Relative Forecasting and Hedging Efficiency of Agricultural Futures Markets in the European Union: Evidence for Slaughter Hog Contracts

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Abstract

The paper aims at analyzing the potentials for reducing income risk and income variation for slaughter hog producers in Germany and Holland by participating at futures markets in Amsterdam or Hannover. The relative market and hedging efficiency for the Amsterdam stock exchange markets is tested and the optimal hedge ratio is derived for minimizing risk and variance of slaughter hog gross margins (income). Relative market efficiency and a significant impact of hedging on income risk and variance can not be rejected. The results show that the optimal hedge ratio is smaller for variance compared to risk minimizing hedging strategy.

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Abstract

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1 Introduction

Many studies have been undertaken to analyze the relative performance of futures markets regarding their primary functions, such as collection and dissemination of information, facilitating risk management, and providing price anticipations.[1] Recent examples in the field of agricultural future markets are presented by Kellard et al. (1999), Graham-Higgs et al. (1999), or Fortenberry and Zapata (1997). Except for Graham-Higgs et al. (1999), these studies analyze the functioning of US agricultural futures markets where futures contract trading has a long tradition and trading volume is significant.

In this study we use data from Amsterdam Stock Exchange (AEX, Holland) and from Warenterminbörse Hannover (Future Exchange, WTB, Germany) to analyze the forecasting performance and the hedging efficiency of slaughter hog contracts by using weekly slaughter hog contract prices for the period from 1991 to 1999. Two series of regional producer prices in Northern Germany are employed to represent cash market prices in Germany and Holland.[2] Neither the AEX nor the WTB have neither a long tradition. Contract trading volume on both markets are low. The forecasting performance and the hedging efficiency are evaluated from the perspective of hog producers in Northern Germany which have equal access to both futures markets.[3]

The paper is structured as follows: In the first section we estimate the variance of the slaughter hog gross margin and the price risk that slaughter hog producers face in Germany and Holland. Both measures indicate significant incentives for risk and variance (income) averse farmers to participate in futures trading. In section 2, the relative efficiency of the futures market in Amsterdam is analyzed by its predictive performance with respect to cash market prices at the time of maturity for different forecasting horizons, including the time span covering the production cycle of about 18

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[1] See originally Giles and Goss (1981) or cited in Graham-Higgs et al. (1999).
[2] As the WTB started business in 1996, data for this market are only available since then.
[3] Because of a quasi fixed exchange rate between the Dutch and the German currency (European Agrimonetary System and European Monetary Union), the impact of exchange rate variation or risk can be neglected.

weeks.[4] Cointegration and time series techniques are applied to evaluate the forecasting performance. Section three is dedicated to the simulation and evaluation of the risk and variance minimizing hedging strategies. In the end, we summarize our findings.

2   The role of price risk and income variation

Income variance

Variation of economic variables is often measured by the standard deviation or the variance over time. Risk or uncertainty is quantified by various measures of forecast errors, such as the root of the mean square error or the mean absolute deviation. If non of the change in a variable is predictable, the measures of variation and risk are identical. Otherwise, measures of variation exceed the respective measures of risk.

On the one hand agents might be concerned about income stabilization. In this case, the primary goal is to minimize the standard deviation of income. For hog producers the gross margin is the key variable to measure income from production of slaughter hogs. On the other hand agents might look for risk reduction. In that case, the main goal might be to minimize the root of the mean square forecast error of the income variable. Reasons for aiming to reducing the variance and/or the risk of income are based on common motives of risk aversion and income stabilization, such as the aim of reducing the likelihood of an insolvency, or on potential gains from improved production planning.[5] Besides risk reduction and income stabilization agents seek to maximize their expected income. These goals often show trade off relationships. For instance, producers that hedge price risks on efficient futures prices reduce their expected income by the costs of transaction for trading contracts, assuming that the expected sales revenues are not affected by a hedge strategy. In our analysis, we do not investigate this interrelationship and focus exclusively on the potential impact of futures trading on risk reduction and income stabilization.[6]

The gross margin per hog (π_t^H) is taken as a measure of income generated by the production of hogs.[7] In the following we assume that the farmer's income originates exclusively from producing and selling slaughter hogs. Producers are buying all necessary variable inputs, in particular piglets (price of the piglets per kg times the weight at the time of purchase: $w^P p_{t-18}^P$), water and electricity, and feed instead of producing them on the farm. Water and electricity cost can be assumed to be constant over time, estimates of these costs are about 30 DM (German Mark) per hog.[8] Feeding cost are also relatively constant through time, though slightly decreasing. Thus, variable inputs, except piglet costs, are assumed to be constant. CMC indicates the marginal

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[4] Fattening piglets of 20 to 25 kg live weight to live slaughter hogs between 100 and 11o kg live weight takes around 18 weeks.

