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A Portfolio Approach to Cooperative Price Risk Management

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Agricultural producers face significant price risk. For some products, farmers may hedge this risk in well-functioning futures markets. For several products, however, no such risk management instrument is readily available. We suggest that farmers reduce price risk by organizing cooperatives where members diversify by creating "accounting" portfolios. The approach is illustrated with data from the Dutch flower market, and some practical problems connected to such cooperative risk pooling in agriculture are addressed.

Introduction

This paper focuses on agricultural cooperation beyond that of processing and marketing farm products and purchasing farm inputs. Specifically, it focuses on cooperative price risk management. We argue that, for many agricultural products, price volatility can be handled more efficiently through cooperative arrangements rather than individual hedging efforts. We present a stylized set-up for such cooperative price risk management, which we shall illuminate by an empirical example based on data from the Dutch flower auctions. The paper is in a similar vein as those by Sporleder (1988) and Buccola, Cornelius, and Meyersick (1989). However, while they focus on pool payment equity in agricultural marketing cooperatives, the present paper takes the pooling idea into the area of price risk management.

Some of the very first agricultural cooperatives were created with the sole purpose of risk management, for example, the mutual fire insurance organizations dating back at least to the nineteenth century. The idea was quite simple. While a fire could represent a disaster for an individual farmer, for one hundred or more fellow farmers in the neighborhood of the one who was struck, it was possible to give a helping financial hand without emptying their own resources. Actuarial intuition and group norms reducing the potential moral hazard turned many of these mutual fire insurance cooperatives into quite successful ventures.

Present day agriculture is confronted with highly volatile prices for many commodities. Most farmers are, for good reasons, risk-averters. While, on the average, a

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farmer's price expectations may be correct in the long run, this yields little comfort if, in the meantime, deviations between expected and actual prices have been so large that the farmer is knocked out of business.

For some commodities, it is possible to reduce price risk by using instruments offered by organized exchanges at which the trading of price risk is the name of the game. Thus, wheat, soy, pork bellies, and other agricultural products are traded at futures exchanges where farmers may hedge against adverse price movements, although not against production risk.[1]

Price risk management through the futures market is, however, an option not available for most farmers. For several products no futures contract exists. Also, the correlation between the price changes of the contracts traded at the futures exchanges and the spot price changes of the commodity produced by a given farmer is often so low that the hedging efficiency of the futures contract is meager. Beyond this, farmers may try to reduce price risk through diversification (for example, plant crops for which prices are not perfectly correlated) and, hence, reduce total (portfolio) price risk (see for instance Helmberger and Chavas [1996, 73]; Johnson [1967]; McFarquhar [1961]).

Such product diversification can, however, be quite difficult and costly when carried out on an individual basis. In biological production it is not that easy to combine different productions in a risk-reducing manner. Although it may technically be feasible, the gains, in terms of risk reduction, may be severely eroded by the costs of investing in equipment for producing a variety of products.

We propose that individual farmers establish risk-management cooperatives through which diversification is achieved without having to reduce individual gains from specializing in one or just a few products. In the next section, we outline the standard method of portfolio diversification. We then proceed with an empirical illustration before we round off with a discussion on how cooperative price risk management could be set up in real life situations.

A Cooperative Portfolio Approach

The major goal of this paper is to instigate further discussion on the possibilities of cooperative risk management in agriculture. We try to stimulate this discussion in two ways. One, we outline the basic methods of portfolio theory and try to point out how this theory can be applied as a basis for cooperative action. Second, we illustrate the portfolio approach by using real market data from the Dutch flower markets, *assuming* that flower producers apply simple portfolio methods in a cooperative setting. Thus, we first outline the standard portfolio theory that may serve as the foundation for cooperative price risk management. In the next section we present empirical evidence as to what, theoretically, could be achieved through such a cooperation among Dutch flower producers. Finally, we discuss briefly some major problems that have to be solved for establishing such risk management cooperatives.

