Futures and Options Risk: with an Application to Agricultural Commodities

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Farmers who have to make preharvest decisions have a range of different price risk management instruments to choose from. Futures and options are potential price risk management instruments for farmers. While much research has been done on the valuation of these instruments, little is known about the risks when using these instruments. Firms such as Barings Bank, Volkswagen and Metallgesellschaft have recently been confronted with these risks (Edwards and Canter, 1995). Not only large enterprises, but also farmers must be aware of these risks in order to avoid unpleasant surprises.

In this article a comparison is made between the risk farmers face, in managing cash price risk by futures or options. This comparison is made theoretically and empirically, the latter on the basis of a simulation using data from the Amsterdam Agricultural Futures Exchange. The empirical analysis shows that options introduce less risk than futures.

Key words: futures and options risk, hedging, agriculture

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There are two general sources of risk to farmers[1], quantity risk and price risk. Quantity risk is a farm-specific phenomenon caused by a myriad of random factors such as disease and weather conditions. Price risk is a market phenomenon caused by random changes in aggregate quantity of a good demanded or supplied (Dwight, 1985). This article focuses on price risk. This type of risk has become more relevant to farmers in both the United States (U.S.) and the European Union (E.U.) because of the free trade policy of the GATT and the reforms of the common agricultural policy of the E.U. There are many different instruments of price risk management. In agriculture, devices, such as cash forward contracts, channel participation, futures and options are used[2].

Because of the increased fluctuations in agricultural prices and the introduction of production and environmental rights, some exchanges are planning to introduce new futures contracts and options on futures (Pennings, Heijman and Meulenberg, 1995, Pennings and Meulenberg, 1995). That is why this article focuses on futures and options as a means of decreasing cash price risk for farmers. On the one hand, price risks in the cash market can be decreased by futures and options; on the other hand, however, futures and options generate risks[3]. Understanding the characteristics of futures and options to reduce price risk is important. (Lolly, 1983; Bosch and Johnson, 1992). The poor knowledge farmers, and firms in general, have about how to use futures and options has caused many failures (Figlewski, Landskroner and Silber, 1991; Edwards and Canter, 1995).

The purpose of this article on price risk management by farmers is threefold. First, in contrast to other studies, this article takes into account that futures and options not only reduce cash price risk but also introduce hedging risk. Second, hedging risk is analyzed in all its aspects. Third, theoretically and empirically the similarities and differences between futures (hedging) risk and option (hedging) risk and the attractiveness of these alternatives for farmers are investigated.

This paper is organized as follows. Section I provides a brief overview of the characteristics of futures and options. After analysis of the possible outcomes of price risk management by futures and options in section II, the expected value and risk of futures and options are determined in section III. In section IV results of section III are used in an empirical analysis of the risks of futures and options. Finally, some conclusions are drawn.

[1] Note that the words farmer and hedger are used interchangeably.

[2] Much research has already been done on the use of cash forward contracts and channel participation in agriculture (see Nelson, 1985; Kimbal, 1988; Hirschleifer, 1988; and Harrison, 1994).

[3] The scope of this article does not include questions about how futures and options can be used as a hedging vehicle, since there is extensive literature on this subject available. See, for instance, Working (1962).

I. Similarities and Differences between Futures and Options

Since farmers' price risk management can take place by either futures or options, first an overview of the pros and cons is given. This is done by comparing both these risk management methods with cash forward contracts, the latter being a widely-used price risk management instrument in agriculture (Paul and Heifner 1976; Nelson, 1985; Antonovitz and Nelson, 1988).

Futures

Futures contracts are standardized contracts traded according to the rules of an organized exchange. Since delivery and payment do not occur until contracts mature, farmers are required to deposit money in margin accounts of the clearing house. Table I summarizes the advantages and disadvantages of futures used as a hedging vehicle as compared with cash forwards (Heifner, Wright and Plato, 1993).

Table I. Advantages and Disadvantages of Hedging With Futures by Farmers in Comparison with Cash Forwards.

Advantages	Disadvantages
Contracts can be entered quickly at highly competitive prices.	Cash reserves or lender support is needed for meeting margin calls.
Contract commitments can be changed easily if conditions change.	Basis[4] risk may be a problem for farmers who are remote from delivery points.
Security of contracts is very high.	Contracts are large for small farmers.
Contract prices are widely reported.	

Options

With the introduction in the 1980s of commodity options[5] on futures for many commodities, options appear to be relevant to a number of production settings, especially in agriculture[6].

[4] Where the basis is defined as the local cash price minus the futures price.

[5] In this article we deal with European options, namely, the options which can be exercised at a specific time in contrast to the American ones, which can be exercised at any time prior to expiration.

