Strategic Interactions, Risks and Coordination Costs in Food Marketing Channels: The Mediating Role of Futures Markets

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Abstract

We examine the interaction of marketing channel members and the influence of these interactions on incentives, coordination costs, and risk allocation strategies in a food marketing channel. For this purpose we specify a three-stage principal-agent marketing channel model involving producers, wholesalers, retailers and a futures market. We compare the situation *with* and *without* futures market. The empirical results regarding the Dutch ware potato marketing channel during 1971-2003 reveals that, possibly as a result of increases in incentives to producers and wholesalers, the coordination costs of the marketing channel decreased significantly, both *with* and *without* futures trade. The coordination costs of a marketing channel *with* a futures market are lower than *without* futures, demonstrating the price discovery role of the futures markets. The results also show that risk shifted from retailers to producers and wholesalers.

Keywords: *Contracts, Risks, Coordination Costs, Futures Markets, Food Marketing Channels*

1. Introduction

Over the last four decades food marketing channels have been transformed from the traditional supply-oriented chains into demand-oriented chains. As a consequence, marketing channel members are required to produce and deliver quality products in order to meet consumers' needs. In this respect, the transaction mechanism in food marketing channels has changed from open-market mechanisms to a coordinated form of transaction through the use of contracts and other forms of vertical alliances, such as franchising. In this paper, we examine the interactions of marketing channel members through the use of contracts and its influence on incentives, coordination costs, and risk allocation strategies in a food marketing channel. For this purpose we specify a three-stage principal-agent marketing channel model involving producers, wholesalers, retailers and a futures market. The rest of the paper is organized as follows. We present the theoretical model in Section 2. The empirical application and results are presented in Section 3. Finally, in Section 4, concluding remarks are provided.

2. The Model

In this model, we examine the strategic interactions of marketing channel members regarding their contract relationships, the need for risk management by some channel members and its influence on the coordination costs of the marketing channel. We have two contract relationships in the model. The first is a contract relationship between the retailer (*i.e.* principal) and the wholesaler (*i.e.* agent), and the second is a contract relationship between the wholesaler (*i.e.* principal) and the producer (*i.e.* agent). Let us consider a product that is produced by farmers, processed and distributed to retailers by wholesalers, and finally sold to consumers by retailers. The payments from the retailer to the wholesaler and from the wholesaler to the producer are partly based on the retail value of the product. We assume hypothetical linear contracts among marketing channel members, see Holmstrom and Milgrom (1987) for the motivations for using linear contract forms. The hypothetical linear contract between the retailer and the wholesaler is as follows:

$$W_w = \alpha_w x + \beta_w \tag{1}$$

where W_w is the total compensation payment from the retailer to the wholesaler, α_w is the incentive parameter, x is the retail value, $\alpha_w x$ is the variable compensation payment, and β_w is the fixed compensation. Similarly, the contractual relationship between the wholesaler and the producer is specified as

$$W_p = \alpha_p \alpha_w x + \beta_p \tag{2}$$

where W_p is the total compensation payment from the wholesaler to the producer, α_p is the variable-revenue sharing parameter between the wholesaler and the producer (i.e., the proportion of the wholesaler's variable revenue that is received by the producer), $\alpha_p \alpha_w$ is the actual incentive parameter from the wholesaler to the producer, and $\alpha_p \alpha_w x$ and β_p are the variable and fixed compensation payments to the producer, respectively.

The retail value of the product is decomposed as:

$$x = e + \varepsilon \tag{3}$$

where x is the retail value, e is the expectation of the retail value, and ε is the random component of the retail value, which is assumed to be normally distributed with mean zero and variance σ^2.

The wholesalers' expected cost of effort is specified as

$$C_w = 0.5 c_w e^2 + d_w \tag{4}$$

Similarly, the producer's expected cost of effort is specified as

$$C_p = 0.5c_p e^2 + d_p \qquad (5)$$

where d_w and d_p denote trend terms that may reflect technological changes in production; c_w and c_p are the increase in marginal costs of wholesalers and producers, respectively.

