ELSEVIER

Journal of International Money and Finance
20 (2001) 659–675

Journal of International Money and Finance

www.elsevier.com/locate/econbase

# Introducing new futures contracts: reinforcement versus cannibalism

Joost M.E. Pennings [a, b,*], Raymond M. Leuthold [b]

[a] *Wageningen University, Department of Social Sciences, Marketing and Consumer Behavior Group, Hollandseweg 1, 6706 KN Wageningen, The Netherlands*

[b] *University of Illinois at Urbana-Champaign, Office for Futures and Options Research, Department of Agricultural and Consumer Economics, 326 Mumford Hall, MC-710, 1301 W. Gregory Drive, Urbana, IL 61801, USA*

**Abstract**

In order to assure survival, futures exchanges around the world are in constant search of new futures contracts that will generate a profitable level of trading volume. Introducing new futures contracts may increase or decrease the volume for those contracts already listed. Using a multi-product hedging model in which the perspective has been shifted from portfolio to exchange management, we study these effects. Using data from two exchanges that differ regarding assets traded and market liquidity (Amsterdam Exchanges versus Chicago Board of Trade) we show the usefulness of the proposed method. The method may also be used to evaluate the benefits for exchanges that plan to internationalize their activities by merging with another exchange or by cross listing other exchanges' futures contracts. 

*JEL classification:* G1

*Keywords:* Cannibalism; Futures exchange; New futures contracts; Multi-product hedging model; Reinforcement

## 1. Introduction

In financial literature it is argued that the success of a futures contract is heavily dependent on both its design and the characteristics of the underlying asset's spot

* Corresponding author. Tel.: +31-317-482205; fax: +31-317-484361.
*E-mail address:* joost.pennings@alg.menm.wau.nl (J.M.E. Pennings).


PII: S0261-5606(01)00013-4

market (Black, 1986). Gray (1987) identifies the importance of contract design. He argues that a futures contract must reflect the commercial movement of the asset both closely and broadly enough to avoid price distortions resulting from specifications in the futures contract. An empirical study by Silber (1981) concludes that futures contracts whose specifications closely reflect the needs of hedgers seem more likely to succeed. Tashjian and McConnell (1989) show that hedging effectiveness is a very important determinant in explaining the success of futures contracts. In accordance with these recent findings, particular attention has been paid to hedging effectiveness. Authors who have proposed measures of hedging effectiveness include Ederington (1979), Hsin et al. (1994), Chang et al. (1996) and Pennings and Meulenberg (1997). Common to all these measures is an attempt to indicate the extent to which hedgers are able to reduce spot price risk by using futures contracts. It has also been argued that the motivation for hedging is not to reduce *spot price risk* of a single asset or commodity but to reduce the *residual risk* of the firm (Anderson and Danthine 1980, 1981; Rolfo, 1980; Zilcha and Broll, 1992). This implies that it may be of interest to an exchange to add to the existing futures contracts new ones that provide the hedger with the opportunity to cover his/her residual risk. This raises an important theoretical and practical question for a futures exchange: is it beneficial to add new futures contracts to those already listed? This question is also relevant in the context of the current development of internationalization of the futures industry, as reflected in mergers and sharing one's trading systems. Such development results in relative new futures contracts being available for an exchange's customers. In such a situation exchanges faces the challenge to evaluate the benefits of their internationalization efforts for their own futures contracts.

In this paper we address this issue by utilizing and then departing from a multi-product hedging model. In contrast to previous research in this area (e.g. Anderson and Danthine, 1981; Duffie and Jackson, 1989; Myers and Thompson, 1989; Fackler and McNew, 1993; Tashjian and Weissman, 1995), we shift the perspective from portfolios to exchange management. Utilizing the properties of a multi-product hedging model we establish a framework that derives the consequences of adding a new futures contract for the optimal hedging ratios of the existing contracts and therewith their trading volume.[1] We show that the introduction of a new futures contract might indeed increase the trading volume of the futures contracts already listed (i.e. reinforcement). However, under certain conditions, the listing of a new futures contract could also lead to a volume decrease for the existing futures contracts (i.e. cannibalism).

This paper applies a multi-product hedging model for a hedger managing a portfolio of assets who faces price risks in these assets and whose only available hedging instruments are futures contracts on these assets. Since the hedging literature is often in the context of a firm who is managing his/her inputs and outputs (i.e. the firm's production process portfolio), we use this context to introduce our method. First, we

[1] Speculators also determine the trading volume. Following the notable work of Working (1953) we assume that the behavior of speculators can be seen as being dependent on hedgers' actions.

focus on the optimal hedging ratio for a firm with multiple hedging opportunities, i.e. the optimal portfolio of futures contracts to hedge the residual risk of the firm. Second, we derive the conditions for futures contract reinforcement. The managerial implications of our findings are demonstrated empirically, using data from the Chicago Board of Trade on the soybean complex and from the Amsterdam Exchanges on financial futures taking liquidity costs into account.

The paper is organized as follows. In Section 2 we present a multi-product hedging model, while Section 3 is devoted to the analysis of reinforcement, assuming optimal multi-product risk minimizing hedging. Section 4 presents findings for the soybean complex traded on the Chicago Board of Trade and for financial futures traded on the Amsterdam Exchanges, the latter being a relatively thin market. In Section 5 the managerial implications for futures exchanges are discussed.

