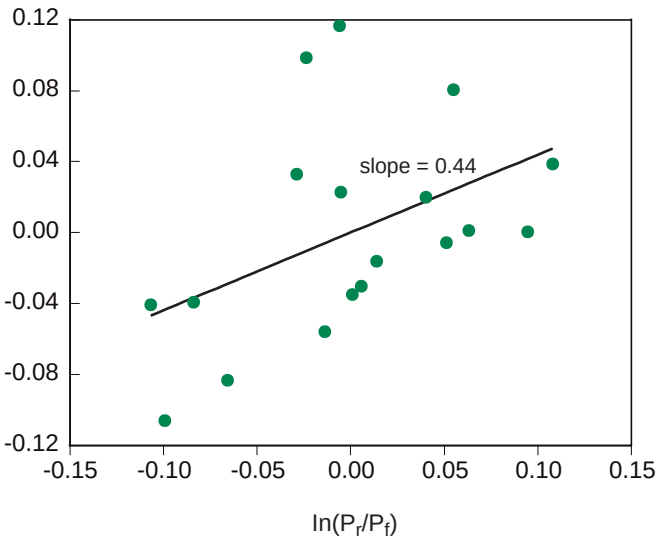


Figure 4

Quantity vs price ratios, eggs

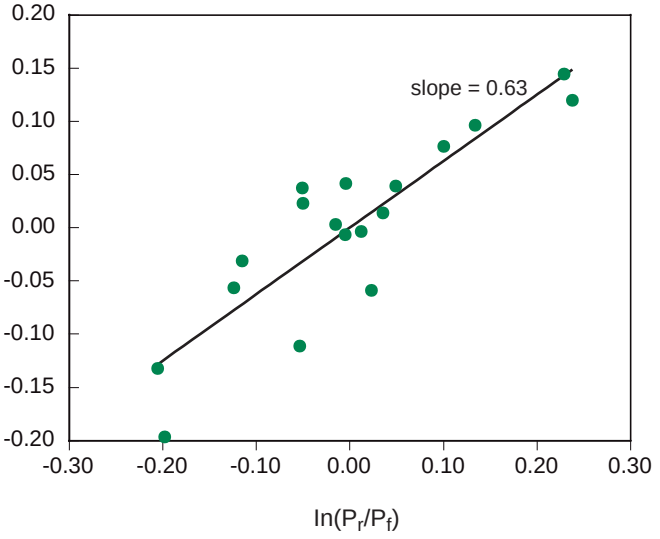


Figure 5

Quantity vs price ratios, dairy

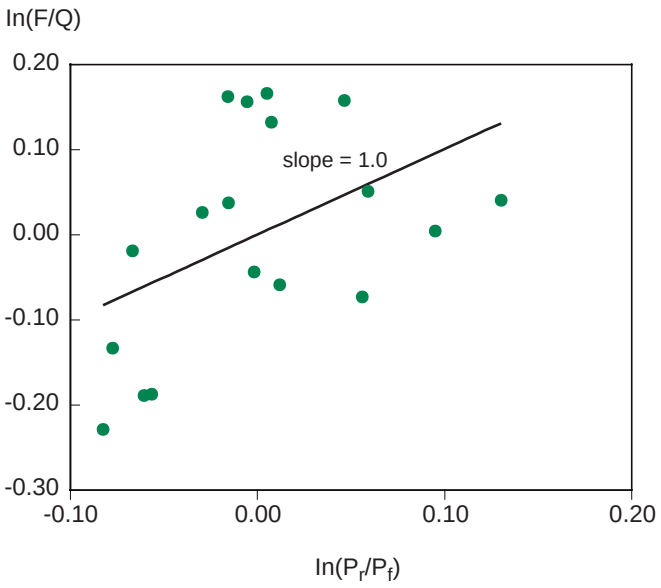


Figure 6

Quantity vs price ratios, fresh fruit

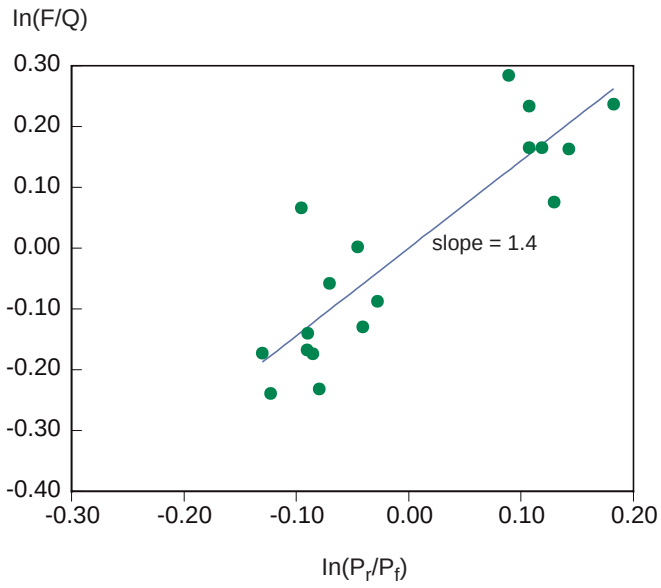
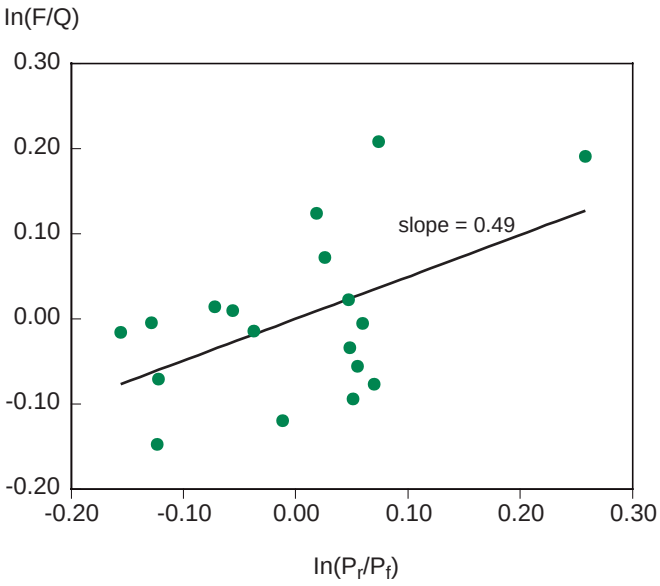


Figure 7

Quantity vs price ratios, fresh vegetables



demonstrate that the divergence between *M* and *S* is correlated with consumers' changing expenditure patterns for the component products of the composite market. The correlation is most transparent for the beef, pork, and poultry markets.

In the beef market, figure 8 illustrates that *M* begins to rise rapidly in 1988 and diverges from *S* over most of the remainder of the sample period. Figure 8a reveals that sirloin steak has been a relatively high-priced beef product over the sample. Figure 8b shows that one reason for the divergence of *M* from *S* is that, from 1988 through 1997, consumers chose to purchase farm-level beef in the form of relatively high-priced sirloin steak.