[6] Note that agricultural commodity options are not yet available in Europe. However, some futures exchanges are planning to introduce them.

Attention is focused on put options, because it is more likely that farmers use those options rather than call options. Moreover, a synthetic call may be constructed using futures and put options (Lapan, Moschini and Hanson, 1991). Table II summarizes the advantages and disadvantages of options as a hedging vehicle in comparison with cash forwards (Heifner, Wright and Plato, 1993)[7].

Table II Advantages and Disadvantages of Hedging With Options by Farmers in Comparison with Cash Forwards.

Advantages	Disadvantages
Ability to set lower or upper limits on prices.	Upfront premiums.
Wide range of choices.	Difficulty in determining the value of options[8].
Absence of margin calls.	Basis risk[9].
Limits on possible losses.	
Pricing competitiveness, contract security and convenient recontracting.	

Futures and options differ in revenue flows. Farmers buying a put option have to pay the premium. This is the only variable in the contract and is determined on the trading floor. Options sellers, however, face similar margin requirements as participants in the futures market. Unlike futures users, option users are not locked into a specific floor or ceiling price, and can take advantage of a market trend.

The hedging theory and portfolio theory maintain that options contracts are superior loss-minimization ones, while futures are better risk-minimization instruments. The option exercise feature creates asymmetric payouts which provides additional flexibility for farmers. Should spot price move in an unanticipated direction, farmers simply allow contracts to expire unexercised and thereby capturing spot market gains. However, option prices have lower limits and are eventually insensitive to spot price movements (Benet and Luft, 1995).

[7] Note that this article focuses on price risk only. If production uncertainty is introduced, the farmer is exposed to revenue risk, which can be partially offset by options (Sakong, Hayes and Hallam, 1993).

[8] The value of an option depends, in a complicated way, on the futures price, strike price, the duration of the option, the interest rate, and the futures price volatility (see Stoll and Whaley, 1993; Chaudhury, 1995).

[9] When a put option is exercised, the holder receives a corresponding short futures position. Hedging with options thus exposes one to the same basis variation as hedging with the underlying futures contract.

In order to gain insight into the differences between futures and options, both markets are compared in table III with respect to some well-known market characteristics (Heifner, Wright and Plato, 1993).

Table III. Characteristics of Futures and Options Markets

	Futures	Options[10]
Liquidity	Commensurate with trading volume at organized exchange.	See futures.
Integrity	Guaranteed by exchange's clearing house.	See futures.
Payment	Over the life of the contract via the margin mechanism.	Lump sum cash transfer when buying put option.
Settlement	Making delivery or offsetting.	Accept delivery or offsetting.
Transaction costs	Brokerage fee and margin income (cost).	Brokerage fee and premium.
Risk[11]	Futures risk.	Options risk.

Farmers, traders, and processors are connected by a web of extensive forward trading. As a result futures and options affect the industrial organization of output markets. The risks faced by processors and farmers may be complementary, which might lead to a risk-reducing benefit to forward contracting. Therefore, vertical integration is a possible response to risk. Vertically-integrated producers are perfectly self-hedged by the offset between the quantity they sell to consumers and the spot price. Therefore, the existence of a futures market reduces the need to integrate vertically in order to avoid price risks: A negative association of futures trading in a commodity with vertical integration has been predicted (Hirschleifer, 1988, 1989).

II. Outcomes of Futures and Options Transactions

Consider a farmer who systematically hedges his/her output and intends to sell the output in period T on the cash market. The farmer can now use futures and options in different ways or strategies to manage price risk. If hedging with futures is used, the strategy of a farmer depends on whether the desired time period T equals the maturity of the futures M. If $T=M$, the farmer will offset his/her position and sell the commodity in the cash market or (s)he will hold the position and make delivery[12]. Whether the farmer will offset or make delivery depends on the standardization requirements, the search cost in the cash market and the liquidity cost in the futures markets. If $T \neq M$, the farmer can only liquidate his/her position by offsetting. Figure 1 depicts the decision tree of the farmer in the case of hedging output with futures.

[INSERT FIGURE 1]

The use of options on futures allows many alternative strategies depending on whether or not 1) the exercise time ET equals the desired time of delivery T, 2) the time of delivery of the underlying futures equals T, and 3) the futures price PF is higher than the strike price K. Figure 2 depicts the decision tree of the farmer in the case of hedging output with options.

[INSERT FIGURE 2]

III. The Value and Risk of Futures and Options

In this section the expected value of futures and options is determined for period T when the farmer wishes to sell his/her commodity. Only the strategies which are likely to occur in practice are analyzed. For futures cases, S1(1), referred to as case 1, and S2(2), referred to as case 2, will be examined and for options, case S4(3), referred to as case 3, and S6(3), referred to as case 4, will be examined (see figures 1 and 2).

