The Development of Index Futures Contracts for Fresh Fruits and Vegetables

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Abstract: *The fruit and vegetable industry does not have a risk management instrument or a well-structured price discovery system, such as commodity futures contracts, to aid in the marketing and management of its price risk. Since the 1980s, financial futures contracts based on indexes of stocks, commodities and currencies have been used to hedge these groups of assets. The purpose of this study was to apply the concept of index futures contracts to the produce industry by developing indexes based on prices of fruits and vegetables and to determine the hedging effectiveness of potential futures contracts written on these indexes. Twenty representative fruits and vegetables were chosen to compile indexes for fruits, for vegetables, and for fruits and vegetables together using a trade-weighted arithmetic average of 1989 to 1992 wholesale prices of selected commodities traded on the Dallas Wholesale Fruit and Vegetable Market. The indexes were then tested by simulating a short and long hedge of a portfolio of commodities and by cross hedging selected individual New Mexico and California produce commodities with the indexes.*

Key Words and Phrases: *Fruits, vegetables, futures markets, index futures contracts.*

Fresh Fruit and Vegetable Marketing

The marketing of fresh fruits and vegetables can be very chaotic as prices can and do rise and drop dramatically within a day or even minute by minute. Prices are usually established over the phone by buyers and sellers based on supply and demand in the market place for various grades, qualities, shipping points, delivery points and amounts. Market participants usually directly call various customers and contacts for market information and general market tone. Some market participants also use market news services such as the ones provided by the U.S. Department of Agriculture (USDA) and such private market news services as Pronet that disseminate market information via fax machine and mail. Additional information is also provided by trade associations.

There is no well-developed, accessible, public price discovery system for fresh fruit and vegetables such as a commodity futures market. To manage some of the price risk inherent in fruit and vegetable marketing, many fruit and vegetable marketers pre-sell a large portion of their produce. Many large shippers pre-sell approximately 10% to

30% of their produce a week or two before shipping. With these contracts, "shippers agree to sell a negotiated quantity at a future date at an f.o.b. price not to exceed a level agreed upon at the time of sale" (Colling et al., p. 5). Pre-selling provides buyers with upside price protection while ensuring the seller of a market outlet. Often produce is pre-sold in conjunction with a retail advertising promotion (Colling et al.).

The overall purpose of this paper is to develop and determine the feasibility of a potential index futures contract(s) for fresh fruits and vegetables. To determine the feasibility of index futures contracts for fresh produce, hypothetical produce indexes will be developed and the hedging effectiveness of potential futures contracts based on these indexes will be examined. The underlying hypothesis is that an index based on a well-diversified portfolio of fruit and/or vegetable commodities can be constructed to represent a broadly-defined market for fresh produce. Hence, a futures contract could be written on such an index, similar to how stock index futures are written on various stock indexes. Hypothetically, a futures contract based on this index could be used as a hedging vehicle by fresh produce producers, by purchasers such as supermarkets and by other elements of the marketing chain including wholesalers, shippers and cooperatives. In addition, the underlying index could provide the produce industry with an overall market performance indicator.

Agricultural Futures Markets

For many years the commodity futures markets have allowed producers and processors of grains, livestock and other commodities to hedge absolute price risk. But for several reasons, commodity futures markets have never been successfully developed for any fruit or vegetable except potatoes and a derivative commodity—frozen concentrated orange juice. For futures contracts on physical commodities to be successful, four conditions usually must exist: price uncertainty, large competitive markets, standardization and storability (Stoll and Whaley).

Since the primary purpose of futures markets is to provide hedging opportunities, uncertainty about price movements must exist. Uncertainty about prices stem from uncertainties about supply and demand conditions of commodities. Large and competitive markets are necessary to provide liquidity for the futures contract. A liquid futures market can only be maintained if there is also a large liquid cash market for the physical commodity. On the other hand, "futures markets could possibly enhance competition in a market that is not fully competitive" since the futures market "provides an alternative to dealing directly with the producer" (Stoll and Whaley, p. 78). In addition to a large and competitive market, the cash market for the underlying commodity needs to be one in which standardized units are available. Standardization of grades allows futures contracts to be easily traded. Storability and deliverability of the cash commodity have usually been considered mandatory for successful futures contracts. Because futures contracts call for delivery, the commodity must be storable so delivery may take place. However, many successful futures contracts written on non-storable commodities exist (i.e., live cattle) and cash settlement of futures contracts is common.

The ability to hedge is a very powerful price risk management tool. This risk management vehicle, however, has not been available to producers and marketers of fresh fruits and vegetables. To facilitate the hedging of the entire fruit and vegetable complex, futures contracts would have to be developed for several commodities, quite possibly as many as 22 major fruits and vegetables, among the 55 or so fruit and vegetable commodities commonly found in U.S. supermarkets. It would be difficult for such a large number of individual fruit and vegetable futures contracts to survive since many fruit and vegetable commodities have relatively small markets. Even the citrus market may not be large and competitive enough to facilitate futures trading despite the fact that citrus is the single largest U.S. fruit group in dollar value of sales. The lack of trading in fruit and vegetable futures markets would create liquidity problems, thus violating a major requirement for successful futures markets. Further, most fresh produce items have a limited storage life and must be sourced from various regions due to seasonality of production.

Index Futures

Since the early 1980s, the financial community has used index futures contracts written on popular stock market indexes such as the S&P 500 index. In addition, index futures contracts have been developed for a number of physical and financial commodities, such as the U.S. Dollar Index (USDX) which commenced trading on the FINEX Exchange in 1985, the Commodity Research Bureau's CRB Index (listed on the New York Futures Exchange in 1986) and the Goldman Sachs Commodity Index (GSCI) (listed on the Chicago Mercantile Exchange in 1992). Commodity indexes, in particular the GSCI, have received much attention in the past few years as futures exchanges continue to look for new and innovative futures contracts that could contribute to their trading volume (Ring). The popularity of index futures contracts is due primarily to these basic properties: (1) they are always cash settled, (2) they represent a hedging tool for a portfolio (few merchants deal only in one commodity) and (3) they avoid the trading volume and contract liquidity problems associated with one commodity or instrument contracts.