In the pork market, figure 9 illustrates that *M* exceeds *S* over most of the sample period. Figure 9a reveals that ham is a relatively high-priced pork product, and figure 9b suggests that the willingness of consumers to purchase farm-level pork in the form of relatively high-priced ham has contributed to $M > S$ over the sample. The increasing proportion of high-priced chop expenditures from 1991 to 1996 has also contributed to $M > S$.

Figure 8

Retail-farm price margins, beef

1982-84=100

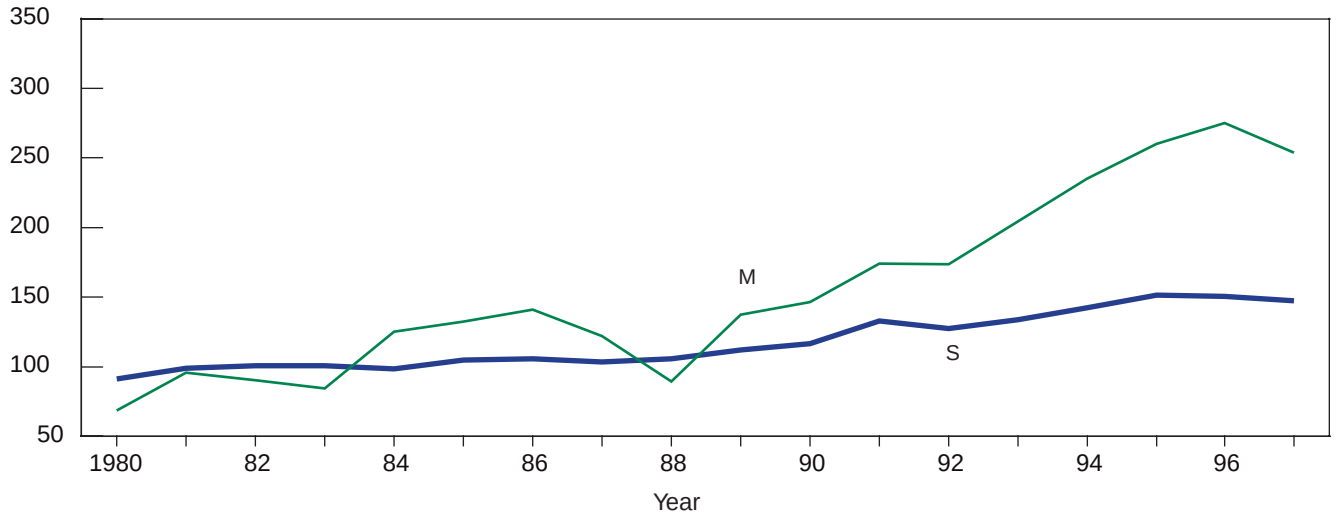


Figure 8a

Relative elementary prices, beef

1982-84=1.0

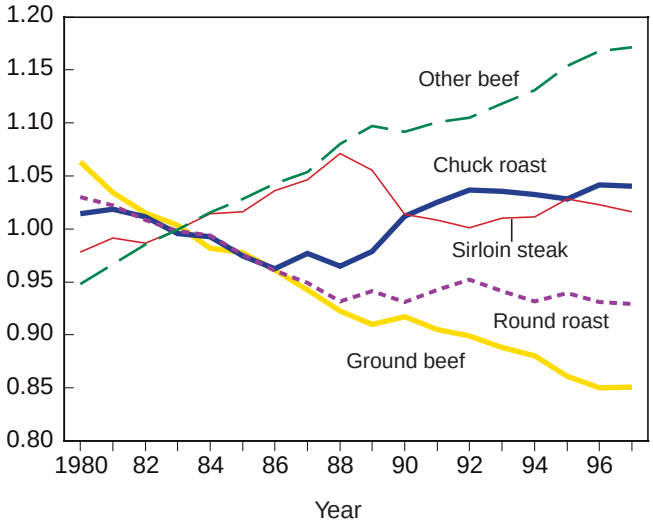


Figure 8b

Elementary output-input ratios, beef

1982-84=1.0

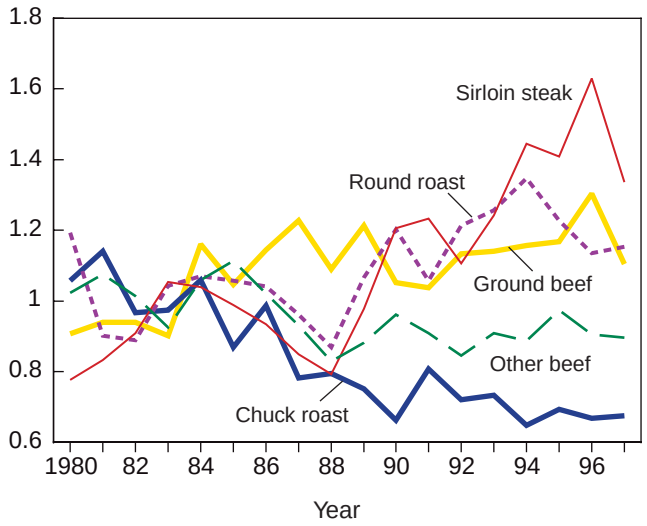


Figure 9

Retail-farm price margins, pork

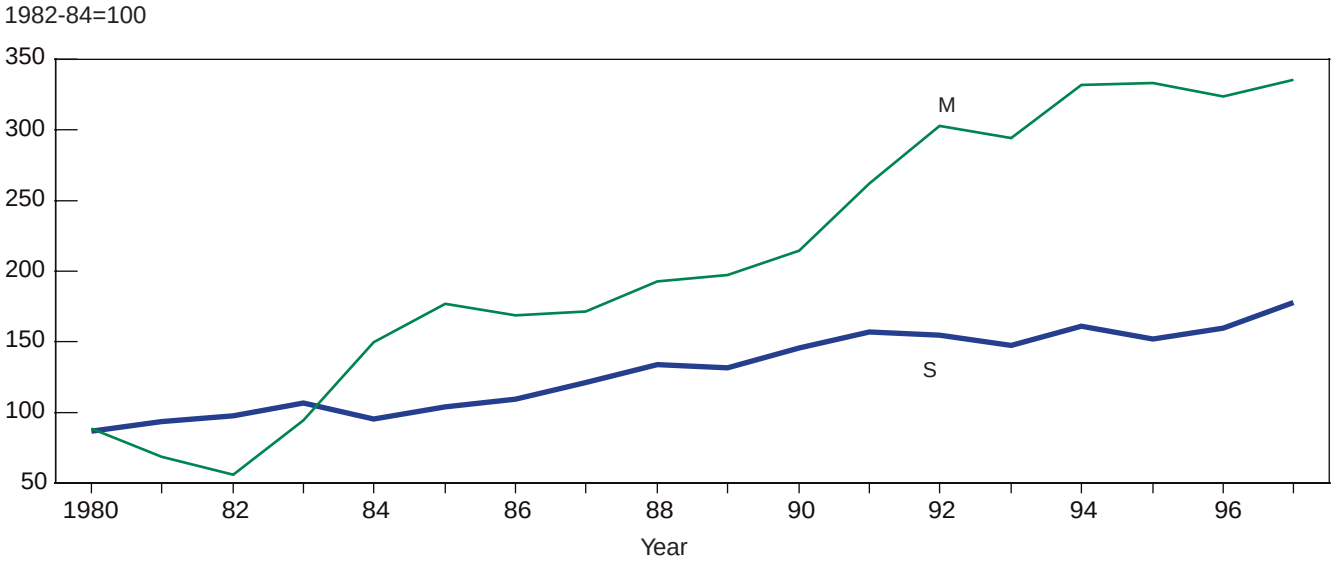


Figure 9a

Relative elementary prices, pork

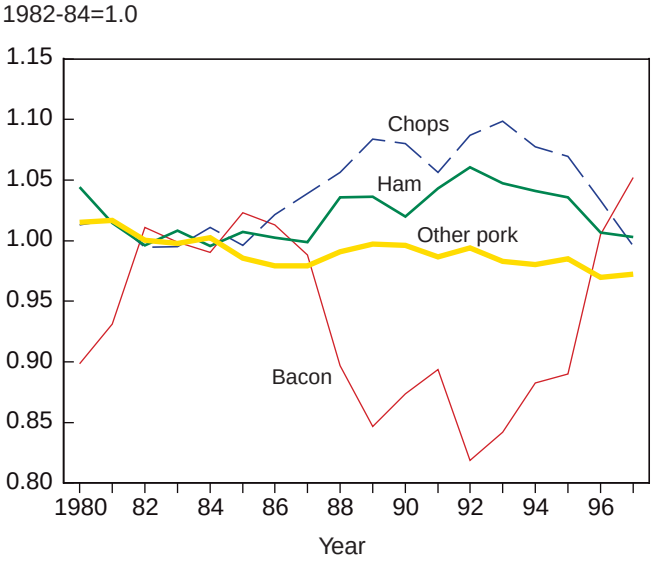
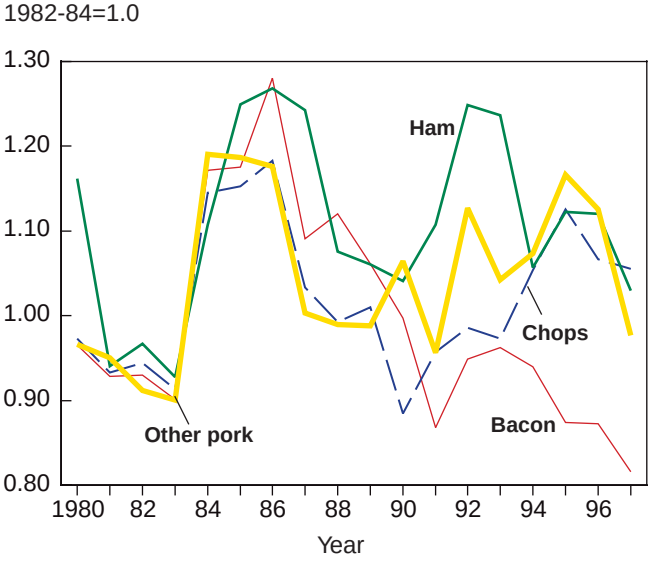


Figure 9b

Elementary output-input ratios, pork



In the fresh poultry market, figure 10 illustrates that *M* rose and remained above *S* from 1990-97. Figures 10a and 10b reveal that, after 1990, chicken parts became the highest priced poultry component. The willingness of consumers to purchase relatively high proportions of poultry in the form of chicken parts over this period has contributed to $M > S$. Also, from 1990-97 the relative price of other poultry rose, so that the willingness of consumers to purchase a high proportion of other poultry also contributed to $M > S$ after 1990.

Despite the different patterns, column 1 of table 2 suggests the correlation between the levels of *M* and *S* in each market is close to one. Moreover, the estimates reported in column 1 imply that one cannot reject the null hypothesis (at the 0.01 level of significance) that the levels of the two estimates are correlated.[12] The results are surprising in light of the differences between equations 1 and 2. However, the high correla-

[12] The estimates in table 2 are Spearman rank correlation coefficients.