Price risk management in a portfolio framework is based on the fact that a less-than-perfect (positive) correlation between two or more asset prices (or cash flow contributions or returns) very often makes the combined (portfolio) risk less than the individual asset risk. If we focus on product price levels (or cash flow contributions), the expected price of n assets put together in a portfolio is simply the weighted sum of the expected price of the individual assets,

$$E(P_P) = \sum_{i=1}^{n} w_i E(P_i)$$

where P_i is the price of asset i, while w_i is the weight of asset i and

$$\sum_{i=1}^{n} w_i = 1$$

The variance of the portfolio price is

$$\sigma^2(P_p) = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j Cov(P_i, P_j)$$

For a given expected portfolio price, the goal is then to choose weights that minimize portfolio variance. This is a trivial quadratic programming problem provided that we have estimates for the co-variances as well as expected prices for each product.

An alternative approach is the so-called single [2)] index approach, assuming that the price of a given product i (P_i) is determined by a single "driving" factor, like, for instance, the market index (P_m). The rest is assumed to be unsystematic noise, i.e.,

$$P_{i,t} = \alpha_i + \beta_i P_{m,t} + \varepsilon_{i,t}$$

The error term is assumed to have zero expectation and constant variance. It is, furthermore, assumed to be unsystematic over time and to have no covariance with the error terms of product j for all i and j. β_i measures the systematic risk of product i, i.e., the risk that cannot be removed through diversifying. This implies that the expected portfolio price is

$$E(P_p) = \sum_{i=1}^{n} w_i [\alpha_i + \beta_i E(P_m)]$$

with variance

$$\sigma^2(P_P) = \left[\sum_{i=1}^{n} w_i^2 \beta_i^2\right] \sigma^2(P_m) + \left[\sum_{i=1}^{n} w_i^2 \sigma^2(\varepsilon_i)\right] \approx \beta_P^2 \sigma^2(P_m)$$

where β_P is the portfolio beta, i.e., the weighted beta of all assets in the portfolio. The portfolio beta measures the systematic risk of a portfolio given the w's. $\sigma^2(P_m)$ is the variance of the market index.

Thus, by assuming a single "driving" force in the price determination, we have estimates for price expectations and a fairly simple way of calculating the price variance of a given portfolio. In agricultural economics, the single index model has been applied in, inter alia, Collins and Barry (1986).

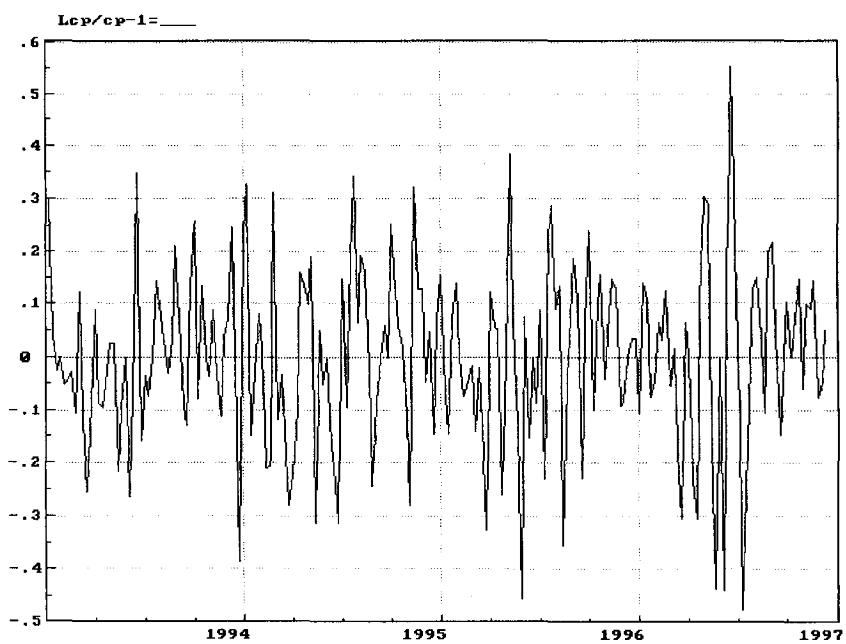
Portfolio management in finance is based on expected returns (in percent) and the return variance. In agriculture the basis might be net return per acre. Alternatively, one may focus on price levels, as we do here, bearing in mind that there is no simple relationship between price levels and returns. Thus, one will have to *scale* price levels one way or another when adding assets together in a portfolio and evaluating gains from diversification. This is more complicated when the portfolio is made up of products produced and owned by different farmers in cooperative risk management. One way of solving this problem is as follows. Let us assume that the cooperating farmers reach a consensus on price expectations (in practical terms, this may be handled within the cooperative's management). Assuming, then, that portfolios are established either through an optimization or simply by any sort of naïve or random weighting, the expected portfolio price and variance can be calculated (given the required inputs). Then *ex post,* the diversification gains can be shared according to deviations between expectations and realized prices. In the next section we shall try to illustrate how the gains from cooperative diversification could be distributed in this way.