Net of fixed retail costs, the retailers' profit is

$$\pi_r = x - W_w \qquad (6)$$

which has the following variance:

$$Var(\pi_r) = (1 - \alpha_w)^2 \sigma^2 \qquad (7)$$

as can be obtained by substituting Eq. (1) and Eq. (3) in Eq. (6). Since the product is one of the many stock-keeping units in the retailer's assortment, we assume that the retailer does not care about this variance. In contrast, in the model, we allow the risk-averse producers and wholesalers to trade futures contracts besides their contractual relationships in the marketing channel, in order to hedge against the risks incurred in the product's spot market. Accordingly, the producer's profit π_p, resulting from selling futures contracts of his/her produce and the contractual relationship with the wholesaler, is given by

$$\pi_p = W_p - C_p + Z_p(F_{t,t-1} - F_{t,t}) \qquad (8)$$

where $Z_p(F_{t,t-1} - F_{t,t})$ represents the producer's gain or loss from selling futures contracts, in which Z_p is the quantity of produce sold in the futures market at time $t-1$; $F_{t,t-1}$ is the futures price at time $t-1$; and $F_{t,t}$ is the futures price at time t. Thus, the producer's result of holding a hedging position can be either positive or negative, depending on whether the futures price at maturity when the position is closed is below or above the price at which the position was initiated. The difference in the futures price between time $t-1$ and t is assumed to follow a random walk with drift as follows:

$$F_{t,t-1} - F_{t,t} = \mu_F + \varepsilon_{Ft} \qquad (9)$$

where μ_F, denoting the drift term, reflects storage costs and interest costs in futures trade, and ε_{Ft} is the error term with zero mean and variance σ_F^2. In the same vein, the wholesaler's profit from buying futures contracts of the produce required for wholesaling and the contractual relationship with the retailer is given as

$$\pi_w = W_w - C_w - W_p - Z_w(F_{t,t} - F_{t,t-1}) \qquad (10)$$

where $Z_w(F_{t,t} - F_{t,t-1})$ represents the wholesaler's gain or loss from buying futures contracts, in which Z_w is the quantity of produce bought at time $t-1$. The wholesaler's result of holding a hedging position can also be either positive or negative, depending on whether the futures price at maturity which is below or above the futures price at which the position was initiated. Producers and wholesalers do not only form expectations regarding their respective profits, they are also aware of the uncertainty in these expectations. We measure the uncertainty in

producers' and wholesalers' profits by their variances as a proxy for their risk. The variance of producer's profit is

$$Var(\pi_p) = \alpha_p^2 \alpha_w^2 \sigma^2 + z_p^2 \sigma_F^2 + 2\alpha_p \alpha_w z_p \sigma_{\varepsilon F} \tag{11}$$

as can be derived from substituting Eq. (2), Eq. (3) and Eq. (9) in Eq. (8). Similarly, the variance of wholesalers' profit can be expressed as

$$Var(\pi_w) = (1 - \alpha_p)^2 \alpha_w^2 \sigma^2 + z_w^2 \sigma_F^2 - 2(1 - \alpha_p)\alpha_w z_w \sigma_{\varepsilon F} \tag{12}$$

after substituting Eq. (1), Eq. (3) and Eq. (9) in Eq. (10). Given that the risk aversion of producers and wholesalers complies with the constant absolute risk aversion (CARA) preference and that their profits are normally distributed, their objective functions are equivalent to the maximization of their respective certainty equivalents of profits (i.e. the profit with no risk that yields an identical level of satisfaction as the profit with risk). It is expressed as the difference between the expectations of profit and the risk premium). The producer's objective function is expressed as:

$$\underset{e, z_p}{Max}\{\alpha_p \, \alpha_w e + \beta_p - d_p - 0.5c_p e^2 + \mu_F z_p$$
$$- 0.5\rho_p \alpha_p^2 \alpha_w^2 \sigma^2 - 0.5\rho_p z_p^2 \sigma_F^2 - \rho_p \alpha_p \alpha_w z_p \sigma_{\varepsilon F} \} \tag{13}$$