[5] Forecast errors indicate a two-sided notion of risk which has a long standing tradition in the finance literature (Lien and Tse, 1998). However, Adams and Montesi (1995) point out that agents might more often be interested in the "bad" realizations of risk. They might be more concerned about potential losses (downside risk) than potential gains to reduce the problem of insolvency. We have not followed this definition here and leave it to future research in this case.

[6] We also presume that the uncertainty about production is negligible.

[7] For the weight of piglets and the weight of finished slaughter hogs 25 and 110 kg live weight are assumed respectively.

[8] See Kühnle and Dabbert (1999).

input costs per kg of slaughter hog.[9] Revenues from hog production equal the price of slaughter hogs times the standard weight: $w^H p_t^H$. The gross margin per hog is calculated by the following equation:

$$\pi_t^H = w^H p_t^H - w^P p_{t-18}^P - w^H CMC.$$ (1)

To illustrate the extent of the variation in the gross margin, in Figure 1 weekly and annual gross margins are shown. The weekly (annual) margins vary from –50 to 150 DM (-10 to 50) per hog in the period from 1991 to 1999.

Include Figure 1 here

Over the entire period of observation the average gross margin is about 30 DM per hog.[10] The variation in the gross margins is mainly caused by the variation of slaughter hog prices. Without considering the correlation between piglet and slaughter hog prices, the variation of the slaughter hog prices make 75 % of the variation of the gross margins. A constant slaughter hog price, however, would lead to a reduction of the variation by 33 % which indicates the stabilizing effect of the input-output price correlation. Because of this positive correlation between hog and piglet prices, a stabilization of piglet prices would have a negative impact on the variation of the gross margin. Thus, producers who diversify their production by including the production of piglets, which is assumed to stabilize the piglet costs in the production of slaughter hogs, would cause an increase of the variation of the gross margin.[11]

Besides the strategy to reduce the income variation by producing piglets on the farm, farmers try to produce and sell their slaughter hogs continuously instead of selling larger numbers at less points in time. To measure the difference between the two strategies, we first calculate the annual average in the gross margin (continuous strategy). Second for the discontinuous strategy the time interval between deliveries is 18 weeks. For instance, we use the first week of a year, week 19 and week 27, and calculate the average from these realizations for the weekly gross margin. This is the average gross margin for a producer that applies discontinuous delivery and starts in the fist week. For a time interval between deliveries of 18 weeks, we have 18 different starting weeks. For these we employ the same calculation. Thus, for the discontinuous delivery we result 18 average annual gross margins depending on the starting week. In Figure 2, the annual average gross margins for the two delivery strategy are shown. As the discontinuous strategy has 18 different values, the range of these is indicated.

Include Figure 2 here

If producers change from discontinuous delivery (e.g. every 18 weeks) to almost continuous delivery (every week), then the standard deviation of the annual gross margins over the sample period from 1991 to 1999 decreases from 19.3 to 18.9 DM (-2,2 %). Depending on the starting point the standard deviation in the case of discontinuous delivery varies between 16 and 23 DM per hog. Thus, even though the income variance is reduced by approaching continuous delivery, half of the potential

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[9] Any losses in the production process are also captured in the CMC term.

[10] Cash market prices and the futures market prices in Hannover are based on slaughter hog weight. To calculate live weight prices, we use a transmission coefficient of 1.25 to transform slaughter weight into live weight prices.

[11] The reverse is likely to hold from the perspective of farmers that exclusively raise and sell piglets.

realizations for the discontinuous selling strategy indicate a lower variation in the gross margin compared to the continuous delivering strategy.

The continuous delivery strategy would work most effectively if hog prices were stationary around an unconditional mean.[12] However, if the variation over time is primarily driven by the variation over long-term time intervals, then the potential impact of a continuous delivery strategy on the income variation is limited. As slaughter hog producer prices indicate significant variations in mean prices between years (variation over long-term time intervals), no significant reduction of the income variation results from a continuous selling strategy (-2.2 %).