If the outcome of using futures and options is not stochastic, that is, that no risk is involved in using those instruments, then the choice between the cases is simple: choose the case with the highest yield. In this section the factors contributing to the variance of returns in the case of futures and options are analyzed. For reasons of convenience it is assumed that one option gives the right to one futures contract, and one futures contract corresponds to one unit of output[13].

Futures

In trading futures contracts the following characteristics are of interest: lumpiness, basis, liquidity cost and the net revenues arising from futures margin requirements. These characteristics are analyzed for farmers hedging price risk.

[10] Note that attention is restricted to put options only.

[11] The risks of using futures and options will be elaborated upon in section IV.

[12] Making delivery on futures is only possible when the cash position of the farmer is equal to the underlying commodity of the futures, which is seldom the case.

[13] This assumption has not affected our conclusions.

Farmers can specify forward contracts in accordance with the quantity they have available for sale in contrast to futures contracts which are traded in standard quantities. Therefore, a futures hedge may not exactly match the amount of the desired sale or purchase, and lumpiness causes a proportion of the cash position to remain exposed to an uncertain price. Note that if the quantity to be hedged increases, the relative importance of lumpiness declines and ultimately approaches zero.

Basis risk exists in futures markets, since the futures and spot prices in the future period are not perfectly correlated. The basis risk can be divided into timing (denoted by B^{tem}) and/or location and quality discrepancies (denoted by B^{sq}) between the cash position of the farmer and those deliverable on futures (Paroush and Wolf (1989)). There is a temporal basis when the hedge is lifted before maturity, and spatial and quality basis shows up if cash positions and futures contracts are not perfect substitutes. Quality and spatial dimension basis risks are less important for products that are already standardized in cash markets, for example in the hog market.

A key aspect of futures market performance is the degree of liquidity. A futures market is considered liquid, if traders and participants can quickly buy or sell futures contracts with little price effect on their transactions. However, in thin markets, the transactions of individual farmers may have a significant price effect and may therefore result in substantial 'transaction costs' (Thompson, Waller and Seibold, 1993). There is liquidity risk if farmers want to offset their futures position, and if this is only possible against a great price fall (rise) in the case of a long (short) hedge.

In general, an individual farmer who manages a family farm needs only a few futures contracts to hedge his/her underlying cash position because of the large size of the futures contract relative to the cash position. For that reason the liquidity costs are probably relatively small. However, for traders or cooperatives that wish to hedge price risks on behalf of a group of farmers, liquidity cost may be large.

Farmers can eliminate liquidity costs if they give orders to a broker in limited pries. However, if they use limited prices, farmers may run the risk that their trade cannot be executed.

The liquidity costs per contract at the initiation of a futures position and the subsequent offsetting of the futures contract (in the case of a short hedge) can be expressed as:

$$LC^{ini}=x(PF_t^1-\sum_{j=1}^{N} PF_t^j/N) \tag{1}$$

$$LC^{o}=x(\sum_{j=1}^{N} PF_T^j/N-PF_T^1) \tag{2}$$

$$LC^{T}=LC^{ini}+LC^{o}$$

where LC^{ini} are the liquidity costs at the initiation of the (short) futures position, LC^{o} are the liquidity costs at the offsetting of the futures position, x is the futures quantity sold, PF_t^j is the price realized in the futures market when entering that market, j gives the serial number, N is the total amount of futures, and PF_T^j is the price realized in the futures market when offsetting at time T.

The net cost arising from futures margin requirements consists of the opportunity costs of the initial margin requirement and the opportunity cost of marking to market (i.e. marking to market means that if futures prices fluctuate, those who hold losing positions must add to their margin accounts, while winners can withdraw their surplus). Farmers holding losing positions incur actual and opportunity interest costs. These income and cost flows compound over the span of the futures hedge. The margin cost is more significant if the time horizon of the hedge increases. So, futures in agricultural commodities with a relatively long growth and storage period, such as potatoes (time horizon is about one year), incur more margin costs than hogs, where there is no storage period and the growth period is short (time horizon is about three months).

These opportunity costs, initial margin and marking to market per contract can be expressed as:

$$I^{im}=m\prod_{t=1}^{T-1}(1+r_t)-m \tag{3}$$

$$I^{mm}=x\sum_{t=1}^{T-1}[(\overline{PF}_t-PF_{t+1})\prod_{t}^{T-1}(1+r_t)] \tag{4}$$

where m is the initial margin requirement, r_t the rate accrued in each period t and $\overline{PF}_t$ is the mean futures price which equals $\sum_{j=1}^{N} PF_t^j/N$ (see equation 1).