## 2. Multi-product hedging model

The vast majority of investigations into the optimal hedging strategy for a risk-averse firm have focused on managing the risk of a single input or output in a setting of price risk and in some cases also uncertain production (see, for example, Ederington, 1979; Rolfo, 1980; Berck and Cecchetti, 1985; Lapan and Moschini, 1994). We assume that firms are interested in the protection of their overall financial performance, since many firms have multiple inputs and outputs. Duffie and Jackson (1989), Fackler and McNew (1993) and Tashjian and Weissman (1995) among others, have extended earlier hedging models, using a multi-product hedging approach. They consider the natural price variation of firms' total inputs and outputs. We use such an approach to derive the conditions under which the introduction of a new futures contract leads to either a volume increase or decrease for those futures already listed.

Following the standard hedging literature (Anderson and Danthine, 1981; Duffie and Jackson, 1989; Myers and Thompson, 1989; Fackler and McNew, 1993; Tashjian and Weissman, 1995), suppose a firm has an endowment of $n$ spot commodity positions. Let $\beta$ be an $n$ vector of these quantities where positive elements represent long (buy) spot positions and negative numbers are short (sell) spot positions. Let $\mathbf{T}$ be an $m$ vector of futures positions, again with positive (negative) numbers representing long (short) positions. In this two-period model, the next period's spot prices $\mathbf{S}$ and the next period's futures prices $\mathbf{F}$ are random vectors. The $m$ vector of today's prices for future delivery is denoted as $f$. Assume unbiased futures markets, or $E(\mathbf{F}) = f$.[2] The mean and variance of next period's prices may be written as:

$$\begin{bmatrix} S \\ F \end{bmatrix} \sim \left( \begin{bmatrix} E(S) \\ f \end{bmatrix}, \begin{bmatrix} \Sigma_{ss} & \Sigma_{sf} \\ \Sigma_{fs} & \Sigma_{ff} \end{bmatrix} \right), \tag{1}$$

where $\Sigma_{ff}$ is the matrix of covariances between the futures prices at maturity, $\Sigma_{ss}$ is

[2] There is considerable empirical evidence support for this assumption (Kamara, 1982).

the matrix of covariances between the spot prices and $\Sigma_{sf}$ is the covariance matrix between spot and futures prices. The firm's random profit $\Pi$ can be written as:

$$\Pi = S'\beta - C(\beta) + (F - f)'T, \quad (2)$$

where $C(\beta)$ is the firm's production process costs.

The first-order condition for the profit variance-minimizing futures position **T** in terms of the spot position $\beta$ in a mean-variance framework, in which firms are assumed to maximize a linear profit function that is increasing in expected returns and decreasing in return variance, is:[3]

$$T = -\Sigma_{ff}^{-1}\Sigma_{fs}\beta. \quad (3)$$

The optimal hedge position can be described in terms of the fraction of the spot commodity offset in the futures market. In such a case, the vector of hedge ratios can be written as:

$$HR = [diag(\beta)]^{-1}\Sigma_{ff}^{-1}\Sigma_{fs}\beta, \quad (4)$$

where $diag(\beta)$ is a diagonal matrix with vector $\beta$ on its main diagonal. Hedge ratios can be defined independent of spot quantities, provided that the latter are always held in fixed proportions, as is the case when they represent inputs and/or outputs for some fixed proportions technology.

## 3. Reinforcement versus cannibalism

One advantage of the multi-product hedging approach outlined above over the single-product approach is its incorporation of correlation between spot prices. In fact, the multi-product hedging model incorporates not only the direct relationships, but also the cross relationships (the relationship between spot price *A* and futures price *B*) and the indirect relationships (the relationship between spot price *A* and futures price *B* through futures price *A*). This characteristic may be helpful in gaining insight into the effects of adding new types of futures contracts to those already listed. When adding a new futures contract, the following effects can be discerned: (1) Demand (reflected in the hedged portion of the firms' endowment) increases for each futures contracts already listed; (2) Demand decreases for each futures contracts already listed; (3) An increase in the aggregate demand across the futures contracts already listed; (4) A decrease in the aggregate demand across the futures contracts already listed; (5) No change in the aggregate demand across the futures contracts

[3] For the conditions which justify the use of the mean-variance framework and a discussion of the use of the mean-variance framework and the general expected utility model, see Pulley (1981), Tew et al. (1991), Coyle (1992), Meyer and Rasche (1992), Bigelow (1993) and Pope and Chavas (1994).

already listed.[4] These five effects are referred to as *strong reinforcement*, *strong cannibalism*, *weak reinforcement*, *weak cannibalism* and *neutralism*, respectively. A futures exchange planning to list a new futures contract will be interested in finding out which of the above effects will occur. The effects of reinforcement and cannibalism also become important when a futures exchange plans to merge with another exchange or to cross list futures contracts from other exchanges. Using the multi-product hedging model we are able to provide insight into the level of either reinforcement or cannibalism.

Myers and Thompson (1989) show that the hedge ratio in the univariate case can be estimated using a simple least squares regression of the spot prices on the futures prices. Under the assumption that the spot and futures prices are conditionally bivariate in distribution, they show that the regression coefficient associated with the futures price is a maximum likelihood estimate of $\Sigma_{ff}^{-1}\Sigma_{fs}$, and hence of the optimal hedge ratios (see Eq. (4)).[5] This result is extended to the multi-product hedging case. We elaborate on the implications of these results in order to predict the effect of introducing a new futures contract on the already listed ones. Note that hedgers are not interested in discovering linear connections, but rather in finding optimal hedge ratios. When a regression coefficient is close to zero and non-significant, hedgers will not include that associated futures contract in their portfolio. The regression coefficients indicate variables of behavior, and we assume that hedgers behave in accordance with them. Subsequently, we use these regression coefficients to deduce the level of reinforcement or cannibalism.