Income risk
As piglet prices are known by the time of starting the fattening period, and feeding and other variable production costs do vary much over the production cycle, slaughter hog prices predominantly determine the short-term risk or uncertainty of gross margins. Hedging on the futures market might reduce the income risk that is caused by the slaughter hog price uncertainty. If future prices indicate a (cointegrated) linear long-run relationship to the cash prices with parameters –1 and 1, the standard risk minimizing strategy would be a full hedge. When producers prefer to minimize their income variation instead of income risk, then the hedging strategy has also to consider the variation of other variables that determine the gross margin. We focus here on hog producers which hedge their production in the short-term, respectively the next production cycle. As all marginal input costs, except the expenditures for piglets, were assumed to be constant, the gross margin at time t is expressed by the following equation:

$$\Pi_t = q^S \left(p_t^{HS} - w^* p_{t-18}^{PS} - CMC \right) + q_{t-18}^F \left(p_{t-18}^{HF} - p_t^{HF} \right) \tag{2}$$

The superscripts indicate prices (DM/kg) or quantities (kg) traded on the cash (spot) (S) or on the futures (F) market. CMC is the sum of marginal costs which do not include the expenditures for piglets. W* is a weighting factor to account for the ratio between input and output quantity. W* is equals the assumed fixed average ratio of piglet to slaughter hog weight of 25 to 110.[13]

From calculating the variance and its first derivative with respect to the quantity hedge on the futures market the income variation minimizing hedge ratio follows.

$$\frac{q^F}{q^S} = \frac{Cov\left[p_t^{HS}, p_t^{HF} \right] + Cov\left[p_{t-18}^{HF}, p_{t-18}^{PS*} \right] - Cov\left[p_t^{HS}, p_{t-18}^{HF} \right] - Cov\left[p_t^{HF}, p_{t-18}^{PS*} \right]}{Var\left[p_t^{HF} \right] + Var\left[p_{t-18}^{HF} \right] - 2Cov\left[p_t^{HF}, p_{t-18}^{HF} \right]}$$
$$\tag{3}$$

Compared to the price risk minimizing hedge ratio equation (3) shows that the hedge ration can become negative even for a linear relationship between futures and cash

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[12] If prices were represented by a constant plus a white noise error term, the variance of average prices decreases by a rate equal to the root of the number of selling dates, which follows from the central limit theorem.

[13] The impact of other factors on the income variation or risk, such as fixed contract quantities, margin calls, or market liquidity, are not considered in this analysis.

market price with a positive slope coefficient.[14] If the futures market price at time t-18 (point of time when production starts) shows a one to one relationship to the contract price at the time of maturity, then no optimal hedge ratio can be determined. In this case hedging has no (positive or negative) impact on the income variance. The hedge ratio in absolute terms decreases with increasing variability of futures market prices.

3   Relative futures market efficiency

A significant social benefit of futures markets is the provision of an efficient price discovery which helps producers and consumers (slaughter houses and meat packers) to better plan their production and processing decisions. The efficiency of the price information provided on futures markets can be measured by the relationship between prices on futures and respective cash market (Fortenberry and Zapata, 1997), which is a necessary condition for price risk reducing effect of hedging (low basis risk).

Futures market prices should in addition indicate a competitive price forecast for the cash market at the time of maturity of the contract. We employ both non-overlapping and overlapping data to analyze the basis risk and the forecasting performance of futures prices of slaughter hogs at the AEX. The use of non-overlapping data avoids problems arising from autocorrelated errors and endogeneity to result unbiased estimates for the linear long-run price relationship to derive the optimal hedge ratio (see Hansen and Hodrick, 1988). To generate forecasts for every point in time overlapping data have to be used as the frequency of contracts is lower than the frequency of observations, thus all available information captured in futures market prices is exploited to test the forecasting performance. Producer prices for slaughter hogs from two regions in Northern Germany are used to represent cash market prices in Germany and in Holland.[15]

We start with estimating the relationship between the cash market price at the time of maturity and the futures price for 1 to 3 weeks before maturity. In Figure 3 future prices three weeks before maturity and cash prices at the time of maturity are shown (non-overlapping data).[16] Product heterogeneity between futures and cash market causes cash prices to be normally higher than futures prices.[17]

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[14] A negative hedge ration indicates that producers should buy instead of sell contracts to minimize their income variation.

[15] The series are almost statistically identical. In addition, producer prices between Northern Germany and Holland are highly interrelated. Estimations for a data set provided by Cramon-Taubadel, Loy, and Mußfeldt (1995) over the period from 1989 to 1992 show that German and Dutch slaughter hog prices are highly correlated, integrated of order one, and the null hypothesis of a cointegrating vector equal to (1,-1) cannot be rejected at the 95 % significance level. Normal distribution, zero correlation, regular and conditional homoscedasticity for the residuals from this cointegrating relationship can also not be rejected at the 95 % significance level.

[16] Weekly data are available for the cash market. Daily futures prices have been averaged to generate weekly observations. 12 different live hog contracts are traded for roughly 6 month each with every month as a maturity date. Cash prices are quoted for slaughter weight, therefore, futures prices have simply been multiplied by 1.2 which is a reasonable coefficient to transform live weight to slaughter weight. Weekly market exchange rates between German Mark and Dutch Guilda have been used to results future prices in German Marks.