Figure 10

Retail-farm price margins, poultry

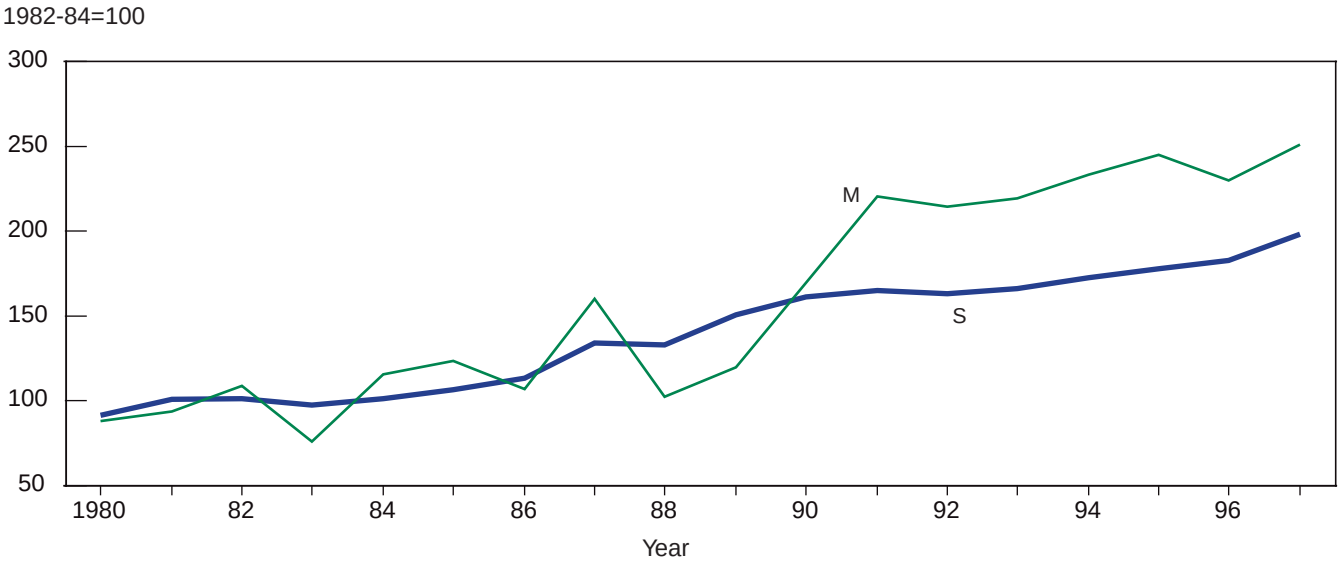


Figure 10a

Relative elementary prices, poultry

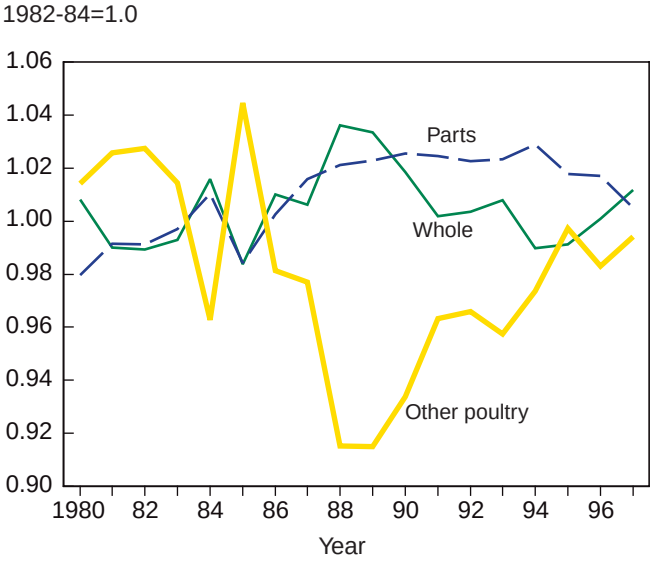


Figure 10b

Elementary output-input ratios, poultry

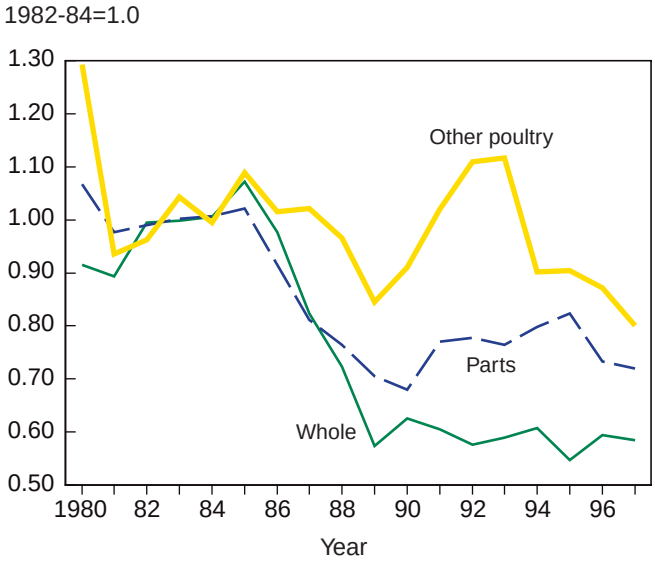


Table 2—Spearman rank correlation estimates between M and S

	Levels	Time trend removed	Annual difference
Beef	0.919**	0.663**	0.500*
Pork	0.936**	-0.185	0.159
Poultry	0.944**	0.430	0.549*
Eggs	0.971**	-0.519*	-0.223
Dairy	0.940**	-0.102	0.069
Fresh fruit	0.990**	-0.661**	0.505*
Fresh vegetables	0.961**	-0.387	-0.037

** Reject zero correlation at the 0.01 level.
* Reject zero correlation at the 0.05 level.

tion might be explained in two ways. First, as stated above, while the current estimates reported are based on a fixed input-output ratio (θ in equation 1), this fixed factor is periodically adjusted for beef and pork. For all other markets, however, more frequent adjustments are made to equation 1 to account for changing consumer expenditures. Second, a high correlation between the series may be attributed to the strong trends displayed by both series over the period. Such trends can mask important differences in the response of the two series to market changes.

Columns 2 and 3 of table 2 report estimates of correlation between *M* and *S* that attempt to control or remove these trends. Column 2 reports correlation estimates after both the mean and the trend are removed from both series.[13] It is noteworthy that Column 2 reports a negative or a statistically insignificant (at the 0.05 level) correlation between *M* and *S* for every market except beef.

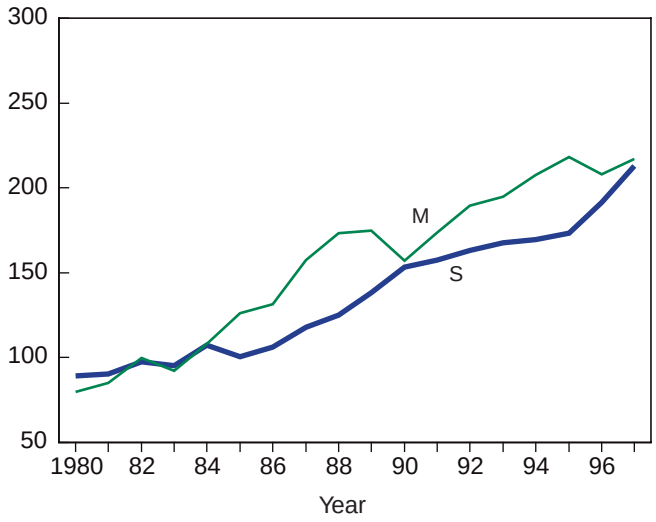
Column 3 reports correlation estimates between annual changes (i.e., first differences) in the series. Column 3 reports either a negative or a statistically insignificant correlation for every market except the beef, poultry, and fresh fruit markets. The results reported in columns 2 and 3 suggest that, with the exception of beef and possibly poultry and fresh fruit, the new estimates respond differently to changing market conditions than the current estimates.

In the previous section, we pointed out that expenditure-based measures of consumer demand lead to a precise measure of food quality that links directly to the new estimates. In particular, equation 2 suggests

[13]The residuals from of each series regressed against a constant and linear time trend are used to compute the correlation estimates.

Figure 11

Retail-farm price margins, eggs



that, conditioned on farm and retail prices, increases in quality translate into increases in *M*. Moreover, estimates of *S* based on a strictly fixed output-input parameter would not respond to changes in food quality.

Figures 15-28 graph the annual percent change in the current ERS estimates (*S*), the annual percent change in *M*, and the annual percent change in quality (*Q/F*). These graphs illustrate that changes in *M* appear to be more frequently "in-phase" with changes in quality over the sample period than do changes in *S*. In markets such as pork, changes in the current ERS estimate appear to be "out-of-phase" with changes in quality (figure 17). These results suggest that the new estimates of retail-farm price ratios are more sensitive to changes in food quality than the current ERS estimates.