A slightly different approach could be that of focusing on price *changes* in the risk management. In that case, one would establish portfolios that reduce the overall per-cent price change from "today" until "tomorrow." As to expected price changes, a simple approach could then be to assume zero price change from today, and then just build the portfolio to minimize variance.

An Empirical Example from Floriculture

Our empirical illustration of portfolio risk management uses data from the Dutch flower auctions.[3] Few, if any, commodities have a price volatility near that of cut flowers. This is visualized in figure 1 below,[4] describing weekly percent price changes for

Figure 1. Weekly Price Changes (%) Chrysanthemums, 1993 to 1997



Source: Weekly editions of *Vakblad voor de Blomisterij* chrysanthemums from 1993 to 1997. As can be seen, chrysanthemum prices change typically +/- 15 to 20% on a *weekly* basis. However, it is not at all uncommon that prices raise or drop by 30 to 40% from one week to the next. Chrysanthemums are quite representative for other cut flowers as far as price volatility is concerned. During the period 1993 to 1997, the annualized standard deviation of the weekly chrysanthemum price changes was above 120%. The standard deviations for carnations and roses were 134 and 142%, respectively!

The correlations between the weekly observed prices for chrysanthemums, carnations, roses, and a bouquet[5] of the other cut flower varieties traded at the Dutch auctions are reported in table 1, together with the respective standard deviations and coefficients of variation. Table 2 reports the results from OLS-estimations of the "flower betas" based on a flower market index calculated as a value weighted index.[6]

Table 1. Means, Standard Deviations, Coefficients of Variation, and Correlations; Weekly Prices, 1993 to 1997

	Chrysanthemums	Carnations	Roses	Others
Carnations	0.097			
Roses	0.767	0.319		
Others	0.626	0.282	0.585	
Mean (Arithmetic)	43.38 (cents)	27.11 (cents)	42.43 (cents)	39.25 (cents)
Std. Deviations	17.83 (cents)	5.75 (cents)	15.77 (cents)	8.26 (cents)
Coeff. of Var.	36.9 (%)	21.2 (%)	37.3 (%)	21.0 (%)

Table 2. OLS-Estimations of a Simple Market Model

	α	β	DW	adjR^2
Chrysanthemums	-16.18	1.61	1.67	0.73
	(-2.94)	(12.04)		
Carnations	18.73	0.21	1.63	0.12
	(5.85)	(2.69)		
Roses	-17.10	1.49	1.30	0.79
	(-4.01)	(14.34)		
Others	8.63	0.76	1.03	0.76
	(3.63)	(13.23)		

(.) = t-values

$$P_{j,t} = \alpha_j + \beta_j P_{m,t} + \varepsilon_{j,t}$$

where $P_{j,t}$ is the weekly price of flower j, while $P_{m,t}$ is the flower market index in week t, and ε is an unsystematic error term.

As can be seen from table 1, the correlations are generally substantially less than one, which again indicates a potential for composing portfolios with price volatility less than that of the individual flowers. This is also confirmed in table 2. Roses and "others" seem to have autocorrelated error terms (low Durbin-Watson values), while the simple market model does not explain the variations in the carnation prices terribly well (low $adjR^2$). Disregarding this, the estimated betas strongly suggest that it is possible to compose portfolios with substantial risk reduction rather than putting all eggs in one basket. Chrysanthemums and roses have a "systematic risk" (betas of 1.61 and 1.49, respectively) well above the market average, while the opposite is the case for carnations (beta of 0.21).

Tables 3 and 4 report the standard deviations and portfolio weights of three portfolios on the efficient set (minimum standard deviation for a given portfolio price expectation). When deriving the efficient set, we assumed (for simplicity) that the expected price for each variety was equal to its historic average, that is, the prices reported in table 1 above. Table 3 includes "others" in the possibility set. Since "others," per definition, represent a portfolio, we have excluded this bouquet from the efficient portfolios reported in table 4 where we have calculated efficient portfolios based on the three major cut flower species at the auctions.