On the basis of the above-mentioned characteristics of futures, the value of the farmer's output for case 1 can be expressed as:

$$\tilde{\pi}_{case1}=x(\overline{FF}_1-\tilde{CP}_T)+(q-x)\tilde{CP}_T+x\tilde{CP}_T+x\tilde{B}_T^{sq}-x\tilde{LC}^T-TC-I^{im}-x\tilde{I}^{mm} \quad (5)$$

where q is the output quantity produced, CP_T is the local cash price at the end of the period and π is the expected profit at the end of the period, TC are the roundturn brokerage costs, B_T^{sq} are the spatial and quality dimensions of basis at the end of the period and a tilde denotes a random variable. The lumpiness is expressed as $q-x$, i.e. the quantity which cannot be hedged because of the quantity standardization of the futures contract.

The difference between cases 1 and 2 can be attributed to the temporal dimension of the basis. The expected value of the farmer's output in case 2 can be expressed as:

$$\tilde{\pi}_{case2}=\tilde{\pi}_{case1}+\tilde{B}_T^{tem} \quad (6)$$

where B_T^{tem} is the temporal dimension of the basis.

To determine the risk of cases 1 and 2, it is necessary to determine the covariance matrix of the stochastic variables contributing to the risk of futures as described above.

The covariance matrix for case 1 can be represented by:

$$\sum_a=\begin{pmatrix} \sigma^2_{CP} & \sigma_{CP,B^{sq}} & \sigma_{CP,LC} & \sigma_{CP,I} \\ \sigma_{B^{sq},CP} & \sigma^2_{B^{sq}} & \sigma_{B^{sq},LC} & \sigma_{B^{sq},I} \\ \sigma_{LC,CP} & \sigma_{LC,B^{sq}} & \sigma^2_{LC} & \sigma_{LC,I} \\ \sigma_{I,CP} & \sigma_{I,B^{sq}} & \sigma_{I,LC} & \sigma^2_I \end{pmatrix}$$

The covariance matrix for case 2 can be represented by:

$$\sum_b=\begin{pmatrix} \sigma^2_{CP} & \sigma_{CP,B^{sq}} & \sigma_{CP,B^{tem}} & \sigma_{CP,LC} & \sigma_{CP,I} \\ \sigma_{B^{sq},CP} & \sigma^2_{B^{sq}} & \sigma_{B^{sq},B^{tem}} & \sigma_{B^{sq},LC} & \sigma_{B^{sq},I} \\ \sigma_{B^{tem},CP} & \sigma_{B^{tem},B^{sq}} & \sigma^2_{B^{tem}} & \sigma_{B^{tem},LC} & \sigma_{B^{tem},I} \\ \sigma_{LC,CP} & \sigma_{LC,B^{sq}} & \sigma_{LC,B^{tem}} & \sigma^2_{LC} & \sigma_{LC,I} \\ \sigma_{I,CP} & \sigma_{I,B^{sq}} & \sigma_{I,B^{tem}} & \sigma_{I,LC} & \sigma^2_I \end{pmatrix}$$

Let $a'=(q-x,\ x,\ -x,\ -x)$, then the variance for case 1 can be expressed as:

$$VAR(\pi_{case1})=a'\sum_a a$$

where $I=I^{mm}$ and $LC=LC^T$.

Let $b'=(q-x,\ x,\ x,\ -x,\ -x)$, then the variance for case 2 can be expressed as:

$$VAR(\pi_{case2})=b'\sum_b b$$

where $I=I^{mm}$ and $LC=LC^T$.

So, it appears that farmers using futures in order to eliminate cash price risk will incur futures risk in return. $\sum_a$ and $\sum_b$ provide insight into the underlying structure of this risk. If there is no lumpiness, $q=x$, the fluctuations in the cash price are eliminated. Thus, for large farmers and cooperatives that represent a group of farmers, the lumpiness will not be large. However, if a large farmer or cooperative enters the market with many contracts, they will face high liquidity cost risk. This is in contrast to a farmer who enters the futures market with only a few futures contracts. So, with a large cash market position, and hence many futures, the cash price risk caused by the lumpiness is relatively low but the liquidity cost risk is relatively high.

Options

Contemporary option pricing theory is based on a hedging process between the option and the underlying commodity (Black and Scholes, 1973; Merton, 1973; Hauser and Andersen, 1987). Theoretically, by purchasing an option, a riskless hedge is made at each instant, such that the resulting portfolio replicates a risk free bond. The number of options hedged against the underlying commodity depends on the strike price, the current price of the underlying commodity, the time to option expiration, the future interest rate for a risk free bond, and the future stochastic process for the underlying commodity price.