[17] On the futures market in Amsterdam hogs of classification U with a minimum share of 50 % muscle meat is traded. On the German markets predominantly pork of classification E is traded (minimum share of 56 % muscle meat). Some of the deviation could also be the effect of the spatial basis.

Include Figure 3 here

The stationarity assumption is tested by various procedures. For the different procedures the hypothesis of integrated processes of order one can in most cases not be rejected for cash and futures market prices.[18] The hypothesis of cointegration between futures and cash market price series is also not rejected and the cointegrating vector is equal to (-1,1).[19] However, the causal relationship is bi-directional. The residuals from the linear long-run price relationship do not show significant autocorrelation or conditional heteroscedasticity for various lags. Thus, the futures price provide an unbiased prediction of cash prices. As no lagged adjustments (autocorrelations) are indicated, market efficiency cannot be rejected. More than 90 % of the variation of cash prices is explained by the variation of the futures prices in short-term forecast (1 to 3 weeks). The precision of predictions decreases with the forecast horizon. For instance, the 18 weeks ahead forecast indicates a coefficient of determination of only 63 %.

Include Table 1 here

While the analysis of non-overlapping data is employed to test the market efficiency hypothesis and to result estimates for the optimal hedge ratio, we use all available information to generate the "best" forecast at the frequency of observations. Market participants generally need to predict prices at each point in time and not only for the periods based on the frequency of futures contract maturity.

To evaluate the predictive power of futures prices, we compare price forecasts with results from other models, such as naïve expectation or time series models.[20] As only 12 contracts (monthly) are offered each year, we have to use 4 to 5 futures market price quotations for each contract to predict the respective cash market prices on a weekly basis. Thus, the periods ahead of the time to maturity vary between the pairs of observations. We choose to switch between contract whenever the time to maturity is equal to the time horizon of the forecast. For instance, contract prices in July (week 1 to 5) from the contract with the maturity at the end of August are used to predict spot prices in August (week 1 to 5) to generate a four week ahead forecast. Thereby it is ensured that futures prices are used that are available at the time of the forecast and the time of maturity is always the closest to the respective forecast horizon.

The slaughter hog production cycle is about 18 weeks. Producers who plan to hedge their short-term production need to sell short 18 weeks ahead. As for the weekly prediction 18 weeks ahead contracts with a maturity closest to the end of the production period are employed. Contract trading generally starts about 5 month ahead of the time of maturity. Because trading volume is low in the beginning, contracts are likely to be used only for short term hedging. To hedge longer-term productions, a rolling hedges have to be used which are not analyzed here. In Figure 3, the naïve forecast and the futures prices 18 weeks ahead from maturity are compared to the cash market prices at the time of maturity.

Include Figure 4 here

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[18] We have applied the procedures by Dickey und Fuller (ADF-Test), Phillips und Perron (1998) and by Kwiatkowski et al. (1993).

[19] The Procedure by Johansen is used to test the lon-run cointegrating price relationship.

[20] As already mentioned the cash market prices are non-stationary. We also estimated various ARIMA-model specifications, however, non of these were significantly better than the naïve expectation model (random walk).

The data in figure 4 indicate that both forecast procedures (futures market prices and naïve expectations) produce significant forecast errors. The futures price predictions show significantly reduced forecast errors compared to time series based forecasts or naive expectations. In addition, futures prices 18 weeks ahead of the time of maturity indicate less variation than cash market prices. As for the non-overlapping series, the stationarity assumption is violated for these series. Even though employing futures prices does improve price prediction, estimation of various ARIMA-model specifications did not results in significant improvements compared to naïve expectations.[21]

<center>Include Table 2 here</center>

Futures and cash prices are cointegrated and the hypothesis that the long-run multiplier is different from 1 could not be rejected. The results is Table 2 for the prediction using futures market prices is therefore based on this restriction.

Futures market prices result an efficient and unbiased forecast of cash market prices. The forecasting performance in significantly improved against the naïve expectations model. However, even the futures prices indicate a low level of precision of forecasts. The degree of determination is about 63 % (43 %) for futures prices (for the naive expectations). In the next section futures trading strategies are tested to which extent the price risk can be hedged.

4   Hedging efficiency

Producers in Germany and Holland can employ futures contracts at the Amsterdam or the Hannover stock exchange. The Dutch contract is specified for live hogs, while the German is based on slaughter weight. Both contracts have a volume equivalent of about 100 hogs. Twelve contracts are offered each year with maturity dates in each month. We assume that farmers continuously delivers 100 hogs per week through the entire year. To simulate the impact of hedging we further assume that he/she always hedge the whole production, meaning each week one contract is bought and one contract is settled. As the estimation for the relationship between futures and cash market prices indicate a long-run relationship with slope parameter of nearly 1, the full hedge is a risk minimizing strategy.