Index futures contracts allow flexibility with hedging. The most common hedging practice with index futures is portfolio hedging which involves hedging the systematic risk that remains after diversification of a portfolio of assets. Individual assets within the index may also be cross hedged. For cross hedging to be effective, there must be a significant correlation between the physical asset and the futures contract. Both of these hedging techniques are difficult to implement because of basis variability. In portfolio hedging, the matching of the cash portfolio to the futures portfolio is very important since a mismatch of the cash portfolio with the index can lead to basis risk greater than absolute price risk. If only a single asset is hedged using an index, the hedger may benefit from hedging the market risk aspect of the component; however, there is still considerable nonsystematic risk remaining since the single asset being hedged is not a diversified portfolio (Weiner). Index futures contracts are also used to participate in market moves before taking a position in the physical asset. This anticipatory hedge strategy is often used instead of taking actual cash positions because of the leverage properties of futures contracts. In addition, futures contracts on commodity indexes, such as the GSCI and CRB, are often used to hedge against inflation.

The manner in which an index is constructed is very important to its success. The individual or organization that develops the index gets to choose how that index is calculated. Three major considerations must be evaluated when developing an index since each can affect the index as a market performance indicator and, subsequently, the hedging performance of a potential futures contract: weighting, calculation procedure and composition (Weiner).

Most indexes use some form of weighting scheme to determine how much each component will make up the index. Value weighting, also known as capitalization weighting, is by far the most popular weighting scheme for index futures contracts. Value weighting multiplies the price of the index component by the number of units outstanding of the component in the market (Stoll and Whaley). For instance, the S&P 500, one of the most active index futures contracts, uses the number of common shares outstanding as the capitalization portion of the equation (price x common shares outstanding) while the Goldman Sachs Commodity Index uses world production statistics (price x world production). Value weighting gives more weight to assets with larger market capitalization, therefore it is easy to mimic because there is no need to rebalance a properly weighted portfolio (Krull and Rai). Trade weighting, which multiplies the price of the component by the percentage that the component represents in the market, is very similar to capitalization weighing since weights are based on the relative share of business of the components. Therefore, the components affect the index price to the same degree they affect the market. For many indexes, it is difficult to compute the exact market capitalization, therefore the relative importance of the component in the marketplace is used. For instance, the USDX uses the importance that individual currencies have in world trade as weights.

The calculation procedure used in developing the index is also important. While most indexes are arithmetically averaged, some are geometrically averaged. By far, arithmetic averaging is more commonly used than geometric averaging. Geometric averaging is complicated, which makes arbitrage and hedging difficult because "it is impossible to assemble a geometrically weighted cash portfolio" of components (New York Futures Exchange, p. 9).

The number of component assets used in the index should adequately reflect the market that the index is attempting to mimic. Surprisingly, a 1987 study done by

Hervey and Strauss which examined twelve trade-weighted indexes revealed that, for the most part, "neither the difference in weights nor the inclusion nor omission of certain countries materially affected their values" (Krull and Rai, p. 552). Despite the results of Hervey and Strauss, Stoll and Whaley discovered that composition did make a difference with stock indexes, but only slightly. They believe the reduction in standard deviation from the Dow Jones Industrial Average (DJIA) (1.6640) to the S&P 500 (1.5825) and, finally, to the New York Stock Exchange Composite Index (NYSE) (1.4916) "reflects increasingly higher degrees of diversification" (Stoll and Whaley, p. 106). The DJIA has 30 stocks, the S&P 500 has 500 and the NYSE has more than 1,500 (Stoll and Whaley).

Data

Secondary data were used in this research. To determine which produce items to include as components in a broad-based fruit and/or vegetable index, the Produce Marketing Association's (PMA) report, "Top Ten Fruits and Vegetables for 1991," was used. The top ten fruits and vegetables, based on national produce department sales, comprised approximately 65% of all produce sales in the nation for 1991. The PMA report listed the most popular varieties of these major fruit and vegetable commodities, but the report was primarily qualitative in nature and the sales data came from multiple, often conflicting, sources.

After using the PMA data to determine which produce items to include as components in sample produce indexes, the actual price data used in computing the indexes was collected from daily reports issued by the USDA Market News Service at the Dallas Wholesale Fruit and Vegetable Market for the years 1989 to 1992.[1] Each of the reports lists a daily high and low price for every produce commodity traded at the Dallas Market for various varieties, sizes, origin and grade (good quality unless otherwise stated).[2] Therefore, there were several prices listed for each commodity.

Because many prices were listed for each commodity, a single price was chosen that was deemed most representative for the particular commodity for that day. The selection criteria was based on the most representative variety, size and origin for the commodity. PMA information was used to determine the most representative variety of the produce commodities. Many times, however, the Market News Service would not distinguish between varieties of commodities since varietal differences were usually only seasonal (i.e., navel oranges in the fall/winter and Valencia oranges in the spring/summer). After determining the most representative variety, the most actively traded size of each commodity was chosen, based on the professional experience of the head market reporter at the USDA Market News Service at the Dallas Market. If more than one origin was listed, the origin selected was the one that had the most volume of shipment into the Dallas Market. The volume of shipment was based on the average truckloads shipped as indicated from yearly summary price reports for the

Dallas Wholesale Fruit and Vegetable Market. If prices were not quoted for a certain commodity, the last quoted price was used. Therefore, the most actively traded size and origin with the largest volume of shipment was assumed to be the most representative price for the commodity for the day. This iterative selection process resulted in 996 daily observations from 1989 to 1992 for twenty-five different fruit and vegetable commodities. Some of the major commodities were divided into subcategories including apples (red and golden), citrus (grapefruit, lemons, limes and oranges), grapes (red and green), potatoes (russet and red) and onions (yellow, red and white). The summary statistics of the sample data are provided in Table 1.[3]

F.O.B. price data were also collected from the USDA Market News Service for selected New Mexico and California grown commodities (New Mexico lettuce, New Mexico yellow onions, Eastern New Mexico russet potatoes, California tomatoes and California peaches). This data was eventually used to test the cross-hedging abilities of the various indexes. This data, however, was only reported for days in which the market was active enough to report a price, therefore, f.o.b. price data for the beginning and ending of a harvest season was sparse.