Figure 12

Retail-farm price margins, dairy

1982-84=100

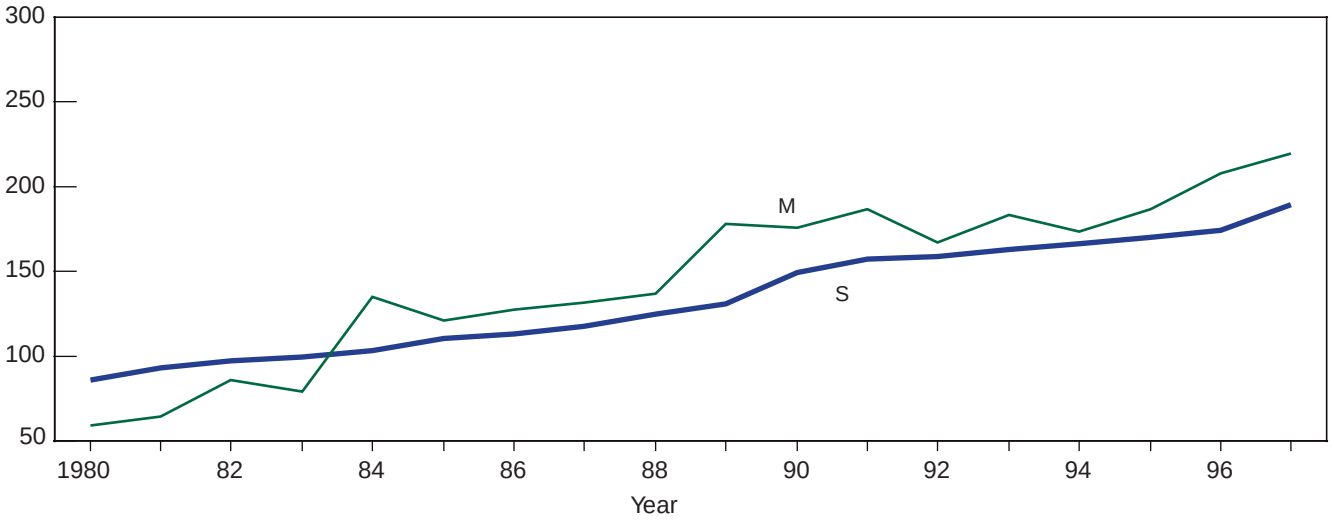


Figure 12b

Relative elementary prices, dairy

1982-84=1.0

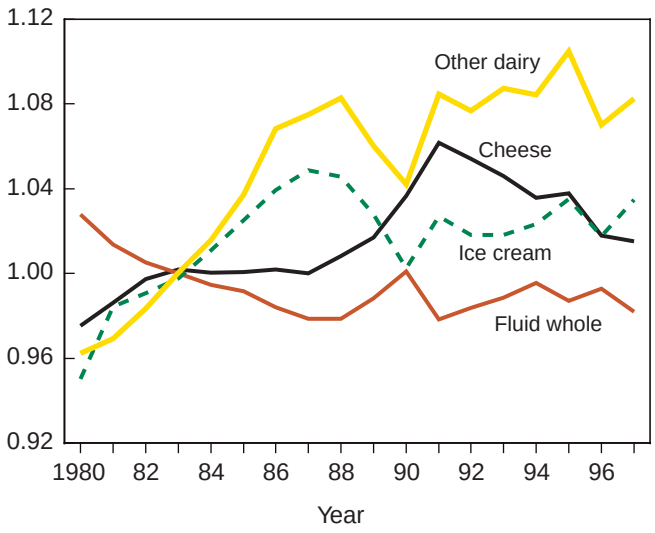


Figure 12c

Elementary output-input ratios, dairy

1982-84=1.0

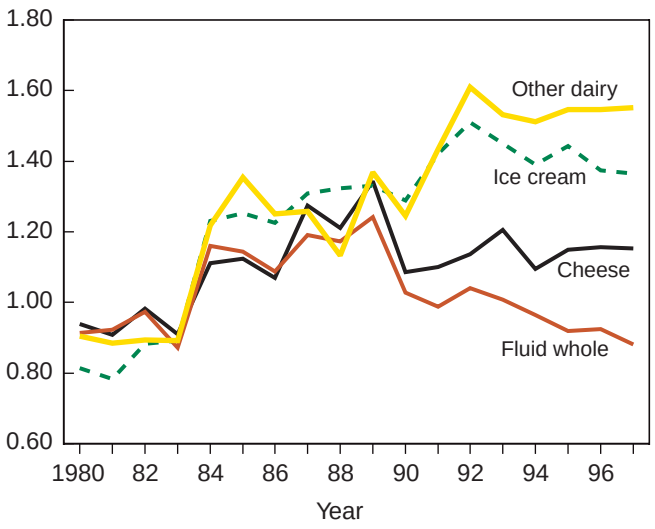


Figure 13

Retail-farm price margins, fresh fruit

1982-84=100

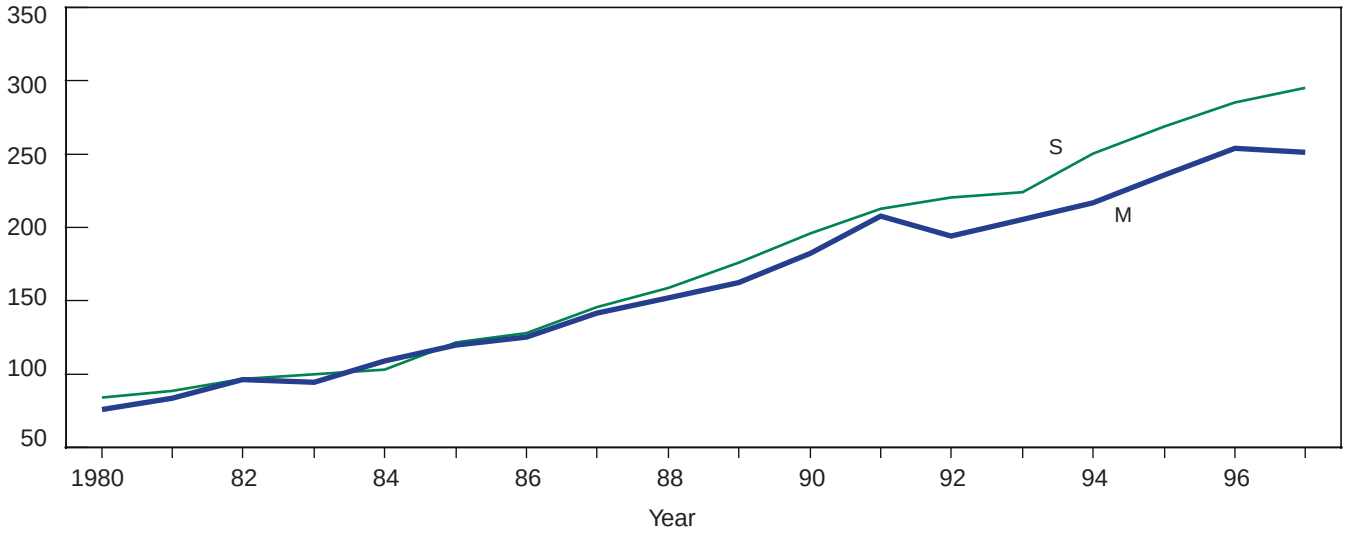


Figure 13b

Relative elementary prices, fresh fruit

1982-84=1.0

Figure 13c

Elementary output-input ratios, fresh fruit

1982-84=1.0