Table 3. Mean-Variance Efficient Portfolios, All Varieties

		Weights			
$E(P_p)$	$\sigma(P)$	Chrysanthemum	Carnations	Roses	Others
30.32 (cents)	5.28 (cents)	0	73.6	0	26.4
36.34 (cents)	6.78 (cents)	3.6	26.7	0	69.7
40.35 (cents)	8.83 (cents)	12.1	0	0	87.9

Table 4. Mean-Variance Efficient Portfolios, "Others" Excluded

		Weights		
$E(P_p)$	$\sigma(P)$	Chrysanthemums	Carnations	Roses
28.60 (cents)	5.61 (cents)	6.9	93.1	0
33.00 (cents)	6.75 (cents)	27.7	72.3	0
39.58 (cents)	10.93 (cents)	55.4	40.1	4.5
46.18 (cents)	16.00 (cents)	79.5	6.4	14.1

The portfolio expected price in the column to the left, are three arbitrarily chosen values on the efficient set. In table 3, including "others," we see that the efficient portfolios generally consist of carnations and "others." Chrysanthemums enter at high expectation levels, while roses never enter at all. Excluding "others," table 4 presents more variations in weights. At high expectations, all species enter the efficient portfolios. The tables, furthermore, demonstrate the diversification effect on price risk. As an example, the portfolio in table 4, with 27.7% chrysanthemums and 72.3% carnations, has an expected portfolio price of 33 cents with a standard deviation of 6.75 cents. This price risk is substantially lower than that of chrysanthemums alone and is just slightly above that of carnations. The expected portfolio price, on the other hand, is somewhat lower than that of chrysanthemums while significantly higher than the expected carnation price. In other words, there is no free lunch, as such. Producers may, however, sleep better if they pool their assets in portfolios.

Real life organization

"Price averaging" is well known in agricultural marketing cooperatives. Various marketing boards have established rules so that members at different locations receive identical prices or so that the marketing board averages payoffs over time. The present paper is, however, considering risk management *without* the cooperative getting involved in the marketing. Similarly, the mutual fire insurance cooperative does not involve itself in constructing or rebuilding burned-down houses; the idea is to specialize in insurance or risk management. *Producers* handle the marketing.

How, then, could farmers apply basic portfolio theory in a risk management cooperative in real life? A major obstacle to creating such a cooperative is related to the fact that, quite often, one will have to put "apples and bananas" into the portfolio. While financial assets can be evaluated in terms of expected (%) returns, agricultural products yield cash flow contributions that cannot be easily compared. Thus, cooperative price risk management would most likely have to focus on expected price levels and to establish portfolios with the aim of averaging prices over time.

One objective for the cooperative would then be to establish some consensus price forecasts among the participants, which could serve as benchmarks for calculating*ex ante* portfolio price-level expectations and risk for given portfolio combinations. Let us assume that the members of a price risk management cooperative are willing to commit themselves to the judgement made by a "market surveillance committee" that the cooperative has appointed. Here, the member specializes in what he or she does the best, that is, agricultural production, leaving the market forecasts to those presumably in a better position to make such forecasts. For such a commitment to be sustainable, the market committee would have to present a good trade record. The TV weather forecaster presents a good analogy: people will adjust behavior according to forecasts only if it seems that they are reasonably good, on the average as well as on a daily basis. If forecasts of a marketing committee are reliable, it would not be unrealistic to assume that farmers would accept that their production (or parts of it) is put into a cooperative management pool.

This pool may be set up as follows. The market committee presents its price expectations for various products for given future dates. The members of the cooperative are then invited to announce given quantities of the relevant products or quantities for delivery in given time periods (weeks). The cooperative does not play any part in taking the physical products to the market. As we see it, the cooperative acts simply as a bookkeeper. It keeps track of the members' positions, that is, the volumes registered for risk management by each member for a given week or month and the market prices for the period and product in question. Prices are, in this way, averaged continuously. The prices members receive may differ greatly from those they might have projected individually, independent of the cooperative. Spot prices would have to be a set of easily observable quotations from a source or a market place agreed upon by the members in advance. The cooperative then takes care of the redistribution of cash among its members.