U.S. per capita consumption and average retail price per pound data for the various commodities used in the index were obtained from the USDA Economic Research Service (ERS) for 1989. This data (Table 3) was subsequently used in developing the weights for the hypothetical fruit and vegetable indexes. If ERS average price data was not available, the average 1989 Dallas Wholesale Market price was used. Subcategories of several major commodities (i.e., red and golden apples) were also used in the development of the index weights. Information on market breakdown percentages was provided by the respective associations: Washington Apple Commission, California Citrus Mutual, California Table Grape Commission, the National Onion Association and U.S.D.A. National Agricultural Statistics Service (potatoes). These trade associations, however, lacked hard data on the market breakdown of their respective commodities, therefore their estimates were used.

Construction of Fruit and Vegetable Indexes

In this study, three produce indexes were calculated: one for fruits, one for vegetables and one for both fruits and vegetables combined. For several reasons, a trade-weighted arithmetic index formula was chosen to compute these three indexes. First, the fruits and vegetables used in the composition of this index represent approximately 65% of all fruit and vegetable sales according to the PMA. Secondly, the formula used to calculate these indexes is similar to the most active and successful index futures contract, the S&P 500. Even though the S&P 500 and its cousins are constructed as capitalization weighted indexes, trade weighting is similar since the weights affect the index price to the same degree they affect the market. In addition, the use of arithmetic averaging in the construction of these indexes makes it easy to

Table 1.
Descriptive Price Statistics for Dallas Market Sample Data[a]

	Unit	Mean	Standard Deviation	Minimum	Maximum
		---------- dollars per unit	----------		
Fruit					
Bananas	40-lb. carton	12.25	2.38	8.75	20.00
Red Apples	40-lb. box	14.43	3.39	8.75	26.75
Golden Apples	40-lb. box	20.00	2.99	13.25	28.75
Grapefruit	40-lb. carton	11.96	2.27	7.25	17.75
Lemons	40-lb. carton	18.95	3.62	10.25	28.25
Limes	40-lb. carton	15.58	10.40	6.50	66.00
Green Grapes	lug	15.91	4.73	8.63	38.75
Red Grapes	lug	15.73	4.39	10.25	39.50
Oranges	40-lb. carton	16.01	5.94	10.50	29.00
Cantaloupes	18-melon crate	14.65	5.39	5.13	28.75
Strawberries	12 1-pt. baskets	11.62	3.76	5.13	28.50
Watermelons	pound	0.17	0.07	0.06	0.48
Vegetables					
Russet Potatoes	50-lb. sack	10.48	2.92	6.50	19.00
Red Potatoes	50-lb. sack	15.06	3.86	7.88	30.50
Lettuce	24-head carton	10.05	3.08	6.50	25.50
Tomatoes	25-lb. carton	11.65	6.22	5.75	36.50
Yellow Onions	50-lb. sack	9.53	3.12	5.75	24.00
White Onions	50-lb. sack	15.23	6.40	7.25	43.75
Red Onions	50-lb. sack	9.57	3.03	6.09	24.00
Carrots	50-lb. sack	12.67	4.20	6.75	25.50
Broccoli	14-head carton	9.52	2.40	6.38	22.50
Peppers	1/9 bu. carton	14.09	5.36	7.50	39.25
Cucumbers	1/9 bu. carton	14.80	4.26	8.13	28.13
Spinach	24-bunch carton	10.42	1.65	7.75	15.00
Celery	3 dozen	11.97	2.65	8.25	20.00

[a]966 observations used.

compute, thus increasing the potential use of these indexes for hedging and arbitrage purposes. For these reasons, a trade-weighted arithmetic index should provide the best chance for these indexes to be accurate performance indicators for the fresh produce industry. The formula for each of the three indexes is:

$$I_t = \frac{\sum_{i=1}^{N} P_{it} W_{it}}{Divisor_0} X\ 100 \tag{1}$$

where:

- N = the number of commodities in the index
- P_{it} = average price of commodity i at time t
- W_{it} = weight assigned to particular commodity at time t
- $Divisor_0$ = Base period value (base period = 1989)

$$Divisor_0 = \sum_{i=1}^{N} P_{i0} W_{i0} \tag{2}$$

Prices were compiled from the USDA Market News Reports from the Dallas Wholesale Fruit and Vegetable Market (Table 1). The base year for all three indexes was the 1989 average of all daily values (the sum of the individual commodity prices multiplied by their respective weights). For the years 1990 to 1992, the index value represents, in percentage terms, how produce prices performed relative to the base year 1989, thus the indexes represent a performance benchmark for the produce industry based on 1989 prices.

The weighting scheme used for the various indexes attempted to account for both quantity and price of the underlying component commodities. U.S. per capita consumption of each commodity was used as the quantity figure. This value was then multiplied by the U.S. average retail price per pound. The dollar values for each commodity (volume x price) were summed and the value proportion weights were calculated for each commodity. These weights are presented in Table 2. Since the average index value for 1989 is the base year value for each of the indexes, the index value oscillates around the 100 level.