Suppose we have a matrix $F$ and $S$ of observations of the futures prices $f'$ and spot prices $s'$ respectively. Now, consider regressing the values of the fixed spot position β, $S\beta$ on the futures prices $F$:

$$S\beta = F\phi + e, \tag{5}$$

where $\phi$ is the vector of regression coefficients and $e$ is the vector of residuals. Applying OLS to Eq. (5) yields:

$$\hat{\phi} = (F'F)^{-1}F'S\beta, \tag{6}$$

and

$$\hat{e} = (S - F(F'F)^{-1}F'S)\beta, \tag{7}$$

[4] Measuring successful derivative innovations is a complicated matter. The critical success levels for trading volume is necessarily arbitrary. A difficulty with volume data is that contracts for different assets are not worth the same amount of money so that the economic significance of total volume across different contracts is unclear. Duffie and Jackson (1989) address this ambiguity by defining the optimal futures contract as the one contributing the most to the unhedged portion of investors' endowment.

[5] The maximum likelihood estimates of $\Sigma_{ff}^{-1}\Sigma_{fs}$ can be obtained by using the iterated Seemingly Unrelated Regression (SUR) approach. In the case where the same set of variables explains both the spot and futures prices, the Ordinary Least Squares (OLS) estimator is also the maximum likelihood estimator. In this paper, the results are derived from within the framework of the OLS estimator. Using the SUR framework would not affect our conclusions.

where Eq. (7) is an estimator of the optimal hedge amount $HP = \Sigma_{ff}^{-1}\Sigma_{sf}\beta$ and thus describes hedging behavior.

In order to estimate the level of reinforcement induced by a new futures contract type we define the vector $\hat{\kappa}$ and $\hat{r}$ as the OLS estimates following from regressing the new futures contract's price $z$ on the other futures' prices:

$$z = F\kappa + r. \tag{8}$$

Applying OLS to Eq. (8) yields the estimates:

$$\hat{\kappa} = (F'F)^{-1}F'z, \tag{9}$$

and

$$\hat{r} = z - F(F'F)^{-1}F'z. \tag{10}$$

In order to analyze the influence that this new futures contract has on the original futures positions, we compare Eq. (5) with the estimates of the coefficients in its extended equivalent:

$$S\beta = F\gamma + z\delta + \mu, \tag{11}$$

where $\mu$ is the error term. Applying OLS to Eq. (11) yields:

$$\begin{pmatrix} \hat{\delta} \\ \hat{\gamma} \end{pmatrix} = \begin{pmatrix} z'z & z'F \\ F'z & F'F \end{pmatrix}^{-1} \begin{pmatrix} z'S \\ F'S \end{pmatrix} \beta. \tag{12}$$

It can be shown that the coefficient estimator $\hat{\delta}$ equals:

$$\frac{1}{\hat{r}'\hat{r}}\hat{r}'S\beta. \tag{13}$$

Note that $\hat{r}'\hat{r} \geq 0$ and that $\hat{r}'S\beta = (z' - z'F(F'F)^{-1}F')S\beta = z'(S\beta + FHP)$ is a consistent estimator of $cov(z, s\beta + FHP)$. Actually, it is a consistent estimator of the covariance between $z$ and $\Pi$, the profit (as defined in Eq. (2)). Since $\hat{\kappa}$ is an OLS estimator, it holds that $F'\hat{r} = 0$. Therefore we can rewrite Eq. (12) as:

$$S\beta = F(\hat{\gamma} + \hat{\kappa}\hat{\delta}) + \hat{\mu} + \hat{r}\hat{\delta}. \tag{14}$$

The incremental change in the optimal hedging position of the futures contracts already in the portfolio is thus given as:

$$\Delta HP = -\hat{\gamma} - (-\hat{\phi}) = \hat{\phi} - \hat{\gamma} = \hat{\kappa}\hat{\delta}. \tag{15}$$

If the difference in Eq. (15) is all positive for outputs and negative for inputs, *strong reinforcement* occurs. If this difference is all negative for outputs and positive for inputs, we are confronted with *strong cannibalism*. Following Eq. (15) we can derive the conditions necessary for strong reinforcement to occur.

***Proposition***. *Adding a new futures contract z to the portfolio leads to strong reinforcement if and only if one of the two following situations applies*:

1. The relation between the new futures price $z$ and the original futures prices, as expressed by the multiple regression coefficients $\hat{\kappa}$, is negative for all inputs and positive for all outputs and $cov(z,\Pi)>0$.
2. The relation between $z$ and the original futures prices, as expressed by the multiple regression coefficients $\hat{\kappa}$, is positive for all inputs and negative for all outputs and $cov(z,\Pi)<0$.

The proposition could be defined for separate futures contracts already listed as well. Table 1 summarizes our finding.

From Table 1 it becomes clear that strong reinforcement/strong cannibalism is dependent on the regression coefficients of the price of the new futures type on the prices of the futures already in the portfolio, $\hat{\kappa}$ and on the covariance between the futures price of the new futures contract and the profit, i.e. the return on the portfolio. By looking at the values of the elements in the vector $\Delta HP$ in Eq. (15), after multiplying the elements that correspond to long positions by $-1$, we are able to pronounce weak reinforcement and weak cannibalism. When the sum of the elements in this transformed vector is positive (without all the individual elements being positive, which would imply strong reinforcement), we speak of weak reinforcement. When the sum of the elements in the vector is negative (again, without all the individual elements being negative, which would imply strong cannibalism), we speak of weak cannibalism.