As previously indicated, buyers of put options are not locked into a specific floor, but can, depending on the strike and futures prices, take advantage of a market trend.

The value of the farmer's output in case 3 can be expressed as:

$$\tilde{\pi}_{case3}=p(x(\tilde{B}_T^{sq})-zOP_t)+$$

$$(1-p)(z(k-\tilde{CP}_T)+(q-z)\tilde{CP}_T+z\tilde{CP}_T+z\tilde{B}_T^{nl}-z\tilde{LC}^e-0.5TC-zOP_t) \quad (9)$$

where p is the probability that the strike price is lower than the futures price at maturity of the options, z is the quantity of put options bought and OP_t is the option premium. Note that z option gives the right to x futures, because of the assumption that one option gives the right to one futures contract, i.e. $z=x$.

Note that the decision whether or not to sell in the cash market is made by comparing the strike price with the futures one. However at time T the futures price does not necessarily equal the cash price, and consequently, although the option user does not exercise his/her right and will enter the cash market, (s)he is still exposed to the basis.

The difference between cases 3 and 4 can be attributed to the temporal dimension of the basis. The expected value of the farmer's output in case 4 can be expressed as:

$$\tilde{\pi}_{case4}=\tilde{\pi}_{case3}+\tilde{B}_T^{tem} \quad (6)$$

The covariance matrix for case 3 can be expressed as:

$$\sum_c = \begin{pmatrix} \sigma^2_{CP} & \sigma_{CP,B^{nl}} & \sigma_{CP,LC^e} \\ \sigma_{B^{nl},CP} & \sigma^2_{B^{nl}} & \sigma_{B^{nl},LC^e} \\ \sigma_{LC^e,CP} & \sigma_{LC^e,B^{nl}} & \sigma^2_{LC^e} \end{pmatrix}$$

The covariance matrix for case 4 can be expressed as:

$$\sum_d = \begin{pmatrix} \sigma^2_{CP} & \sigma_{CP,B^{nl}} & \sigma_{CP,B^{tem}} & \sigma_{CP,LC^e} \\ \sigma_{B^{nl},CP} & \sigma^2_{B^{nl}} & \sigma_{B^{nl},B^{tem}} & \sigma_{B^{nl},LC^e} \\ \sigma_{B^{tem},CP} & \sigma_{b^{tem},B^{nl}} & \sigma^2_{B^{tem}} & \sigma_{B^{tem},LC^e} \\ \sigma_{LC^e,CP} & \sigma_{LC^e,B} & \sigma_{LC^e,B^{tem}} & \sigma^2_{LC^e} \end{pmatrix}$$

Let $c'=((q-z)(1-p),\ px,\ -(1-p)z)$, then the variance for case 3 can be expressed as:

$$VAR(Case3)=c'\sum_c c$$

Let $d'=((q-z)(1-p),\ px,\ px,\ -(1-p)z)$, then the variance for case 4 can be expressed as:

$$VAR(case4)=d'\sum_d d$$

It can be concluded that the risk introduced by options is caused by p, which is determined simultaneously by the futures contract, the option, and the underlying futures contract. It can also easily been seen from the specification of the covariance matrix that, when covariances are zero, case 3 introduces the least risk followed by case 4, case 1 and case 2; thus, options introduce less risk than futures.

However, it should be kept in mind that options are relatively expensive as compared with futures. An option buyer has to pay the option premium to buy the option. In practice it turns out that if the put option runs out of money, further price changes of the underlying futures will not cause the value of the put option to decrease further. Unlike a short futures position, the put option does not move into the opposite direction any more, even if time value is taken into account. So, if options move out of the money, they do not resemble (in the hedging sense) the underlying futures contract any more.

If covariances are not equal to zero we cannot draw any conclusions beforehand about the differences in risks of futures and options. In order to determine the risk of the two alternatives, futures or options, a simulation was conducted by applying our theoretical model to empirical data.

IV. Comparison of Variances of Futures and Options on the Basis of Empirical Data

The risks of futures and options were compared by a simulation process, using data on the potato futures contract traded at the Amsterdam Agricultural Futures Exchange (ATA). The potato futures contract is a relatively successful futures contract. In fact, the volume generated is large relative to competitive potato futures contracts in Europe. With the aid of transaction-specific data it was possible to measure the risk run by trading potato futures contract delivery April 1996. Because only transaction-specific data over the period February 1994 - June 1994 were available, the time horizon of the simulation was limited. For that reason no distinction could be made between the temporal basis and the spatial and quality basis. Options on agricultural futures have not been introduced yet on European Exchanges. This did not pose a problem. As section III indicates, the characteristics of the underlying futures determine the risk of using options. The option characteristic which determines the variance of the option is p (equations 9 and 10); this probability was varied in the analysis.