For a futures contract to be listed, and subsequently for futures contracts being cash settled from such an index number, the index would have to be well recognized in the industry (e.g., the S&P 500 stock index). Depending on the contract specifications of a potential futures contract, the index should be based on the prices of commodities from various terminal markets, not Dallas alone. For instance, the Chicago Mercantile Exchange's (CME) new Lean Hog futures contract is cash settled based on a broad-based lean hog index. This index, developed by the CME, is

Table 2.
Calculation of Fruit, Vegetable, and Fruit & Vegetable Weighting Schemes

Commodity	Volume	Price	Value	Separate	Combined
Bananas	24.7	0.449	11.09	20.1	9.3
Apples (total)	20.5	0.688			
red (73%)	15.0	0.688	10.30	18.7	8.6
golden (27%)	5.5	0.688	3.81	6.9	3.2
Other Citrus					
grapefruit	6.4	0.525	3.36	6.1	2.8
lemons	2.3	0.995	2.29	4.2	1.9
limes	0.7	0.370	0.26	0.5	0.2
Grapes (total)	7.2	1.205			
green (60%)	4.3	1.205	5.21	9.4	4.4
red (40%)	2.9	1.205	3.47	6.3	2.9
Oranges	11.8	0.558	6.58	11.9	5.5
Cantaloupes	9.5	0.330	3.14	5.7	2.6
Strawberries	3.0	1.296	3.89	7.1	3.3
Watermelons	12.3	0.140	1.72	3.1	1.4
Total Fruit	98.4		55.11	100.0	
Potatoes (total)	48.0	0.342			
russet (80%)	38.4	0.342	13.13	20.5	11.0
round reds (20%)	9.6	0.342	3.28	5.1	2.8
Lettuce	26.8	0.605	16.21	25.3	13.6
Tomatoes	14.3	0.912	13.04	20.3	10.9
Onions (total)	13.9	0.361			
yellow (89%)	12.4	0.361	4.47	7.0	3.7
white (7%)	1.0	0.361	0.35	0.5	0.3
red (4%)	0.6	0.361	0.20	0.3	0.2
Carrots	7.6	0.136	1.03	1.6	0.9
Broccoli	3.5	0.390	1.37	2.1	1.1
Peppers	4.3	0.962	4.14	6.5	3.5
Cucumbers	4.4	0.656	2.89	4.5	2.4
Spinach	0.6	0.500	0.30	0.5	0.3
Celery	7.0	0.531	3.72	5.8	3.1
Total Vegetables	130.4		64.13	100.0	
Total Fruit & Vegetables	228.8		119.24		100.0

Notes: Volume is 1989 per capita in pounds; price is 1989 average price per pound; value is volume times price; Separate is value proportion weights of fruit in percentage; Combined is value proportion weights of fruits and vegetables in percentage.

comprised of individual indexes from various USDA reporting regions throughout the hog producing regions of the country.

Initially, two other weighting schemes based on the PMA sales data were also examined. However, the weighting scheme in Table 2, using the per capita consumption data and average U.S. retail prices, was the only weighting scheme used for the hedging simulations since accounts for both price and quantity. The other two weighting schemes initially tested were only based on total sales. All of the indexes had similar patterns of movement regardless of the weighting scheme used. This supports Hervey and Strauss' 1987 conclusion that differences in the weighting of an index do not materially affect their values. Within the hedging examples that follow, the calculated index price is assumed to be the futures price.

Hedging a Portfolio of Fruits and Vegetables: A Short-Hedge Example

The hypothetical short hedge assumes that the hedger is a marketer of fresh produce, most likely a wholesaler or a wholesale buying unit for a supermarket chain, who desires to take possession of produce commodities and then attempt to sell the produce to retailers at a later date (Table 3). The wholesaler is concerned that produce prices may fall between the time the produce is purchased and the time when the produce is sold to a retailer. This scenario assumes that the wholesaler acquires a variety of fruits and vegetables on April 1, 1992, worth approximately $50,000. The wholesaler has purchased this produce in an attempt to mimic the composition of the fruit/vegetable index and has thus purchased commodities in the same proportion as the index weights. The fruit/vegetable index value on April 1, 1992, is 126.23. Anticipating that the value of this portfolio could decrease before it is sold to the retailer, the wholesaler hedges the portfolio. On April 1, 1992, the wholesaler sells enough fruit/vegetable index futures contracts at 126.23 to cover the $50,000 portfolio.[4] Since the wholesaler has perfectly mimicked the index, the value of his cash portfolio is also 126.23 on April 1, 1992. The value of 126.23 is acquired by taking the sum of the contributions of each of the components and dividing it by the base year value 1989 = 12.02.

The wholesaler subsequently sells the portfolio on April 10, 1992. As seen in this example, the value of some of the cash portfolio components have changed. Overall, the value of the portfolio has decreased from $50,000 to $46,626—a loss of $3,374 from the original value of the portfolio. On the date of the sale, the wholesaler simultaneously buys back the futures contracts at 111.62. The value of the cash portfolio decreased by 6.75% and the index moved in the same direction by 11.57%. Since the cash portfolio was exactly compiled to mimic the fruit/vegetable index, a perfect hedge has taken place. Both the cash portfolio and the index fell by 11.57% (sum of the cash portfolio index contribution/base year 1989=12.02).