We do not consider any risks induced by hedging, such as roll-over-risk, standard quantity risk, margin risk, lumpiness risk, and risks due to thin markets etc. (Pennings, 1997), except the basis risk which occurs when contracts are saddled which is assumed here. The extent of the basis risk indicates the efficiency of hedging. The basis risk is measured by the standard deviation of the difference between nearby maturity contract prices and the cash price at the time the hogs are sold on the cash market and the futures contract is settled. From the estimation of the relationship between nearby futures and cash prices we obtain a basis risk of about 0.10 DM per kg slaughter hog weight (estimated standard deviation of residuals), which indicates a reduction of the price risk of about two third compared with the forecast error. In Figure 5 the nearby futures and cash prices are shown.

<center>Include Figure 5 here</center>

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[21] These results are not reported here, but can be obtained from the authors.

Futures prices significantly ahead of the time of maturity show less variation than cash prices. Thus, hedging might not only minimize the income risk from hog production, but eventually also reduce the total variation of the gross margin. To test this hypothesis we compare the annual average gross margin per hog for a producer that is continuously delivering hogs on the cash market with the gross margin for a hedger who employs futures contracts under a full hedge strategy.

Include Figure 6 here

Without hedging the annual average gross margin per hog varies from –10 to 50 German Mark; with a full hedge strategy the margin ranges between 20 and 35 DM in the sample period. Measured by the standard deviation over the entire period of observation, hedging reduces the price risk by about two third and stabilizes the annual gross margin significantly by about 50 %. Besides, hedging appears to generate an extra profit during that period. Over the entire period from 1991 to 1999 producers that fully hedged their production ended up with an increase of 5 German Mark in the gross margin. This extra profit cannot be explained by the costs of hedging which are about 2 DM per hog. The increase is caused by the exceptional price fall in 1998. During periods with falling prices hedging is often profitable and especially during that year. If we leave 1998 out the average gross margins are nearly equal between the scenarios with and without hedging. In that situation the producer seems to be willing to pay the costs for the hedging as a refund for the risk reduction effect.

The optimal hedging strategy for minimizing the total variance of the gross margin, which is derived in equation (3), we result an optimal hedge ration of 81 %. Applying this hedge ratio result in a further decrease of the total variance of about 6 % compared to the full hedge strategy. Thus, income risk minimizing and income variance minimizing strategies result in fairly similar strategies and outcomes.

5   Amsterdam versus Hannover

Since the opening of the Hannover Stock Exchange in 1996 hog producers in Germany have a second futures market to hedge their production. To test whether these markets are equal efficient regarding hedging, we compare futures prices of Hannover with futures prices in Amsterdam with the same times to maturity.

We compare 7 different series, such as nearby contract prices, one month ahead to 6 months ahead from maturity contract prices. Markets are equally efficient if the price series are highly correlated (cointegrated) and if the differences between the series which are caused by the differences in the contract specification are constant between the various times to maturity. The coefficient of determination increases from 81 % to 96 % from 6 months ahead from maturity contract prices to nearby contract prices. In most cases a linear log-run relationship is indicated with slope coefficient of 1. The larger market in Amsterdam is generally tested to be weakly exogenous. The average price differences between the respective series decreases with the time to maturity; however, this change is fairly small and likely well below the costs of arbitrage transactions. Thus, with respect to the basis risk the markets in Hannover and Amsterdam appear to be equally efficient. However, other risks of futures trading, especially those related to the trading volume, might be higher at Hannover as the trading volume there is well below to the trading volume in Amsterdam

6   Summary

In this paper we analyze the relative market and hedging efficiency of the Amsterdam Stock Exchange contract for live hogs in Amsterdam. Relative market efficiency is not rejected if futures prices can be employed as efficient and unbiased short-term forecast of cash prices. The hedging efficiency is measured by the impact of optimal hedging on the extent of income (price) risk and variance. Using futures contract prices of live slaughter hogs the market efficiency hypothesis cannot be rejected for the futures market in Amsterdam. Forecasts errors for non-overlapping data do not indicate autoregressive or moving average components which would indicate potential inefficiencies. The prediction of cash prices by employing futures prices performs significantly better than predictions base on naïve expectations or different ARIMA model specifications. Even though the futures price forecasts seem to be competitive, for medium-term time horizon, such as for an 18 weeks time span (production cycle), significant forecast errors are obtained. Therefore, hedging might be used to reduce the price risk. The simulation for a full hedge strategy, which is the risk minimizing strategy in this case, reveals that hedging reduces the price risk by two third. In addition, as futures prices are less volatile than cash prices, the gross margin with hedging shows less variation than without hedging. Compared to the full hedge, the application of the variance minimizing strategy does only lead to a slight reduction in the total variance of the gross margin. For hog producers in Germany and Holland the futures markets in Amsterdam and Hannover indicate equally efficient market places to hedge the production of slaughter hogs. As trading volume is significantly lower in Hannover, risks related to the trading volume are likely to be lower in Amsterdam. Different contract specifications, however, might lead producers to favor either one.