In order to calculate the liquidity costs the covariance matrix for the futures was calculated on the basis of the Rotterdam potato cash prices, the closing prices of the potato futures and on the basis of transaction-specific data collected by the Clearing Cooperation. The liquidity costs were calculated as the area under the price path in case of a selling order (see equation 1) and as the area above in case of a buying order (see equation 2). It was impossible to infer from the data the exact split between an increasing and decreasing price path, since prices are constant for several contracts in the local minimum or maximum. Therefore, we followed the following procedure: for an odd number intersecting contracts we used the middle contract, whereas for an even number of constant contracts a random assignment with equal probabilities was used to determine the split. Subsequently, all order-specific liquidity costs were converted into daily liquidity costs per futures contract. The margin costs depend on the price of the futures contracts sold. The margin costs were calculated for several prices on the basis of a debit interest rate of 5% and a credit interest rate of 4%.

The research sample consisted of 81 week observations in the period of 10 February 1995 to 12 June 1995. So, this period captured the preharvest period of the potato growth and marketing cycle. This implied that the basis between the cash prices February - June 1995 and the price of futures April 1996 included the full storage costs of harvest period September 1995-April 1996. Changes in the basis in the sample period are therefore not due to storage costs changes. It is assumed that the estimated variance of the cash price and of the basis from the sample were constant over time because these are characteristics of the market.

The amount of output which the farmer wishes to hedge q, the standard amount of the futures x the price for which the farmer has locked in his price in the futures market PF and the probability that the strike price is lower than the futures price p were specified ex ante (see tables VI and V).

Four combinations of the output farmers wish to hedge and the futures quantity were examined in order to investigate the sensitivity of the results for lumpiness. For every combination of probabilities x and q, 17 different futures price levels for which the farmer enters the futures market and five levels of p were examined. Tables IV and V summarize the levels of x, q p and PF being combined in the analysis of the variance.

Table IV **Research Design for Calculating the Variance of Returns in case of Price Risk Management by Futures for Different Values of the Futures Position x, Cash Position q and Futures Price PF.**

x	q	PF
$x_1=1$	$q_1=1$	$PF_i=23, 24, 25, 26, 27, 29, 31, 33, 35, 40, 45, 50, 55, 60, 65, 70, 75$
$x_2=1$	$q_2=1.5$	PF_iidem
$x_3=10$	$q_3=10$	PF_iidem
$x_4=10$	$q_4=10.5$	PF_iidem

Table V **Research Design for Calculating the Variance of Returns in case of Price Risk Management by Options for Futures Position x, Cash Position q and Probability p that the Strike Price is Lower than the Futures Price at Maturity of the Options.**

x	q	p
$x_1=1$	$q_1=1$	$p_i=0.3, 0.4, 0.5 0.6, 0.7.$
$x_2=1$	$q_2=1.5$	$p_i$idem
$x_3=10$	$q_3=10$	$p_i$idem
$x_4=10$	$q_4=10.5$	$p_i$idem

In figure 3 the variance per futures contract is given.

[INSERT FIGURE 3]

The results of our simulation suggest two conditions about the variance of price risk management by futures. First, the effect of lumpiness on the variance decreases when the output which farmers wish to hedge increases. Second, the variance does not significantly depend on the price for which farmers enter the market hence; the liquidity risk in the potato futures market is relatively low compared with the cash price risk and basis risk. The covariance matrices suggest that the variance introduced by the potato futures can mainly be attributed to the basis.

[INSERT FIGURE 4]

Figure 4 depicts the variance which an option introduces for different p and different cash positions. The variance increases when p increases, which has already been concluded in section III.

Just as in the case of futures, the risk per option decreases, when the underlying cash position increases.

Comparing figures 3 and 4 shows that futures generate more variance than options in all cases. This result is in agreement with the expectations.

From the empirical results it can be concluded that futures and options introduce risk, which has to be taken into account by farmers who manage price risks in order to avoid unpleasant surprises. Farmers can reduce those risks, especially risks due to lumpiness, by not hedging their cash position individually, but by jointly hedging the cash position of a group of farmers. An agricultural cooperative could do so by futures trading for a group of farmers. However, as already indicated, trading large amounts of futures might increase liquidity costs. Knowing the characteristics of the underlying structure of liquidity cost is helpful in order to reduce this risk (Pennings, Kuiper, Ter Hofstede and Meulenberg, 1995).

Finally, it should be kept in mind that on the one hand options do not introduce as many risks as futures, but on the other hand, they are relatively expensive.