A key aspect of futures market performance is the degree of liquidity in the market. The relationship between market depth and futures contract success has been thoroughly investigated in the literature (Black, 1986; Cuny, 1993). A futures market is considered liquid if traders and participants can buy or sell futures contracts quickly with little price effect resulting from their transactions. However, in thin markets transactions of individual hedgers may have significant price effects and result in substantial transaction costs. The introduction of a new futures contract can, for example, turn one liquid futures contract into two illiquid contracts. This liquidity effect, or better stated, lack of liquidity, can be incorporated in our model by cor-

Table 1
Strong reinforcement and strong cannibalism by additional futures contract $z$

| | $\hat{\kappa}$ negative for inputs<br>$\hat{\kappa}$ positive for outputs | $\hat{\kappa}$ positive for inputs<br>$\hat{\kappa}$ negative for outputs |
|---|---|---|
| $cov(z,\Pi)>0$ | Strong reinforcement | Strong cannibalism |
| $cov(z,\Pi)<0$ | Strong cannibalism | Strong reinforcement |

recting the futures market price for liquidity costs. In this way, we calculate the net futures price, which equals the futures price minus the liquidity costs. The stochastics of the net futures price is made up of the variance of the futures price, the variance of liquidity costs and the covariance between liquidity costs and the futures price. So, whenever we suspect a thin futures market, because of small trading volume or the absence of scalpers on the floor to absorb temporary order imbalances, we use the net futures price instead of the quoted futures price. In the next section we present an example of a relatively thin futures market where we use the net futures price.

## 4. Empirical illustration

In this section, we illustrate the respective effect of reinforcement and cannibalism on the soybean complex traded at the Chicago Board of Trade (CBOT) and the financial futures spread traded at the Amsterdam Exchanges.[6] The soybean complex traded at the CBOT is used internationally by firms that use soy products in their production processes, and by fund managers who use these futures as an addition to their financial portfolios. The importance of this soybean complex is shown by its volume: in 1999 a total of 30 775 545 contracts in the soy complex traded at the CBOT, representing an underlying value of approximately $448 billion (Source: annual report of the CBOT 2000). The financial futures traded at the Amsterdam Exchanges (AEX) are mainly used by European financial institutions and have lower volumes than the CBOT futures.

The proposed framework in Section 3 assumes that the futures price of the new futures contract is known before the introduction of the new futures contract, which could make an empirical application of our method difficult. However, in an empirical application, the spot market price of the new futures contract's underlying asset may be used, it being an accurate approximation of the development of the futures contract price. In the empirical study outlined below we use the futures price of the new futures contract in our analysis, following closely the framework of Section 3. To test the robustness of our method we repeated our empirical study using the underlying spot price of the new futures contract. The results were similar to the ones presented below, substantiating the usefulness of our method in practice.[7]

### *4.1. Soybean complex at the Chicago Board of Trade*

Soybean processors manage a portfolio consisting of soybeans (which is the input in the production process), and soy meal and soy oil (which are the outputs of the

[6] In the illustration, we focus our attention on soybean processors using the soybean complex traded at the Chicago Board of Trade and fund managers who use the financial spread at Amsterdam Exchanges. The choice for these two types of market participants was a deliberate one: both account for a large share of volume on these markets. Moreover, the proposed framework can easily be applied to other participants in these markets.

[7] The results are available on request.

production process). They have at their disposal three futures contracts relevant to their portfolio and hence production process, which consists of processing soybeans (major input) into soy oil and soy meal (major outputs). The production process has fixed input/output ratios of 47 pounds of meal and 11 pounds of oil per bushel of beans. Estimates of the optimal hedge amounts for the three futures contracts are made using futures prices for the nearby contract month. We calculate the optimal hedging amounts of soybeans, oil and meal for a soybean processors who is planning to process one bushel of soybeans into 11.19 pounds of oil and 0.02397 tons of meal. Daily spot (Central Illinois) and futures prices for the period January 1990 to December 1997 were obtained from the Chicago Board of Trade. Table 2 shows the descriptive statistics for the futures and spot data.

First, we estimate the optimal hedge amounts for the univariate case, the model that does not take into account the cross effects and the indirect effects, by regressing the spot prices on the futures prices. Next, we estimate the separate hedge amounts for the scenario in which the hedger wishes to hedge/cover profit fluctuations instead of price risk, as the univariate case presupposes. For this reason, we calculate the gross profit, as reflected in $S\beta$ in Eq. (5) from the production process, by determining the spot value of the processor's endowment (i.e. the soybean processing spread, or

Table 2
Descriptive statistics of the soybean complex at the CBOT and the financial futures at the AEX[a]

| | Mean | SD | Mean | SD |
|---|---|---|---|---|
| *Soybean complex* | | | | |
| *Spot prices (n=2017)* | | | *Futures prices (n=2017)* | |
| Soybeans | 635.90 | 89.14 | 638.37 | 86.66 |
| Soy meal | 19516.00 | 3966.37 | 19798.25 | 3341.58 |
| Soy oil | 23.28 | 3.15 | 23.43 | 2.93 |
| *Financial complex* | | | | |
| *Spot prices (n=1592)* | | | *Futures prices (n=1592)* | |
| AEX | 487.33 | 194.39 | 486.25 | 192.82 |
| FUS | 178.51 | 13.58 | 178.76 | 13.75 |
| DT5 | 848.28 | 315.24 | 846.53 | 313.00 |
| FTSE | 1331.77 | 414.38 | 1329.84 | 410.30 |
| | | | *% of underlying value* | |
| $LC_{AEX}$ | 0.24 | 0.19 | 0.05% | |
| $LC_{FUS}$ | 0.76 | 0.35 | 0.43% | |
| $LC_{DT5}$ | 0.93 | 0.42 | 0.11% | |
| $LC_{FTSE}$ | 6.79 | 3.78 | 0.51% | |