Table 3
Hedge for a Portfolio of Produce Commodities

			Cash Market					
Fruit or Vegetable	Units	Weight	Dollar Value[a]	Price/ Unit[a]	Index Contribution[a]	Dollar Value[b]	Price/ Unit[b]	Index Contribution[b]
Bananas	361	9.30	4,650	12.88	1.20	4,289	11.88	1.10
Red Apples	248	8.63	4,315	17.38	1.50	4,407	17.75	1.53
Golden Apples	70	3.19	1,595	22.75	0.73	1,595	22.75	0.73
Grapefruit	120	2.82	1,410	11.75	0.33	1,410	11.75	0.33
Lemons	58	1.92	960	16.50	0.32	960	16.50	0.32
Limes	7	0.22	110	15.13	0.03	110	15.13	0.03
Green Grapes	163	4.37	2,185	13.38	0.58	2,185	13.38	0.58
Red Grapes	98	2.91	1,455	14.88	0.43	1,455	14.88	0.43
Oranges	251	5.52	2,760	11.00	0.61	2,760	11.00	0.61
Cantaloupes	58	2.63	1,315	22.75	0.60	853	14.75	0.39
Strawberries	105	3.26	1,630	15.50	0.51	1,130	10.75	0.35
Watermelons	2,571	1.44	720	0.28	0.00	771	0.30	0.00
Russet Potatoes	847	11.01	5,505	6.50	0.72	5,505	6.50	0.72
Round Red Potatoes	87	2.75	1,375	15.75	0.43	1,375	15.75	0.43
Lettuce	907	13.61	6,805	7.50	1.02	6,805	7.50	1.02
Tomatoes	176	10.94	5,470	31.00	3.39	3,264	18.50	2.02
Yellow Onions	90	3.75	1,875	20.75	0.78	2,169	24.00	0.90
White Onions	5	0.29	145	28.50	0.08	151	29.75	0.09
Red Onions	5	0.17	85	17.00	0.03	120	24.00	0.04
Carrots	40	0.87	435	11.00	0.10	435	11.00	0.10
Broccoli	42	1.14	570	13.50	0.15	380	9.00	0.10
Peppers	70	3.47	1,735	24.88	0.86	1,735	24.88	0.86
Cucumbers	67	2.42	1,210	18.13	0.44	1,077	16.13	0.39
Spinach	11	0.25	125	11.50	0.03	125	11.50	0.03
Celery	160	3.12	1,560	9.75	0.30	1,560	9.75	0.30
Portfolio value		100.00	50,000			46,626		
Index value[c]					126.23			111.60

[a] 4/1/92.
[b] 4/10/92.
[c] Sum of index contribution/(base year = 12.02) x 100.

Hedging a Portfolio: A Long-Hedge Example

If a wholesaler has promised a specific quantity of produce for delivery at a future date, the wholesaler is concerned that prices will rise between the time the order was placed and the time of purchase and delivery. In this case, the wholesaler would take a long position in the futures market on April 1, 1992, the date that order was made. In the meantime, the wholesaler would source the produce. Delivery would take place on April 10, 1992, and subsequently the futures position would be offset by selling the appropriate number of futures contracts. In this scenario, the wholesaler would have actually had a gain in the cash market of 6.75% (11.57% if the cash portfolio is converted into the index value) and a loss in the futures market of 11.57% since the value of the portfolio decreased. If the wholesaler has exactly mimicked the index, any gains in the cash market would have been equally offset in the futures market (a perfect hedge). Therefore, by long hedging, the wholesaler would have been protected if the price of the produce commodities in the portfolio would have risen before delivery took place.

Implications of Hedging a Portfolio of Produce Commodities

The success of hedging a portfolio of produce commodities depends heavily on how the cash portfolio is constructed. Since the cash market portfolios in these examples exactly matched the fruit/vegetable index, perfect hedges took place. By holding a diversified portfolio of produce commodities, the nonsystematic risk of the components is virtually diversified away. Obviously the assumption that the wholesaler compiles produce commodities to exactly mimic the index is a strong one. However it is an appropriate assumption for this initial study since the component fruits and vegetables in the index are the most representative in the market and the weights ultimately reflect purchases by consumers (retail average price and per capita consumption) and subsequently supermarket purchases of produce. This assumption, however, was used merely to simplify the examples for this initial study and to show how a potential index futures contract could be used.

In real life situations, it would be very difficult to exactly mimic an index. Therefore, there will be increased basis variability if the cash portfolio does not exactly match the index. Marketers of produce who would use an index instrument such as the fruit/vegetable index would need to make sure the cash portfolio closely follows the index in order to prevent basis risk (value of cash portfolio - index value) being greater than the absolute price risk. If basis risk is greater than absolute price risk, then it is actually detrimental to hedge since losses in the cash market would also be realized in the futures market. Therefore, it would be difficult for small wholesalers who may not deal in all the commodities to use an index futures contract on fresh produce since their business would most likely not be represented by the index.

Cross Hedging

In addition to being used as a way of protecting the value of a portfolio of produce commodities, produce indexes might also be used as a vehicle for cross hedging. Cross hedging is merely the process of hedging a particular commodity with a futures contract that is different. More important than the physical similarities or differences between the cash commodity and the futures contract is the degree to which the cash and futures prices move together. According to Anderson and Danthine (p. 1189), "cross hedges are in order whenever the cash/futures correlation is a constant different from zero." Therefore, if the price relationship between the individual commodities in the produce indexes move together with the indexes in such a manner to yield correlation coefficients significantly different from zero, cross hedging may be possible. This would aid growers of produce commodities, especially growers of single commodities, in the marketing of their products by providing an opportunity to protect the value of their crops against falling prices, thus decreasing the variance of revenues.

To determine the cross-hedging abilities of the produce indexes, simple Pearson correlation coefficients (Dowdy and Weardon) were calculated between the cash price at Dallas of the underlying index components and the index values for the years 1989 to 1992. These correlation coefficients, along with confidence intervals, are shown in Tables 4 and 5. Most of the calculated correlation coefficients are statistically significant at the alpha = 0.0001 level. This shows that the underlying cash prices and the index prices tend to move together (either positively or negatively) over the four-year period from 1989 to 1992. The statistically significant correlations give rise to the possibility of cross hedging individual components of the indexes with the indexes themselves.[5] The correlations between the component cash prices and the fruit/vegetable combination indexes appear to reflect a combination of the rho values for the cash fruit/fruit index and cash vegetable/vegetable index.