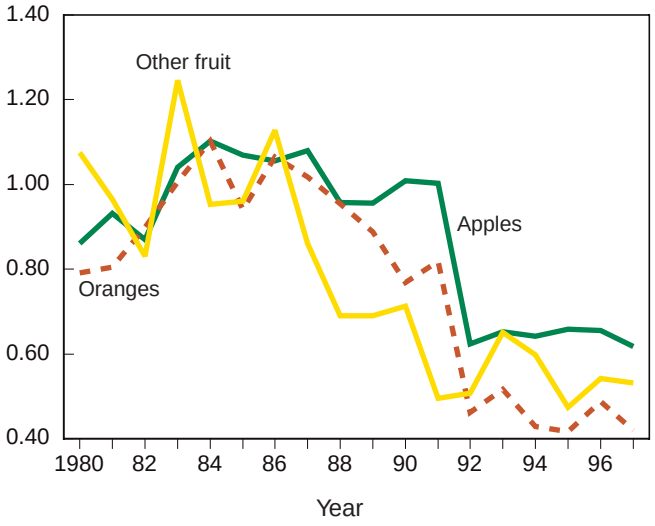


Figure 14

Retail-farm price margins, fresh vegetables

1982-84=100

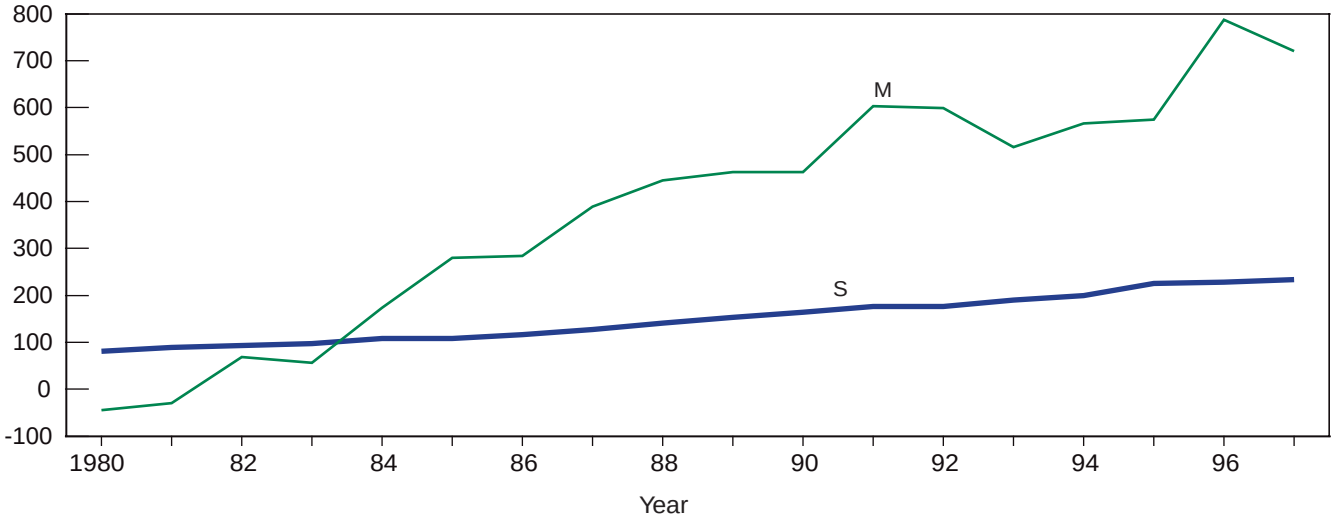


Figure 14b

Relative elementary prices, fresh vegetables

1982-84=1.0

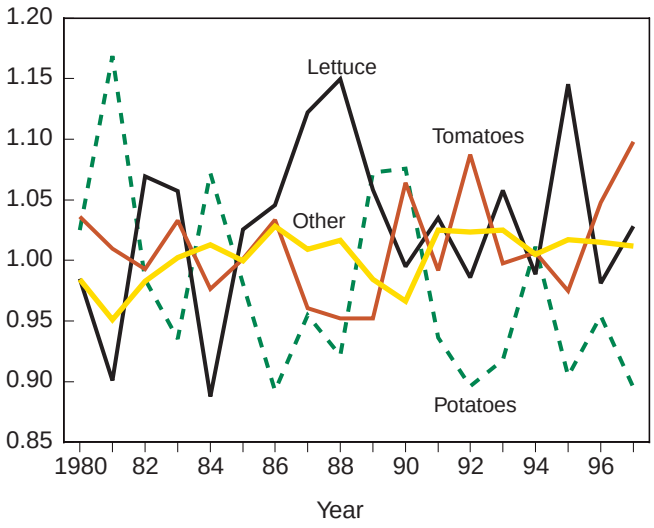


Figure 14c

Elementary output-input ratios, fresh vegetables

1982-84=1.0

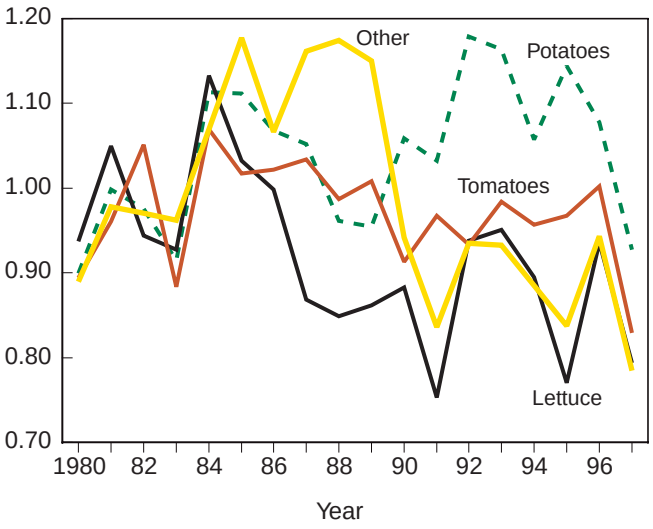


Figure 15

Percent change in S and quality, beef

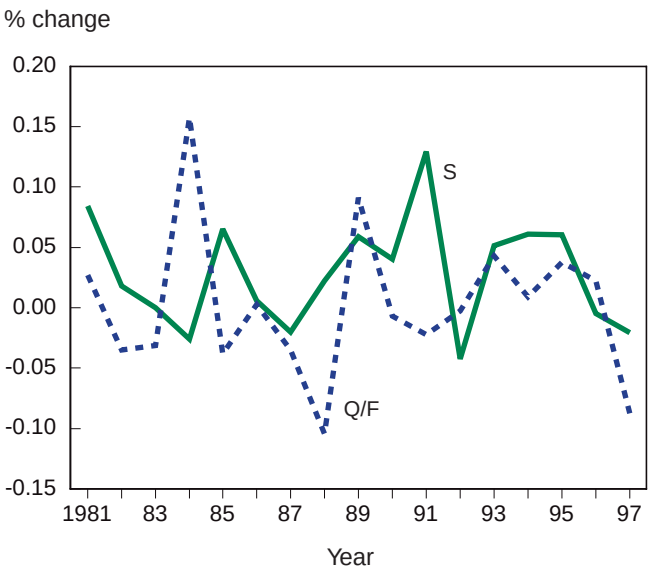


Figure 16

Percent change in M and quality, beef

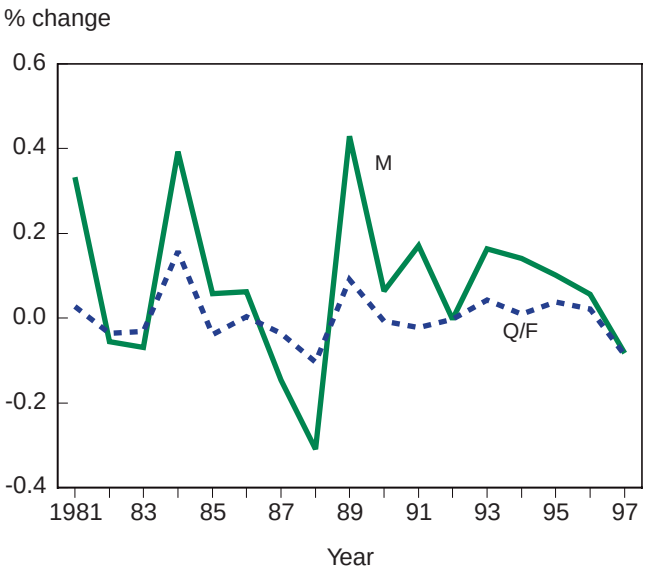