[a] SD is the standard deviation, AEX the Amsterdam Exchanges stock index, FUS the US dollar futures (i.e., the value of $100 in Dutch Guilders), DT5 the Dutch top 5 index, FTSE the FTSE Europe top 100 stock index (for the index futures a one-point change in the index corresponds to a change of the underlying value of the futures contract of 200 Dutch Guilders) and LC the average liquidity costs per contract. Soybeans are quoted in $ cents per pound, soy meal in $ cents per ton, soybeans in $ cents per bushel.

margin) based on the fixed input/output structure of the soybean processor.[8] Regressing the gross profit, $S\beta$, on the futures prices, as reflected in $F$ in Eq. (5), then enables us to estimate the optimal hedge amount.[9]

Table 3 shows that less hedging occurs when the hedging motivation is reduction of the firm's residual risk than when the objective is reduction of a single commodity's spot price risk (here and elsewhere the absolute value of the hedge amounts are displayed). Our findings, which suggest lower hedging levels necessitated in profit risk management, can be explained through the presence of natural hedges within the soybean complex, that is to say, a positive correlation between the spot prices of inputs and outputs, which reduces the need for hedging. These results support somewhat those of Tzang and Leuthold (1990).

The optimal hedge amounts are also estimated for a scenario in which the exchange would list either soybeans, soy oil or soy meal only (see Table 4). These hedge amounts are equal to the optimal hedge amounts in Table 3 for the case where profit risk management constitutes the motivation for hedging. Subsequently, we are able to investigate the hedge amounts and reinforcement-cannibalism levels of a total of seven different combinations of futures contract listings following the framework provided in Eqs. (5) and (11), by regressing the gross profit, $S\beta$, on the futures prices, $F$ (see Table 4).

Table 4 shows that listing all three contracts realizes an optimum. That is, the aggregate demand for the hedging services provided by the futures exchange is maximized. In that case, for each bushel of soybeans the processors plan to purchase and

Table 3
Optimal hedge amounts for single commodities and different hedging motives[a]

| Motivation for hedging: | Optimal hedge amounts[b] | | |
|---|---|---|---|
| | Soybeans (SB) | Soy oil (SO) | Soy meal (SM) |
| 1. Reduction of spot price risk | 1.019 | 11.861 | 0.028 |
| 2. Reduction of profit risk (residual risk) | 0.076 | 4.239 | 0.004 |

[a] Assume the soybean processor's endowment is 1 bushel of soybeans, 11.19 pounds of soy oil and 0.02397 tons of soy meal. All the standard errors from the estimated coefficients were smaller than 0.01.

[b] Hedging amounts are in bushels for soybeans, pounds for oil and tons for meal.

[8] The gross profit equals the cost of buying the beans and selling the oil and meal. We did not include the processing costs, $C\beta$ in Eq. (2) (i.e. the costs to process the beans into meal and oil), since the costs cancel out when deriving the optimal hedge ratio (see Eqs. (3) and (4)).

[9] A common concern in the hedging literature is whether lag variables should be included in the regression. Myers and Thompson (1989) noted that a model that does not include lags might provide poor estimates because it omits important conditioning information relevant to the means of both the cash and futures prices. We estimated the regression with and without lags (following the procedure of Britten-Jones (1999)). Including the lags did not make much difference for the optimal hedge ratios and hence, the results regarding reinforcement and cannibalism. This is in line with the recent findings of Ferguson and Dean (1998). In the paper we present the results without the lags.

Table 4
Optimal hedge amounts for different combinations of futures contracts (CBOT)[a]

| Listings | Optimal hedge amounts[b] | | | |
|---|---|---|---|---|
| | Soybeans (SB) | Soy oil (SO) | Soy meal (SM) | HE[c] |
| 1. SB | 0.076 | * | * | 4.0% |
| 2. SO | * | 4.239 | * | 14.4% |
| 3. SM | * | * | 0.004 | 13.6% |
| 4. SO added to SB | 0.000 | 4.035 | * | 14.6% |
| 5. SM added to SB | 0.359 | * | 0.013 | 26.7% |
| 6. SM added to SO | * | 3.489 | 0.003 | 22.9% |
| 7. SM added to SB and SO | 0.885 | 9.907 | 0.003 | 72.6% |

[a] Assume the soybean processor's endowment is 1 bushel of soybeans, 11.19 pounds of soy oil and 0.02397 tons of soy meal. All the standard errors from the estimated coefficients were smaller than 0.01.
[b] Hedging amounts are in bushels for soybeans, pounds for oil and tons for meal.
[c] The hedging effectiveness (HE) is measured as the percentage reductions in variances relative to the unhedged position (Ederington, 1979).

process, their endowment is 1 bushel short for soybeans, 11.19 pounds long soy oil and 0.02397 tons long soy meal, the risk minimizing multivariate hedge is to go long 0.885 bushels of soybeans, short 9.907 pounds of soy oil and short 0.003 tons of soy meal. In this situation the hedging effectiveness reaches an optimum as well.