Just as the clearing house at a futures exchange requires margin installments when hedgers buy futures contracts, the risk managing cooperative probably would charge its members a cash insurance premium. The redistribution of risk could then be calculated according to the deviations between the forecasts and the portfolio result *ex post*. In simple words, the members of the price risk management cooperative substitutes an "average" (portfolio) price for an individual product price. The idea is that the portfolio price is less volatile than the price of the member's specific product, or (alternatively) that the member can obtain a higher expected portfolio price by taking on some of his or her neighbors' risk. What such an arrangement simply achieves is the same as what the individual member would have done by diversifying his or her own production, for example, by growing more varieties or spreading harvesting or marketing over time. In a cooperative, the member can diversify without loosing the benefits from specialization.

In practical terms, cooperative members are simply credited or debited in the co-op's books according to whether actual prices (and portfolio average) turned out to be lower or higher than expected.

In financial portfolio management, it is generally quite easy to fine tune portfolio weights in order to establish portfolios on the efficient set. In farming, this is obviously not easy. Consequently, cooperative portfolio management cannot expect to end up with weights that represent minimum risk for a given expected portfolio price or return. The goal would have to be somewhat less ambitious. Portfolio weights, most likely, would have to be whatever the cooperative's members "announce" as their desired volumes to be put into the portfolio. This simply means that portfolio expected price and variance will have to be estimated *given* a set of weights. These estimates can then serve as benchmarks for the *ex post* redistribution of prices among the participants.

Assume that the cooperative's portfolio was weighted together so that the *expected* portfolio price was 33 cents, based on three different assets put into the portfolio. These assets, we assume, had expected prices of 28 cents, 32 cents, and 40 cents, respectively, and each asset made up a third of the portfolio. Reality then turns out to yield a portfolio price of, say, 29.70 cents, that is, 10% below expected price. A simple redistribution among the participants could then be to "pay out" a price that is a weighted adjustment of each asset's expected price. In this example, with each asset counting as a third, the prices to participants would be 25.20, 28.80, and 36.00.

Concluding Comments

The floriculture example above mainly serves as an example. There are, obviously, a number of problems related to cooperative price risk management along the lines that we have suggested. One problem relates to specifying *qualities* when establishing a market reference price against which the cooperative accounting portfolio is evaluated. There also exists the issue of potential moral hazard or the possibility of individual large members cornering the market. Apparently, the cooperative would need rules regarding members' rights to take outright speculative positions in the pool. Thus, one would have to discuss whether a member should be allowed to register in the pool amounts significantly larger than his or her real production. There is also a problem related to the heterogeneity of different producers. In our example above, carnation growers seem to have a low systematic risk (a low β). Their participation in the cooperative portfolio would, therefore, require a willingness to take on additional risk and, as compensation, receive a higher expected return. In a way, this resembles the function of the speculator or investor, and it may be difficult to convince a sufficiently large number of producers to take such a role. Finally, the cooperative would have to establish rules in those cases where reality happens to be significantly different from expectations on the downside. Thus, if the marketing board is consistently wrong about future prices, the obvious result is that the cooperative represents no benefit to its members.

One could easily conceive different agricultural settings in which price risk management could be set up in a cooperative portfolio approach. Thus, hog producers confronted with wide price variations for both inputs and outputs could probably smooth net revenues by pooling their feed costs as well as their planned deliveries in the books of a cooperative accounting system.[7] It is not unlikely that farmers participating in this way could achieve the same amount of risk reduction as they would have been able to obtain through futures hedging. It may also turn out that simple cooperative risk management could be quite cost efficient.

Notes

1. This disregards the possibilities for hedging production risk through the so-called yield contract recently introduced at the Chicago Board of Trade.
2. For the sake of simplicity, we stick to a single-index model.
3. Purcell et al. (1993) presented a portfolio approach to risk management in the horticultural industry. Their focus, however, was on space allocation.
4. All price data are collected from weekly editions of *Vakblad voor de Blomisterij*, 1993 to1997.
5. The bouquet represents a value-weighted index of all other varieties traded.
6. The weights are average values for the period 1993 to 1997.
7. An interesting example of risk pooling in the hog industry is found in Sweden. Hog producers buy their piglets through the slaughterhouse. The price of the piglets is fixed as a function of the market price of pork at the time of slaughtering, that is, some ten to twelve weeks after the farmer received the piglets.

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