Summary and Conclusions

Because agricultural markets become more free, price volatility will increase, and thus there is more need for hedging. The increasing opportunities for farmers of risk management by futures and/or options require a better understanding of the risks involved when using futures and options. In contrast to previous research, not only attention has been paid to the decrease of price risks by hedging, but also to risks that futures and options introduce. Futures introduce temporal basis risk, spatial and quality basis risk, liquidity risk and marking to market risk, while options introduce basis risk and liquidity risk. These risks are particular important to farmers hedging their output on new and small futures exchanges. It has been shown theoretically (under certain assumptions) as well as by simulation that options introduce less risk than futures. So, it seems worthwhile to develop agricultural options also at European exchanges. However, the use of options is more expensive than futures because it has turned out that if options run out of money, a further price change of the underlying futures will not cause the option value to change. The empirical results have shown that the risk decreases when more futures or options are used. Hence, farmers who cooperate in hedging their underlying commodity will bear less risk than farmers who trade separately. The price for which the farmers enter the market has almost no effect on hedging risk i.e. marking to market risk was relatively low. Further empirical research which includes hedging risks and the cost of hedging is clearly called for in order to deepen the understanding of the optimal price risk management by farmers.

References

Antonovitz, F., and R.D. Nelson."Forward and Futures Markets and the Competitive Firm under Price Uncertainty" *Southern Economic Journal* 55 (1988):183-195.

Benet, B.A., and C.F. Luft." Hedge Performance of SPX Index Options and S&P 500 Futures." *Journal of Futures Markets* (September 1995) 15:691-717.

Black, F, and M. Scholes."The Pricing of Options and Corporate liabilities." *Journal of Political Economy* 81(1973): 637-59.

Bosch, J.D., and C.J. Johnson. "An Evaluation of Risk Management Strategies for Dairy Farms." *Southern Journal of Agricultural Economics* (December 1992): 173-182.

Chaudhury, M.M. "Some Easy-to-Implement Methods of Calculating American Futures Options Prices." *Journal of Futures Markets* 15 (May 1995): 303-344.

Dwight, G. "Theory of the Firm with Joint Price and Output Risk and a Forward Market." *American Journal of Agricultural Economy* 67 (August 1985): 630-635.

Edwards, F.R., and M.S Canter. "The Collapse of Metallgesellschaft: Unhedgeable Risks, Poor Hedging Strategy, or Just Bad Luck." *Journal of Futures Markets* 15 (1995):212-264.

Figlewski, S., Y. Landskroner and W. Silber. "Tailing the Hedge: Why and How." *Journal of Futures Markets* 11 (1991): 200-212.

Harrison, R. W. "Risk Sharing Through Contractual Arrangement: An Application to the Feeder Cattle Industry" PhD-thesis, University of Kentucky, 1994.

Hauser, R.J., and D.K. Andersen."Hedging with Options under Variance Uncertainty: An Illustration of Pricing New-Crop Soybeans." *American Journal of Agricultural Econonomics* 1987

Heifner, R.G., B.H. Wright, and G.E. Plato. "Using Cash, Futures, and Options Contracts in the Farm Business." USDA Economic Research Service, Agricultural Information Bulletin 665 April 1993.

Hirschleifer, D. "Risk, Futures Pricing and the Organization of Production in Commodity Markets." *Journal of Political Economy* 96 (1988):1206-1220.

Hirschleifer, D. "Futures Trading, Storage and the Division of Risk: A Multiperiod Analysis" *Economic Journal* 6 (September, 1989): 700-719.

Lolly, R.W. "Risk Management in Agriculture Production" *American Journal of Agricultural Economics* (1983):1107-1113.

Lapan, H., G. Moschini, and S.D. Hanson."Production, Hedging, and Speculative Decisions with Options and Futures Markets." *American Journal of Agricultural Economics*. 73 (February 1991):66-74.

Kimbal, M.S. "Farmer's Cooperatives as Behavior Towards Risk." *American Economic Review* 78 (1988):224-232

Merton, R.C. "Theory of Rational Option Pricing." *Bell J. Econ. and Mgmt.Sci* 4 (1973):141-83

Nelson, R.D."Forward and Futures Contracts as Preharvest Commodity Marketing Instruments." *American Journal of Agricultural Economics* 67 (February 1985): 15-23.

Paroush, J and Wolf A. " Production and Hedging Decisions in the Presence of Basis Risk" *Journal of Futures Markets* 9 (1989): 547-563.

Paul, A., R. Heifner, and J. Helmuth. "Farmer's Use of Forward Contracts and Futures Markets." *Agricultural Economic Report No.320*, 1976, USDA, Economic Research Service.