When adding soy oil to soybeans, strong cannibalism occurs. That is, the optimal hedge amount for soybeans decreases (going from row 1 to row 4 in Table 4). However, when adding soy meal to soybeans and soy oil, strong reinforcement occurs (going from row 4 to row 7 in Table 4). That is, the hedge amounts of the futures already listed (soybeans and soy oil) increase by adding soy meal. This is evident from proposition 1 as well. The regression of soy meal on the futures already in the portfolio, soy oil (output) and soybeans (input), is positive and negative respectively ($\hat{\kappa}$ in Eq. (15)), and the covariance between the futures price of the new futures contract, in our case soy meal, and the profit, i.e. the return on the portfolio, is positive. This puts us in the upper-left quadrant of Table 1, strong reinforcement. This example illustrates why an exchange would have an interest in studying the whole production structure, i.e. the portfolio of inputs and outputs, of the potential hedger. Listing only part of a production structure may imply a sub-optimal situation for the exchange.

### *4.2. Financial futures at Amsterdam Exchanges*

Pension funds hold money (which can be seen as an input), which results in interest revenues, which is the pension funds output.[10] A pension fund has several possi-

[10] Although, the financial futures case is not a "traditional" input–output processing case as the soybean complex, it can be presented in such a framework, which shows the merits of the proposed method.

bilities to cover its risks resulting from fluctuations in interest rates. One way to hedge against adverse interest rate changes is to hedge with the help of a bond futures contract. In the Netherlands, however, this contract was not successful and was de-listed. At the Amsterdam Exchanges (AEX) the following relevant futures contracts are being traded: the AEX stock index (which consists of Dutch blue chip stocks), the Dutch top-5 index, the FTSE Europe top-100 stock index (which include European blue chip stocks) and the US Dollar/Dutch Guilder futures contract. The AEX stock index was introduced on 24 October 1989, the Dutch top-5 index futures on 21 March 1990, the FTSE Europe top-100 index futures on 6 June 1991 and the US Dollar futures on 27 September 1991. Pension funds that wish to hedge against adverse interest rates on the Dutch Guilder have at their disposal four futures contracts traded at Amsterdam Exchanges. Contrary to the futures from the soybean complex at the Chicago Board of Trade, the market for these futures at the Amsterdam Exchanges is rather thin. The volume of the AEX stock index in 1997 was 2 554 776 contracts, the Dutch top-5 index was 58,891, the FTSE Europe top-100 index was 249, and the US dollar futures was 19 914. Because we suspect that a trader incurs liquidity costs when trading in these thin futures, we incorporated these costs. In order to calculate the liquidity costs and hence, the net futures price, we gathered daily transaction-specific data for the period 1992 through 1997. In the case of an order-selling imbalance, liquidity costs were calculated as the area between the downward-sloping price path and the price for which the hedger enters the futures market, hence

$$LC = PF^1 \cdot N - \sum_{i=1}^{N} (PF^i), \tag{16}$$

where $PF^1$ is the futures price for which the hedger enters the market, $PF^i$ is the price of the $i$th futures contract and $N$ the total order flow.

The liquidity costs in the case of order buying imbalance were calculated as the area between the upward-sloping price path and the price for which the hedger enters the futures market, hence

$$LC = \sum_{i=1}^{N} (PF^i) - PF^1 \cdot N. \tag{17}$$

The net futures price is now calculated as the quoted futures price minus the average liquidity costs per futures contract. Table 2 provides some descriptive statistics for the liquidity cost measure $LC$ and the financial futures of the AEX. In further analyses we use these net futures prices.

We now calculate the optimal hedging amounts of a holder of one million Dutch Guilders. The dependent variable in the regression is the interest given on a 10-year Dutch Treasury bond. In Table 2 descriptive statistics are given of the financial futures contracts and the liquidity costs.

In order to gain insight in the reinforcements and cannibalism effects we use the same actual sequence that was used by the Amsterdam Exchanges when introducing the several futures contracts. That is, we first estimated the optimal hedging amount when only the AEX stock index is available, followed by the Dutch top-5 index, the FTSE Europe top-100 index and finally the US Dollar contract using the framework outlined in Eqs. (5)–(15).

Table 5 reflects the optimal hedge amounts and hedging effectiveness of the different futures. It shows that the addition of the Dutch top-5 index to the AEX stock index leads to strong reinforcement, that is the hedging demand for the AEX stock index has increased from 34.45 to 80.56 due to the listing of the Dutch top-5 index. Adding the FTSE Europe top-100 index leads to weak reinforcement. The introduction of the FTSE Europe top-100 index leads to a decrease for AEX stock index futures and an increase for Dutch top-5 index futures, which finds its reflection in the change of the optimal hedging amounts. Table 5 shows that listing the US Dollar futures contract leads to weak cannibalism. The introduction of the US Dollar futures leads to a decrease for both the AEX stock index futures and the FTSE Europe top-100 index futures. This decrease is not fully offset by the increase in the Dutch top-5 index futures.