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8   Table and Figures

***Fig. 1:Annual and weekly gross margins per hog (110 kg live weight) in DM (German Mark) from 1991 to 1999***
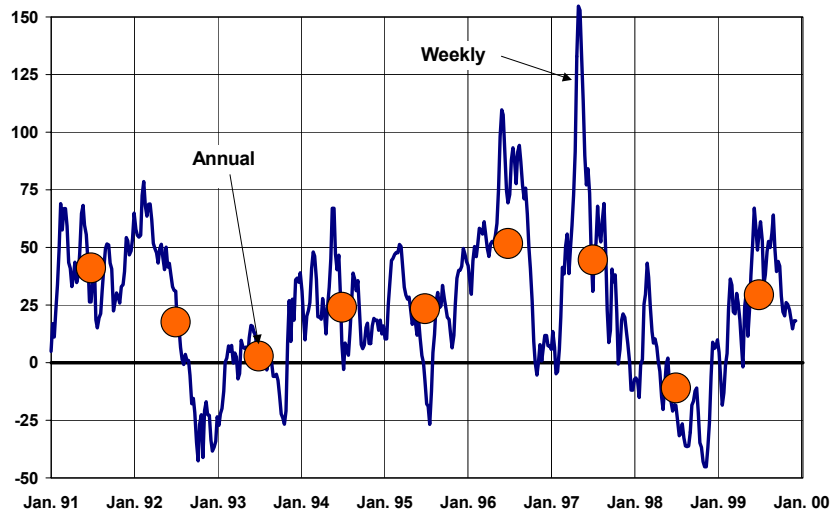
Source: Data from County Ministry of Agriculture in Schleswig-Holstein, Federal Ministry of Agriculure, and Amsterdam Stock Exchange (AEX).

Fig. 2:Annual gross margins per hog (110 kg live weight) for farmers in Northern Germany with continuous or discrete delivery in German Mark from 1991 to 1999
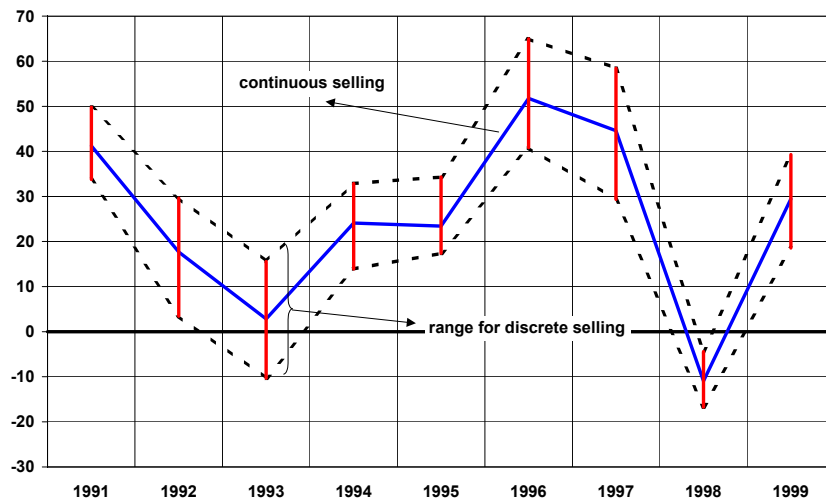
Source: Data from County Ministry of Agriculture in Schleswig-Holstein, Federal Ministry of Agriculure, and Amsterdam Stock Exchange (AEX).