In addition, regression equations were estimated to test the relationship between cash prices of the various individual commodities and the respective index values. The model tested was:

$$P_{it}=\beta_0+\beta_1 I_{kt} \qquad (3)$$

where:

P_{it} = average price of commodity i at time t
I_{kt} = index value k at time t.

Table 4.
Correlation Coefficients and Confidence Intervals Between Individual Fruits and Indexes for 1989-92 (Prob>rho Under Ho: Rho=0)

	Fruit Index			F & V		
Fruit	Correlation	CI at 95%		Correlation	CI at 95%	
Bananas	0.473	0.422	0.515	0.603		
Red Apples	0.574	0.530	0.611	0.230	0.168	0.291
Golden Apples	0.439	0.388	0.485	0.232	0.168	0.291
Grapefruit	0.062	0.000	0.119	0.033	-0.030	0.090
Lemons	0.353	0.291	0.405	0.231	0.168	0.291
Limes	0.137	0.080	0.197	0.188	0.129	0.245
Green Grapes	0.378	0.327	0.430	0.260	0.197	0.319
Red Grapes	0.409	0.354	0.462	0.266	0.207	0.327
Oranges	0.745	0.711	0.766	0.334	0.273	0.388
Cantaloupes	0.333	0.273	0.388	0.366	0.319	0.422
Strawberries	0.183	0.119	0.235	0.136	0.080	0.197
Watermelons	0.324	0.264	0.371	0.443	0.388	0.485

Theoretically, the estimated beta (β_1) value provides the hedging ratio (the percentage of the cash position that should be hedged with the index futures contract). That concept has previously been applied to the futures price, not the index value as done here. Since no futures price actually exists, we assumed the index was the futures price. The R^2 values from these regression equations provide a measure of the expected effectiveness of the cross hedge (Leuthold et al.). The results of these regression equations are reported in Table 6 along with statistics for the two specific examples used in the following sections. These statistical results should be viewed as only an initial indication of the hedging potential of such a contract.

Cross Hedging: A New Mexico Example. To illustrate the potential use of the produce indexes for cross hedging, hypothetical cross hedges were constructed using f.o.b. prices for selected New Mexico produce crops. Simple Pearson correlation coefficients were calculated between the New Mexico f.o.b. cash prices and the value of the indexes for the years 1989 to 1992. Correlations were calculated between each commodity and the fruit, vegetable and fruit/vegetable indexes. Several of the correlations were significant at the alpha = 0.0001 level illustrating potential for cross hedging. The correlations were calculated only for the time window in which New Mexico f.o.b. prices were reported (during the harvest season). Correlation coefficients were also calculated for each year individually to help illustrate the movement of the f.o.b. cash price and the index values during these very short time

Table 5.
Correlation Coefficients and Confidence Intervals Between Individual Vegetables and Indexes for 1989-92 (Prob > rho Under Ho: Rho = 0)

	Vegetable Index			F & V		
	Correlation	CI at 95%		Correlation	CI at 95%	
Russet Potatoes	0.229	0.168	0.291	-0.027	-0.090	0.030
Round Reds Potatoes	0.332	0.273	0.388	0.266	0.207	0.327
Lettuce	0.302	0.245	0.354	0.275	0.226	0.336
Tomatoes	0.791	0.762	0.811	0.673	0.635	0.701
Yellow Onions	0.429	0.380	0.478	0.417	0.371	0.470
White Onions	0.281	0.226	0.336	0.387	0.336	0.438
Red Onions	0.122	0.060	0.178	0.092	0.030	0.149
Carrots	0.226	0.178	0.300	0.401	0.345	0.454
Broccoli	0.016	-0.040	0.080	0.125	0.060	0.178
Peppers	0.698	0.664	0.731	0.640	0.604	0.675
Cucumbers	0.428	0.380	0.478	0.385	0.327	0.430
Spinach	0.032	-0.030	0.090	0.185	0.129	0.245
Celery	0.341	0.282	0.397	0.253	0.188	0.310
New Mexico Onions[a]	0.352	0.245	0.454	0.254	0.139	0.363
California Tomatoes[a]	0.244	0.149	0.327	0.010	-0.080	0.110

[a]In forming the correlations and confidence intervals, 996 observations were used for all commodities except New Mexico onions (278 observations) and California tomatoes (423 observations).

periods. Cross hedges were simulated for the New Mexico yellow onion crop for the years 1990 to 1992. In all cases, the hedge was assumed to be placed on the first day that f.o.b. prices for New Mexico yellow onions were listed by the USDA Market News Service. The hedge was lifted on the last day that f.o.b. prices were listed. This assumes the producer would be selling the crop on the last day that prices were reported. The grower is concerned that prices may decline between the beginning and the end of the harvest season and therefore hedges the position using the produce indexes. Table 7 shows the results of these hedges while the results of the hedging ratio regression equations are shown in Table 6.

Hedging in 1990 would have resulted in losses in the cash market and in the index futures market because the cash and index prices did not follow each other. In 1991, however, an onion grower would have benefitted from hedging since the average New Mexico yellow onion price declined by 34.38% from June 10, 1991, to August 26, 1991, and the vegetable index price decreased by 42.02% while the fruit/vegetable

Table 6.
Hedging Ratios Between Individual Components and Indexes for 1989-92[a]