Figure 17

Percent change in S and quality, pork

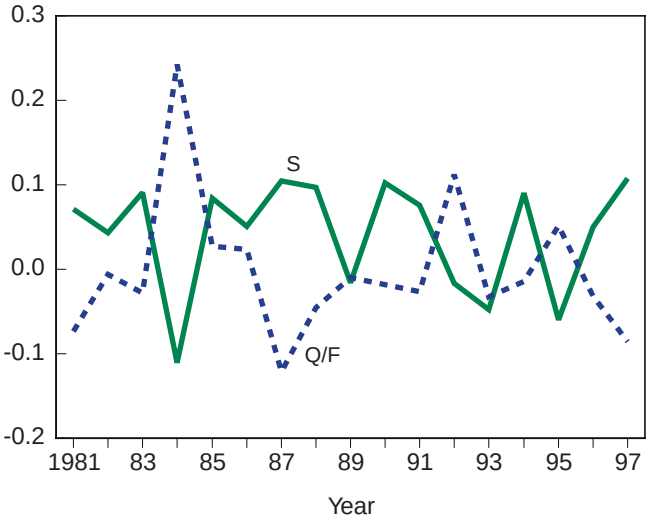


Figure 18

Percent change in M and quality, pork

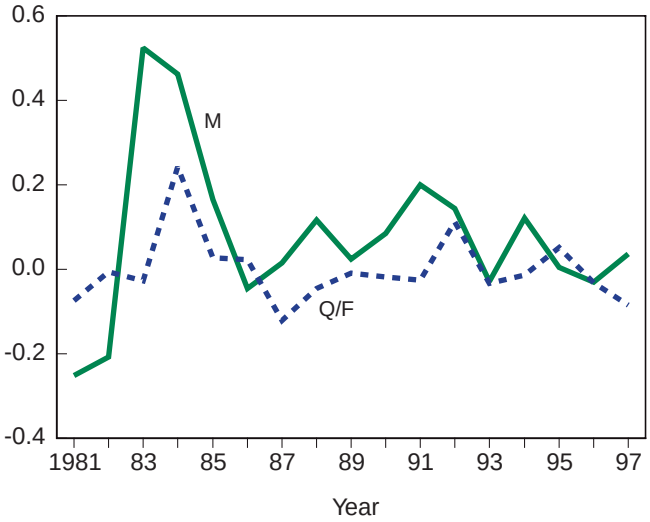


Figure 19

Percent change in S and quality, poultry

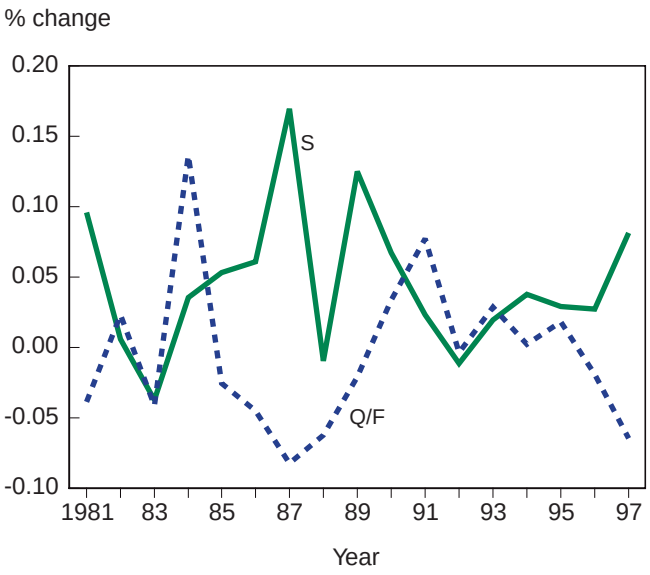


Figure 20

Percent change in M and quality, poultry

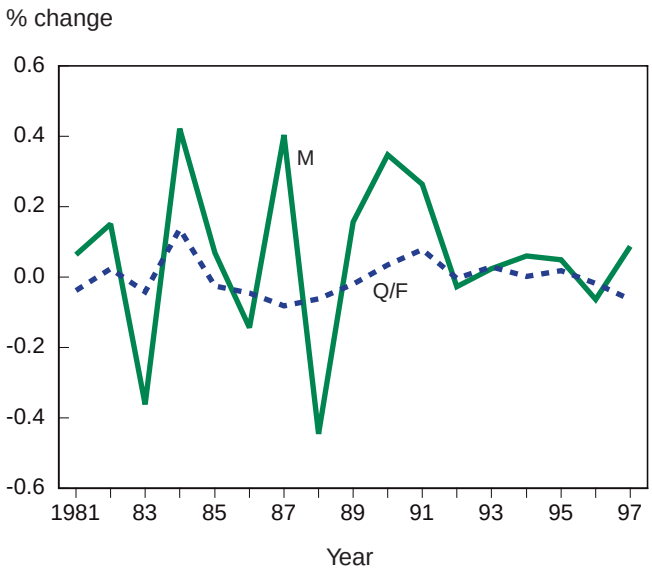


Figure 21

Percent change in S and quality, eggs

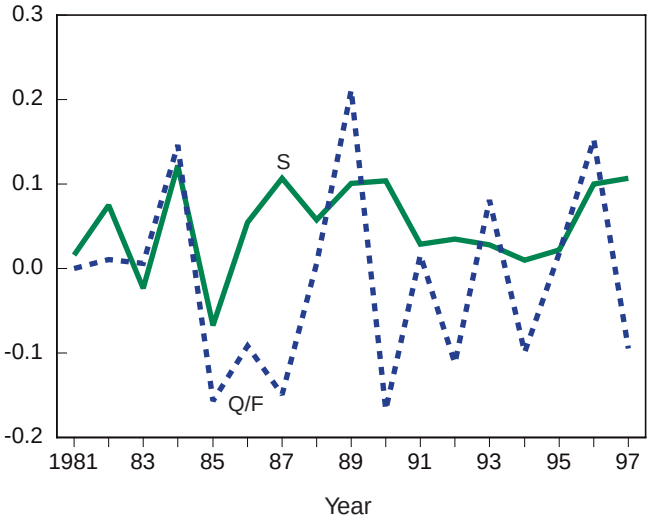


Figure 22

Percent change in M and quality, eggs

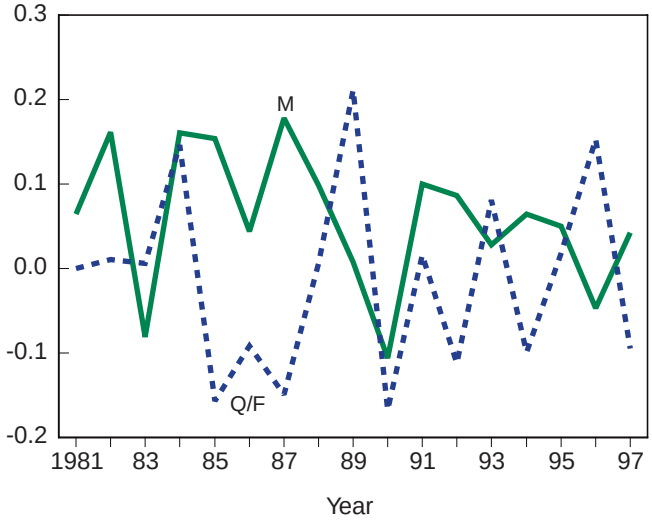