In the above analysis, the liquidity costs have been taken into account. In order to investigate the effect of thin markets on reinforcement and cannibalism, we performed the analysis again, this time without calculating the liquidity costs as indicated in Eqs. (16) and (17). These results show no major changes in the conclusions about reinforcement and cannibalism. They do show increased hedging effectiveness for the various combinations, which also overrates hedging effectiveness in each case (about three percent) because of excluding liquidity costs. These results correspond to the findings of Pennings and Meulenberg (1997). The fact that the extent of the lack of liquidity is not very severe might explain the lack of finding any major effects in this analysis. In another empirical setting, however, differences in reinforcement

Table 5
Optimal hedge amounts for different combinations of futures contracts (AEX)[a]

| Listing | Optimal hedge amounts | | | | |
|---|---|---|---|---|---|
| | AEX stock index (AEX) | Dutch top-5 index (DT5) | FTSE Europe top-100 index (FTSE) | US dollar futures (FUS) | HE[b] |
| AEX | 34.45 | * | * | * | 50.8% |
| DT5 | * | 20.07 | * | * | 45.1% |
| FTSE | * | * | 16.96 | * | 54.5% |
| FUS | * | * | * | 263.51 | 15.3% |
| DT5 added to AEX | 80.56 | 28.98 | * | * | 53.8% |
| FTSE added to AEX, DT5 | 64.11 | 66.85 | 97.91 | * | 70.2% |
| FUS added to AEX, DT5, FTSE | 41.51 | 76.77 | 92.95 | 123.48 | 72.5% |

[a] All the standard errors from the estimated coefficients were smaller than 0.01.

[b] The hedging effectiveness (HE) is measured as the percentage reductions in variances relative to the unhedged position (Ederington, 1979).

and cannibalism might very well be found when the incorporation of liquidity risk in the analysis is omitted. For this reason, it is recommended to incorporate the liquidity component into the model whenever a lack of liquidity is expected.

These two examples show to an exchange the value of studying the effects that individual contracts may have on other contracts listed.

## 5. Implications and conclusions

Our findings carry important implications for a futures exchange's innovation policy. Before introducing a new futures contract, it is important for a futures exchange to firstly study the effects of such an introduction on those futures contracts already listed. The possibility of cannibalism when introducing a new futures contract exists, leading to a volume decrease for those futures contracts currently traded. This volume decrease might, in turn, lead to a decline in liquidity, which would ultimately threaten the exchange's viability. These results gain special relevance when applied to new futures exchanges because of their smaller scale (Kilcollin and Frankel, 1993). For young exchanges, volume sufficiency is of vital importance. Through a thoughtful strategy of new introductions or listings of futures contracts of other exchanges, an exchange should be able to generate a volume increase for the futures contracts already listed, thereby automatically increasing its overall viability and, by doing so, increasing contract liquidity. Moreover, such an exchange would be better equipped to comply with the demands of companies wanting to hedge their profits. Not only can the proposed method be used when evaluating the introduction of new futures contracts, also exchanges that become more international, by merging with other exchanges or by listing other exchange's futures contracts, face the question: what will happen to our futures contracts when we add the futures contracts of our partner? This question can be partly answered by our framework since the futures contracts of the partner are relatively new to the exchange, and may be new for their customers, especially when there is an international partner involved. Furthermore, the framework proposed in this paper can be used for hedgers who may need to adjust their futures positions when new futures contracts become available.

In view of this, it is valuable for an exchange to investigate the hedger's underlying input–output portfolio, that is, the firm's residual spot market risk, before introducing new futures contracts. Listing futures contracts that reflect the residual spot market risk of the hedger's industry would be advantageous to the clearing system as well. A combination of futures contracts reflecting the input–output structure (and hence, the residual spot market risk) keeps margin requirements at a lower level than they would be if all futures contracts were listed separately (Goldberg and Hachey, 1992; Gemmill, 1994). This creates an opportunity for the hedger to free up more capital and hence, the possibility of enlarging futures contract positions whenever the capital requirement is the limiting factor in taking positions. Cross margining between exchange-traded futures contracts is an option offered by some clearing houses in conjunction with futures contracts reflecting the production structure. Gathering information on input–output structures for different industries seems to be of great importance to futures exchanges. Computer technology and advancements in telecommunications will make this easier in the future, which will, in turn, lead to improvements in the structure of futures exchanges (Merton, 1995).

Some caveats of the proposed framework should be mentioned. First, our analysis is derived from a multi-product hedging model in which the spot positions were fixed. However, as Anderson and Danthine (1981) showed decreasing the residual risk for the hedger will lead to an increase in the optimal production level, which in turns leads to an increase in the scale of hedging. Since adding a new futures contract that reflects the underlying input–output structure of the hedger will decrease residual risk, this effect will induce reinforcement and offset cannibalism, at least partially. Second, we did not account for the effect of redistributing liquidity, that is, the effect of redistributing liquidity from highly liquid futures contracts to relatively illiquid futures contracts due to the introduction of a new futures contract, which may increase the attractiveness of the futures exchange and hence its success.

Our findings suggest several directions for further research. First, including the demand for speculation might extend our framework. Listing futures contracts reflecting the input–output structure of the hedger's industry will increase spreading opportunities, which might increase the attractiveness of the futures exchange for speculators and hence, contribute to its success. Second, the competitive environment of the exchange will have an impact on reinforcement and cannibalism. Modeling these competitive forces within the framework, as proposed here, is an avenue of future exploration.

## Acknowledgements

We are grateful to the co-editor, Michael Melvin, and an anonymous referee for their critical comments and suggestions that significantly improved the manuscript. We are also grateful for the helpful comments on the research project and preliminary versions of this manuscript by D.F. Broens, R.A. Collins, H. den Hertog, M.T.G. Meulenberg, and M. Rockinger. We thank Joseph Poncer from the Chicago Board of Trade for providing data on the soybean complex and Hein den Hertog from the Amsterdam Exchanges for providing data on the financial futures. Research support provided by the Amsterdam Exchanges, Chicago Board of Trade, the Niels Stensen Foundation, the Office for Futures and Options Research and the Foundation for Research in Derivatives is gratefully acknowledged.