	Fruit or Vegetable			F & V		
Commodity	β	SE	R^2	β	SE	R^2
Bananas	0.085	0.005	0.224	0.127	0.005	0.363
Red Apples	0.146	0.007	0.329	0.069	0.009	0.053
Golden Apples	0.099	0.006	0.193	0.062	0.008	0.054
Grapefruit	0.011	0.005	0.004	0.007	0.006	0.001
Lemons	0.096	0.008	0.124	0.074	0.010	0.054
Limes	0.107	0.025	0.019	0.173	0.029	0.034
Green Grapes	0.134	0.010	0.143	0.109	0.013	0.067
Red Grapes	0.135	0.010	0.167	0.103	0.012	0.071
Oranges	0.332	0.009	0.555	0.176	0.016	0.112
Cantaloupes	0.135	0.012	0.111	0.175	0.014	0.134
Strawberries	0.052	0.009	0.033	0.045	0.010	0.019
Watermelons	0.002	0.000	0.106	0.003	0.000	0.195
Russet Potatoes	0.039	0.005	0.052	0.007	0.008	0.001
Round Red Potatoes	0.075	0.007	0.110	0.091	0.010	0.071
Lettuce	0.054	0.005	0.091	0.075	0.008	0.076
Tomatoes	0.287	0.007	0.626	0.370	0.013	0.453
Yellow Onions	0.078	0.005	0.184	0.115	0.008	0.174
White Onions	0.105	0.011	0.079	0.219	0.017	0.150
Red Onions	0.022	0.006	0.015	0.025	0.009	0.008
Carrots	0.005	0.008	0.051	0.149	0.011	0.161
Broccoli	0.002	0.004	0.000	0.026	0.007	0.016
Peppers	0.218	0.007	0.487	0.304	0.012	0.410
Cucumbers	0.106	0.007	0.183	0.145	0.011	0.148
Spinach	0.003	0.003	0.001	0.027	0.005	0.034
Celery	0.053	0.005	0.116	0.059	0.007	0.064
New Mexico Onions	0.063	0.011	0.124	0.057	0.015	0.064
California Tomatoes	0.043	0.008	0.059	0.002	0.013	0.000

[a]Hedging ratio (β), standard error (SE) of the regression coefficient, and R^2 value of the regression equation.

Table 7.
Cross Hedges for New Mexico Yellow Onions

	Cash	Futures			
	Cash Price	Vegetable Index		Fruit/Vegetable Index	
1990 hedges	($/sack)				
6/5/90	$7.00	Sell @	85.85	Sell @	95.93
8/24/90	$4.50	Buy @	97.80	Buy @	103.40
Absolute change	($2.50)		11.95		7.47
% change	-35.71%		13.92%		7.79%
1991 hedges					
6/10/91	$8.00	Sell @	131.61	Sell @	131.97
8/26/91	$5.25	Buy @	76.31	Buy @	100.32
Absolute change	($2.75)		-55.30		-31.65
% change	-34.38%		-42.02%		-23.98%
1992 hedges					
6/4/92	$5.00	Sell @	83.51	Sell @	93.80
8/7/92	$7.50	Buy @	107.66	Buy @	108.61
Absolute Change	$2.50	Buy @	24.15	Buy @	14.00
% change	50.00%		28.92%		15.79%

index decreased by 23.98%. In 1992, the cash and the index prices did move together, illustrating a potential hedging opportunity. However, in this situation (when the cash price increased), an onion grower would ideally not want to be hedged since the gains in the cash market would be offset by losses in the index futures market. However, if the position was hedged with the proper quantity of index futures contracts, the cash equivalence of the initial $5.00/sack price of the crop could have been protected reducing the variance of the final price received. Overall, this example shows there was positive directional movement between New Mexico yellow onion prices and the vegetable and fruit/vegetable indexes, suggesting possible successful cross hedging of New Mexico yellow onions.

Cross Hedging: A California Example. Hypothetical cross hedges were also conducted for two selected California grown commodities to test the cross hedging effectiveness of California commodities with the produce indexes since the produce indexes in this study are calculated from wholesale prices at the Dallas Wholesale Fruit and Vegetable Market. California tomatoes were selected for the test because of the strong correlations this component has with the vegetable and fruit/vegetable

Table 8.
Cross Hedges for California Tomatoes (1990-92)

	Cash	---------- Futures	----------	----------	----------
	Cash Price	Vegetable Index		Fruit/Vegetable Index	
1990 hedges	($/carton)				
6/4/90	$5.00	Sell @	86.50	Sell @	98.79
11/9/90	$4.50	Buy @	106.53	Buy @	105.35
Absolute change	($0.50)		20.03		6.56
% change	-10.00%		23.16%		6.64%
1991 hedges					
6/25/91	$11.00	Sell @	132.66	Sell @	134.52
11/7/91	$5.50	Buy @	116.15	Buy @	124.19
Absolute change	($5.50)		-16.51		-10.33
% change	-50.00%		-12.45%		-7.68%
1992 hedges					
6/8/92	$5.50	Sell @	84.65	Sell @	96.07
11/19/92	$6.00	Buy @	87.49	Buy @	95.30
Absolute Change	$0.50	Buy @	2.84	Buy @	-0.77
% change	9.09%		3.35%		-0.80%

indexes (approximately 80% with the vegetable index and 67% with the fruit/vegetable index (significant at the alpha = 0.0001 level).

California tomatoes were hedged using both the vegetable and fruit/vegetable indexes (Table 8). In 1990, the California f.o.b. price and the index values moved in opposite directions, thus, if a California tomato grower hedged in 1990, the producer would have recognized losses in both the cash market and the futures market. In 1991, however, the cash and index values moved together and a tomato grower would have benefited from hedging. In 1992, the average f.o.b. cash price and the vegetable index moved together with the cash price increasing by 9.09% and the futures by 3.35% from June 8, 1992, to November 19, 1992. Again, in this case, the grower would have preferred not to be hedged since there was a cash market gain. The fruit/vegetable index for 1992 did not move with the cash market as evidenced by the correlation coefficient of −0.1239 at alpha = 0.1890, therefore, if the grower used the fruit/vegetable index to hedge, losses in both the cash market and futures market would be realized. Again, there was positive directional movement between the vegetable index and California tomatoes two out of the three years, similar to that of the New Mexico yellow onion cross hedge. However, for the fruit/vegetable combined index, positive directional movement was only realized for one year. Cross hedges were also simulated for New Mexico fall lettuce, eastern New Mexico russet potatoes and California peaches with similar results.