Fig. 3: **Futures (1 week from maturity) and cash prices for slaughter hogs in Amsterdam and Northern Germany in German Mark from 1991 to 1999**
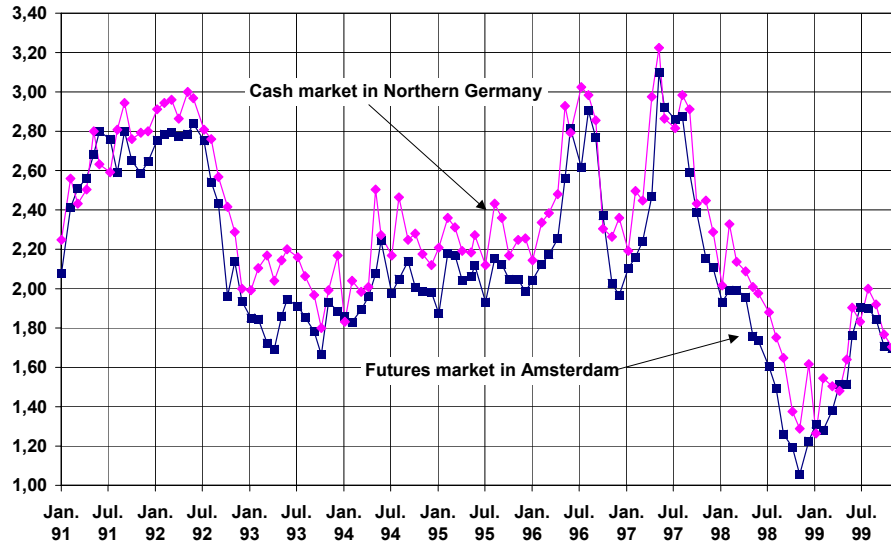
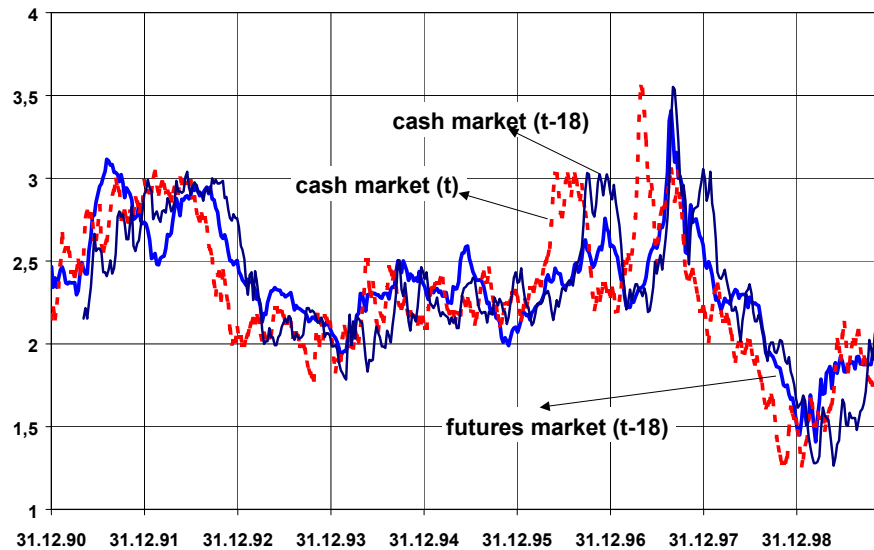*Source: Data from County Ministry of Agriculture Schleswig-Holstein and Amsterdam Stock Exchange (AEX).*

Tab. 1: **Results for the OLS estimation and the Johansen procedure of the relationship between cash and futures prices for non-overlapping periods from 1991 to 1999**

Futures price	Cash price $\left(p_t^C = \hat{\beta}_0 + \hat{\beta}_0 p_{t-i}^F + \hat{u}_t \right)$						
	$\hat{\beta}_0$	$S\left(\hat{\beta}_0\right)$	$\hat{\beta}_1\left(\hat{\beta}_1^*\right)$	$S\left(\hat{\beta}_1\right)$	R^2	DW	$ARCH$
p_{t-3}^F	0.29	0.07	0.94 (0.99**)	0.03	0.89	2.01	0.07
p_{t-2}^F	0.33	0.06	0.92 (0.95**)	0.03	0.91	1.88	0.26
p_{t-1}^F	0.31	0.04	0.93 (0.94**)	0.02	0.95	1.67	0.67

*Legend: $\left(\hat{\beta}_1^*\right)$: Results for beta 1 obtained from the Johansen (1988) procedure, which has been run with the minimum number of lags necessary for that procedure (lag 1) . ** The hypothesis of one linear long-run relationship (cointegrating vector) between cash and futures prices could not be rejected at the 99 % significance level. The hypothesis that the slope coefficient is equal to 1 could not be rejected, except for p_{t-1}^F at the 95 % significance level. The Null-hypothesis of homoscedasticity and normality could not be rejected, except the normality assumption of residuals in the case of p_{t-1}^F.*

Source: Data from County Ministry of Agriculture Schleswig-Holstein and Amsterdam Stock Exchange (AEX). PcGive/PcFiml,version 9.0 is used to estimate the models (Doornik and Hendry, 1999).