## References

Anderson, R.W., Danthine, J.P., 1980. Hedging and joint production, theory and illustrations. Journal of Finance 35 (2), 487–489.

Anderson, R.W., Danthine, J.P., 1981. Cross hedging. Journal of Political Economy 89 (6), 1182–1196.

Berck, P., Cecchetti, S.G., 1985. Portfolio diversification, futures markets and uncertain consumption prices. American Journal of Agricultural Economics 64 (3), 497–507.

Bigelow, J.P., 1993. Consistency of mean-variance analysis and expected utility analysis. Economics Letters 43 (2), 187–192.

Black, G.D., 1986. Success and failure of futures contracts: theory and empirical evidence. Monograph 1986-1 Salomon Brothers Center for the Study of Financial Institutions, New York.

Britten-Jones, M., 1999. The sampling error in estimates of mean-variance efficient portfolio weights. Journal of Finance 54 (2), 655–671.

Chang, C.W., Chang, J.S.K., Fang, H., 1996. Optimal futures hedge with marketing-to-market and stochastic interest rates. Journal of Financial Research 19 (3), 309–326.

Coyle, B.T., 1992. Risk aversion and price risk in duality models of production: a linear mean-variance approach. American Journal of Agricultural Economics 74 (4), 849–859.

Cuny, C.J., 1993. The role of liquidity in futures market innovations. Review of Financial Studies 6 (1), 57–78.

Duffie, D., Jackson, M., 1989. Optimal innovation of futures contracts. Review of Financial Studies 2 (3), 275–296.

Ederington, L.H., 1979. The hedging performance of the new futures markets. Journal of Finance 34 (1), 157–170.

Fackler, P.L., McNew, K.P., 1993. Multi-product hedging: theory, estimation, and an application. Review of Agricultural Economics 15 (3), 521–535.

Ferguson, R., Dean, L., 1998. Are regression approach futures hedge ratio stationary? Journal of Futures Markets 18 (7), 851–866.

Gemmill, G., 1994. Margins and the safety of clearing houses. Journal of Banking and Finance 18 (5), 979–996.

Goldberg, L.G., Hachey, G.A., 1992. Price volatility and margin requirements in foreign exchange futures markets. Journal of International Money and Finance 11 (4), 328–329.

Gray, R.W., 1987. Why does futures trading succeed or fail: an analysis of selected commodities. In: Peck, A.E. (Ed.), Readings in Futures Markets. Chicago Board of Trade, Chicago, pp. 235–248.

Hsin, C.-W., Kuo, J., Lee, C.-F., 1994. A new measure to compare the hedging effectiveness of foreign currency futures versus options. Journal of Futures Markets 14 (6), 685–707.

Kamara, A., 1982. Issues in futures markets: a survey. Journal of Futures Markets 2 (3), 261–294.

Kilcollin, T.E., Frankel, M.E.S., 1993. Futures and options markets: their new role in Eastern Europe. Journal of Banking and Finance 17 (5), 869–881.

Lapan, H., Moschini, G., 1994. Futures hedging under price, basis, and production risk. American Journal of Agricultural Economics 76 (3), 465–477.

Merton, R.C., 1995. Financial innovation and the management and regulation of financial institutions. Journal of Banking and Finance 19 (3-4), 461–481.

Meyer, J., Rasche, R.H., 1992. Sufficient conditions for expected utility to imply mean-standard deviation rankings: empirical evidence concerning the location and scale condition. The Economic Journal 102 (410), 91–106.

Myers, R.J., Thompson, S.R., 1989. Generalized optimal hedge ratio estimation. American Journal of Agricultural Economics 71 (4), 858–868.

Pennings, J.M.E., Meulenberg, M.T.G., 1997. Hedging efficiency: a futures exchange management approach. Journal of Futures Markets 17 (5), 599–615.

Pope, R.D., Chavas, J.P., 1994. Cost functions under production uncertainty. American Journal of Agricultural Economics 76 (2), 196–204.

Pulley, L.B., 1981. A general mean-variance approximation to expected utility for short holding periods. Journal of Financial and Quantitative Analysis 14 (3), 361–373.

Rolfo, J., 1980. Optimal hedging under price and quantity uncertainty: the case of a cocoa producer. Journal of Political Economy 88 (1), 100–116.

Silber, W.L., 1981. Innovation, competition, and new contract design in futures markets. Journal of Futures Markets 1 (2), 123–155.

Tashjian, E., McConnell, J., 1989. Requiem for a market: an analysis of the rise and fall of a financial futures contract. Review of Financial Studies 2 (1), 1–23.

Tashjian, E., Weissman, M., 1995. Advantages to competing with yourself: why an exchange might design futures contracts with correlated payoffs. Journal of Financial Intermediation 4 (2), 133–157.

Tew, B.V., Reid, D.W., Witt, C.A., 1991. The opportunity cost of a mean variance efficient choice. The Financial Review 26 (1), 31–43.
Tzang, D.N., Leuthold, R.M., 1990. Hedge ratios under inherent risk reduction in a commodity complex. Journal of Futures Markets 10 (5), 497–504.
Working, H., 1953. Futures trading and hedging. American Economic Review 43 (3), 314–334.
Zilcha, I., Broll, U., 1992. Optimal hedging by firms with multiple sources of risky revenues. Economics Letters 39 (4), 473–477.