Pennings, J.M.E., and M.T.G. Meulenberg."Hedging Efficiency: A Futures Exchange Management Approach" Working paper Wageningen Agricultural University, 1995.

Pennings, J.M.E., W.J.M. Heijman and M.T.G. Meulenberg."Environmental rights on the futures markets: An Application to the Dutch Manure Market." Forthcoming *Environmental and Resource Economics* 1996.

Pennings, J.M.E., W.E. Kuiper, F Ter Hofstede and M.T.G. Meulenberg "Futures Market Depth: A Price Pattern Model." Working paper Wageningen Agricultural University, 1995.

Sakong, Y., D.J. Hayes and A. Hallam. "Hedging Production Risk with Options." *American Journal of Agricultural Economics* 75 (May 1993):408-415.

Stoll, H.R., and R.E. Whaley. *Futures and Options, Current Issues in Finance*, South-Western Publishing, Ohio, 1993.

Thompson, S.R., M.L. Waller and, D. Seibold. "Comparison of Liquidity Costs Between the Kansas City and Chicago Wheat Futures Contracts". *Journal of Agricultural and Resource Economics* (1993) 18:185-197.

Working, H."New Concepts Concerning Futures Markets and Prices." *American Economic Review* (1962) 52: 431-459.

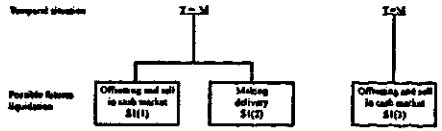

Figure 1 Hedging strategies in the case of futures.

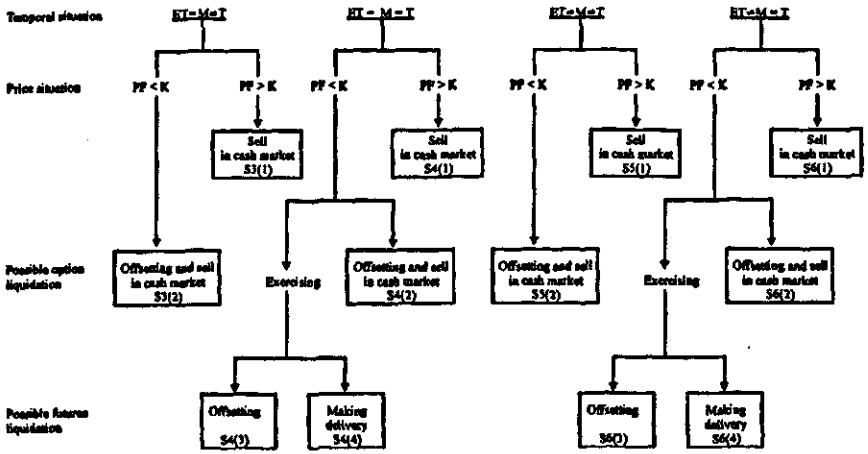

Figure 2 Hedging strategies in the case of options.

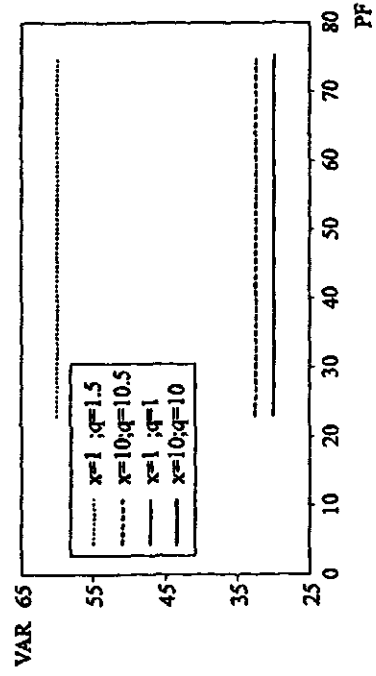

Figure 3 Variance introduced by futures

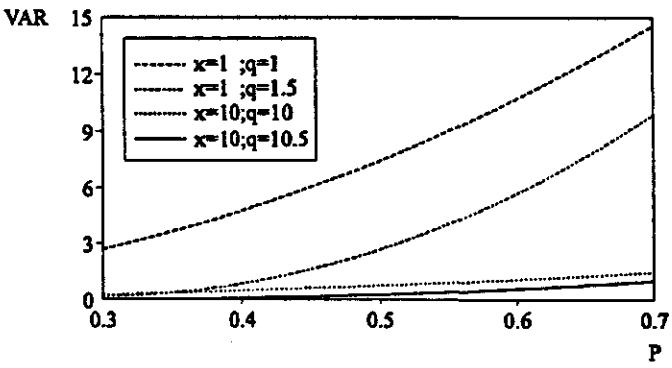

Figure 4 Variances introduced by options