Figure 23

Percent change in S and quality, dairy

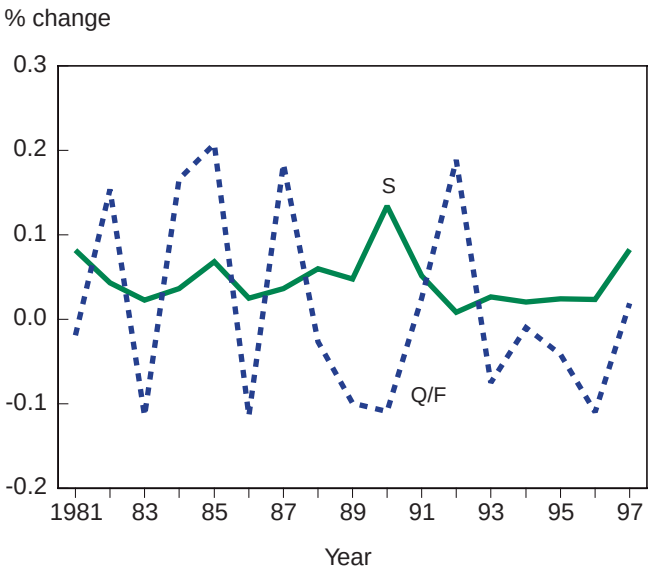


Figure 24

Percent change in M and quality, dairy

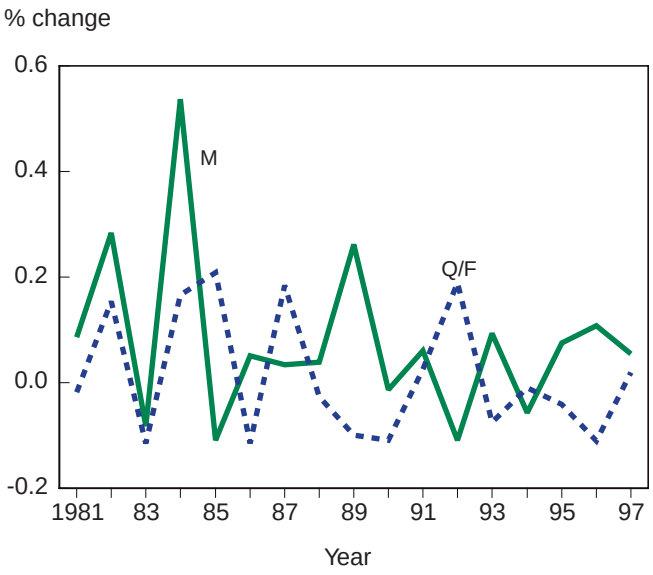


Figure 25

Percent change in S and quality, fresh fruit

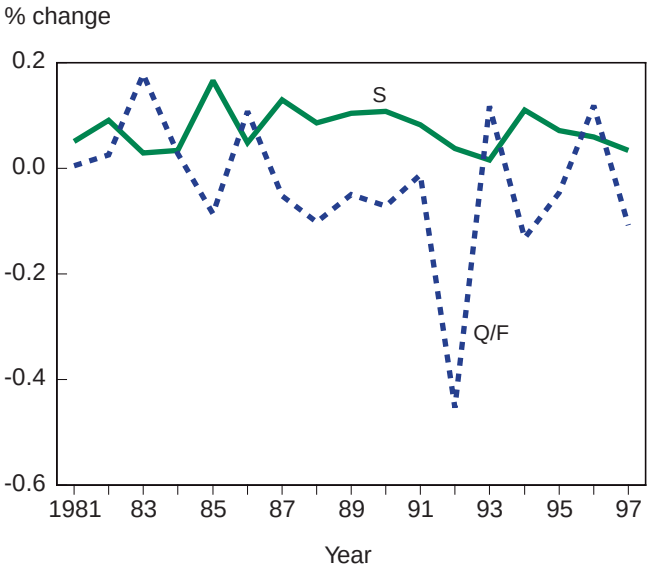


Figure 26

Percent change in M and quality, fresh fruit

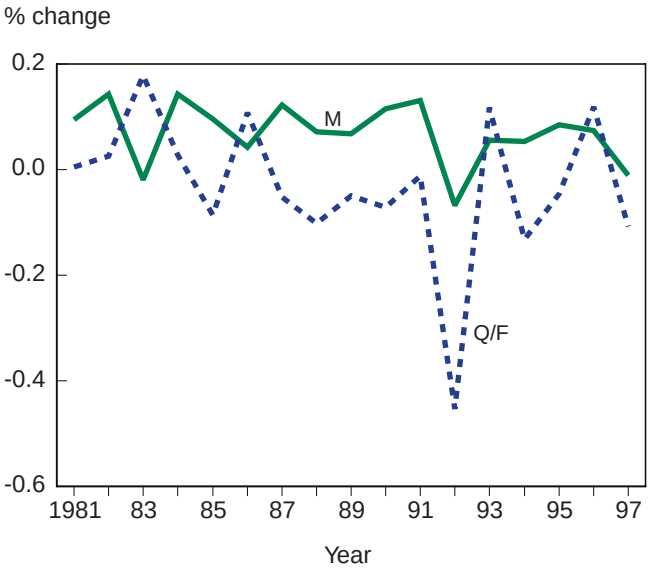


Figure 27

Percent change in S and quality, fresh vegetables

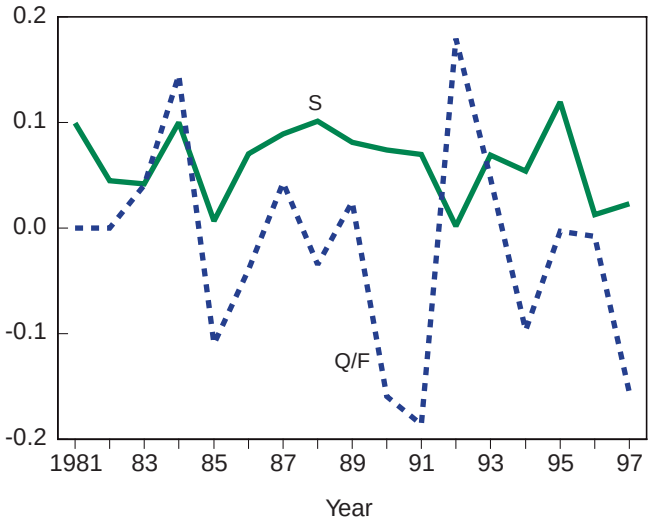


Figure 28

Percent change in M and quality, fresh vegetables