Fig.4: Futures (18 to 23 weeks from maturity), current and lagged (18) cash prices for slaughter hogs in Northern Germany in German Mark from 1991 to 1999

Source: Data from County Ministry of Agriculture Schleswig-Holstein and Amsterdam Stock Exchange (AEX).

Tab. 2: Predictions base on naïve expectations and on futures prices for a time horizon of 18 weeks from 1991 to 1999

Jan. 91-Dez. 99	Naive Expectations	Futures prices	Change in %
MAD	0.34 DM/kg	0.26 DM/kg	-24 %
RMSE	0.45 DM/kg	0.33 DM/kg	-27 %
R^2	43 %	63 %	+47 %
Standard deviation	0.54 DM/kg	0.46 DM/kg	-15 %
Coefficient of variation	19 %	16 %	-16 %

Source: Source: Data from County Ministry of Agriculture Schleswig-Holstein and Amsterdam Stock Exchange (AEX). PcGive/PcFiml,version 9.0 is used to estimate the models (Doornik and Hendry, 1999).
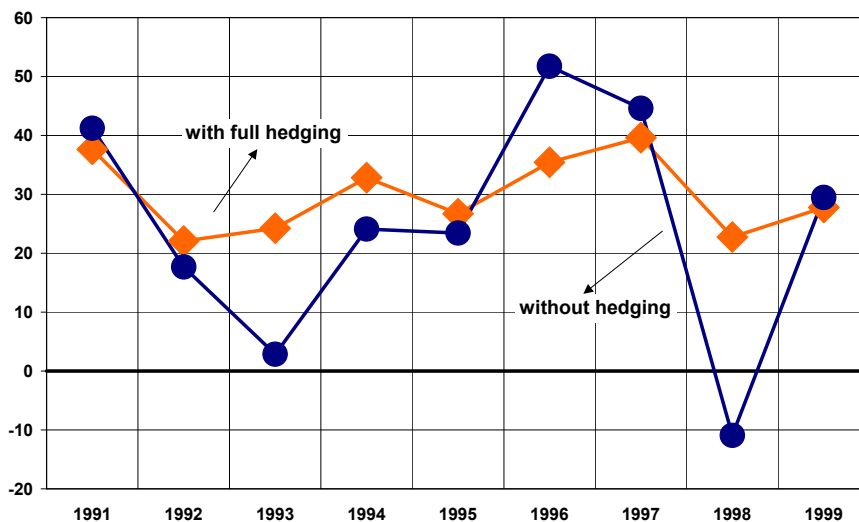
Fig. 5: Nearby futures (Amsterdam) and cash prices (Northern Germany) in German Mark from 1991 to 1999
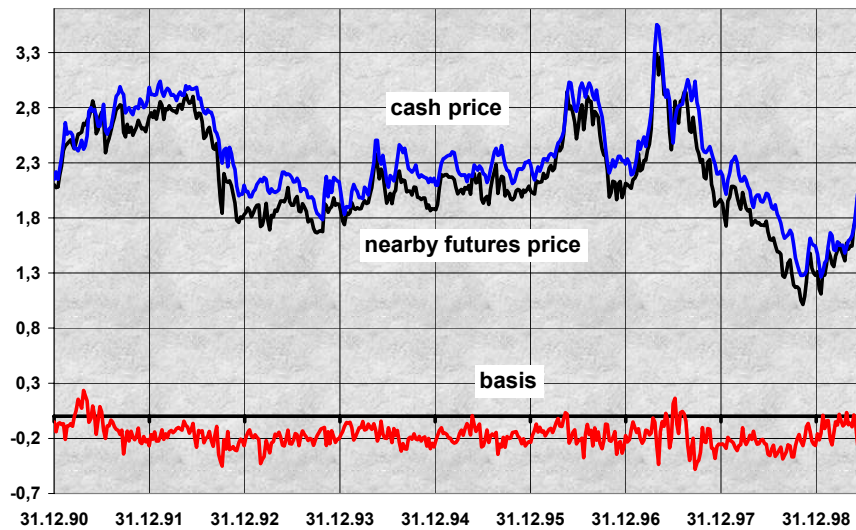
Source: Data from County Ministry of Agriculture Schleswig-Holstein and Amsterdam Stock Exchange (AEX).

Fig. 6: Annual average gross margins per hog for producers in Northern Germany with and without hedging at the Amsterdam Stock Exchange in German Mark from 1991 to 1999

Source: Data from County Ministry of Agriculture in Schleswig-Holstein, Federal Ministry of Agriculure, and Amsterdam Stock Exchange (AEX).