Implications for Cross Hedging. There are several things to consider when using an index vehicle to cross hedge a single commodity. First, the grower or marketer must examine his or her own risk preference/avoidance factor. One of the problems inherent in cross hedging is basis variability. The stronger the movements of the cash market are correlated with the index, the less basis variability there will be. Therefore, commodities that have stronger correlations with the indexes would tend to be better candidates for successful cross hedges. With any cross hedge, the hedger must determine whether the increased basis risk is greater than the absolute price risk associated with the commodity. As illustrated, significant correlation coefficients do not guarantee that the cash and index prices will move together. The correlations are merely a tool to help determine if there will be adequate correlation of price movements between the cash and indexes to warrant a cross hedge. Therefore, as seen in the above examples, if basis risk is greater than the absolute price risk, losses may be realized in both the cash market and futures market.

The hedging of only one component in the index leaves the hedger exposed to a considerable amount of nonsystematic risk since one commodity does not constitute a diversified portfolio. In essence, only the market risk exposure is being hedged. However, a hedger may still benefit from hedging the market risk aspect of the component. Again, this is a risk preference decision for the producer. Also, in an up market, gains in the cash market will be negated by losses in the futures market with a short hedge. However, if properly hedged, the initial cash value of the crop would be locked in guaranteeing that revenue. A producer must decide whether to hedge the entire value of the crop or only a portion (the decision to over or under hedge). A producer with good price forecasting skills can aid in this decision with selective hedging techniques. For instance, if a grower anticipates that his or her crop price will increase, he or she may decide not to hedge or hedge only a portion of the value of the crop. An understanding of hedging ratios is also important since it is necessary to have an adequate number of futures contracts to properly hedge the cash position. An exact matching of the value of the futures position to the cash position would appear to be difficult, based on the above examples since it is hard to predict how much the cash market would change in relation to the index value.

Summary and Conclusions

The main purpose of this paper was to examine the concept of creating indexes and eventual index futures contracts based on a wide range of fresh fruits and vegetables. Fruit, vegetable and fruit/vegetable indexes were calculated for the years 1989 to 1992 using USDA data from the Dallas Wholesale Fruit and Vegetable Market. A trade-weighted arithmetic index formula provided the best chance for these indexes to be accurate market performance indicators and successful hedging vehicles.

This study also set out to evaluate the hedging capabilities of such instruments in the context of hedging a portfolio of fruits and vegetables and the hedging of individual produce commodities. The results indicate that a portfolio of fruits and vegetables may be successfully hedged if the hedger is able to compile portfolios of fruits and vegetables that closely match the index. Conceptually, the index and eventual futures contracts listed on the index have the most promise to be used by large supermarkets and/or large wholesalers. Since the components of the index are based on the top ten fruits and vegetables by supermarket sales (PMA), a futures contract based on a fruit and/or vegetable index still might be a useful price-risk management instrument since these firms deal with similar portfolios of fruits and vegetables. Successful cross hedging of individual produce commodities appears to be difficult, since the results indicate that no single commodity closely follows the indexes. However, successful cross hedging may still be possible depending on the hedger's price forecasting abilities since for each of the commodities examined, the cash price and the index value moved in the same direction two out of the three years tested. Significant correlation coefficients between the produce commodity and the index as well as significant regression results may be helpful in identifying potential cross hedges but in no way guarantee their success.

The evidence would suggest that several issues should be considered before developing an index futures contracts for fresh fruits and vegetables. Daily price data for fresh produce is plentiful yet very unorganized and difficult to put into a framework for calculating an index number. A considerable amount of data computation was required to conduct this study which may have contributed to weak empirical results. Also, the Dallas Wholesale Fruit and Vegetable Market is just one of nineteen terminal produce markets in the United States. Indexes should be calculated for larger terminal markets (e.g., Los Angeles) and examined in the context of which terminal market or combination of markets best represents the produce market on a nationwide basis. Further research into the development of produce indexes themselves could be conducted to examine alternative weighting schemes that incorporate changing weights for different periods of the year based on seasonality of the components. Also, an in-depth survey of the characteristics and idiosyncrasies of the fresh produce industry could provide a greater insight into how these indexes could be utilized and to the acceptance of such a product by the produce industry.

One of the most promising implications of this study, however, is that of the index numbers themselves and their use as market performance indicators. The development and maintenance of produce indexes, such as the ones illustrated in this study, may provide an important piece of information to the industry by organizing produce price information and providing an objective measure of market tone. Also, since futures exchanges are constantly looking for new futures contracts to list, this paper provides exchanges with a conceptually new idea of how to incorporate futures contracts on fresh produce.

Overall, it appears the fresh produce industry could benefit from index futures contracts for fresh fruits and vegetables. The ability to hedge in the futures market would provide producers and marketers with greater marketing and risk management alternatives.

Notes

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1. The Dallas Wholesale Fruit and Vegetable Market is one of nineteen major terminal fruit and vegetable markets monitored by the USDA. A more robust test and more representative index should be based on a broader market definition such as an average of all or a specific subset of the nineteen major markets. The data needed to construct such an index would have been too costly for this initial investigation.

2. Prices represent the wholesale price paid by primary receivers for the respective produce item.

3. Two of the fruits that were originally in the PMA's top ten list, peaches and mangoes, were eventually eliminated from further analysis since neither of these prices was consistently quoted on the Dallas Wholesale Fruit and Vegetable Market.

4. Ideally, such an example would be illustrated showing how many futures contracts were used to hedge. However, futures contract specifications would have to be assumed, which is beyond the scope of this initial investigation.

5. Three different weighting schemes were initially tested. There was no substantial difference in the correlation coefficients among the various weighting schemes.

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