of which the first-order conditions are

$$e = \alpha_p \alpha_w / c_p \tag{14}$$

and

$$Z_p = (\mu_F - \rho_p \alpha_p \alpha_w \sigma_{\varepsilon F}) / \rho_p \sigma_F^2 \tag{15}$$

where ρ_p is the producer's coefficient of risk aversion. Having defined the objective function of the producer (*i.e.*, agent), it is important to elaborate on the constraints in the contract between the producer and the wholesaler (*i.e.*, principal). In the contract outlined above, the wholesaler (*i.e.*, principal) is subjected to the participation constraint and the incentive compatibility constraint. The participation constraint suggests that the producer (*i.e.*, agent) equates his/her reservation wage $\overline{W}_p$ to his/her certainty equivalent of profit. From this condition and after inserting e in Eq. (14) and Z_p in Eq. (15) into the certainty equivalent of profit in Eq. (13), the producer's fixed compensation β_p is then derived as

$$\beta_p = \overline{W}_p + d_p - 0.5\alpha_p^2 \alpha_w^2 / c_p - 0.5\mu_F^2 / \rho_p \sigma_F^2 + 0.5\rho_p \alpha_p^2 \alpha_w^2 \sigma^2$$
$$+ \alpha_p \alpha_w \mu_F \sigma_{\varepsilon F} / \sigma_F^2 - 0.5\rho_p \alpha_p^2 \alpha_w^2 \sigma_{\varepsilon F}^2 / \sigma_F^2 \tag{16}$$

Having derived the conditions for the parameters in the contract offered by the wholesaler to the producer, we now turn to the derivation of the optimality conditions for the parameters in the contract offered by the retailer to the wholesaler. From Eq. (1) – Eq. (4), Eq. (10), Eq. (12), Eq. (14), Eq. (15) and Eq. (16) the risk-averse wholesaler maximizes the certainty equivalent of profit as follows:

$$Max_{\alpha_p, z_w}\{(1-\alpha_p)\alpha_w^2\alpha_p / c_p + \beta_w - d_w - 0.5c_w\alpha_p^2\alpha_w^2 / c_p^2 - \overline{W}_p - d_p +$$

$$0.5\alpha_p^2\alpha_w^2 / c_p + 0.5\mu_F^2 / \rho_p\sigma_F^2 - 0.5\rho_p\alpha_p^2\alpha_w^2\sigma^2 - \alpha_p\alpha_w\mu_F\sigma_{\varepsilon F} / \sigma_F^2 +$$

$$0.5\rho_p\alpha_p^2\alpha_w^2\sigma_{\varepsilon F}^2 / \sigma_F^2 - \mu_F Z_w - 0.5\rho_w(1-\alpha_p)^2\alpha_w^2\sigma^2 - 0.5\rho_w Z_w^2\sigma_F^2 +$$

$$\rho_w(1-\alpha_p)\alpha_w Z_w\sigma_{\varepsilon F}\}$$

(17)

The first-order conditions yield:

$$\alpha_p = (1 - c_p\mu_F\sigma_{\varepsilon F} / \alpha_w\sigma_F^2 + c_p\rho_w\sigma^2 - c_p\rho_w Z_w\sigma_{\varepsilon F} / \alpha_w)$$

$$/(1 + c_w / c_p + c_p\rho_p S + c_p\rho_w\sigma^2)$$

(18)

and

$$Z_w = [\rho_w(1-\alpha_p)\alpha_w\sigma_{\varepsilon F} - \mu_F] / \rho_w\sigma_F^2$$

(19)

where

$$S \equiv (\sigma^2\sigma_F^2 - \sigma_{\varepsilon F}^2) / \sigma_F^2$$

(20)

where ρ_w is the wholesaler's coefficient of risk aversion. Next, like the producer, the wholesaler considers a participation constraint, according to which the certainty equivalent of the wholesaler's profit, equals the wholesaler's reservation wage, $\overline{W}_w$. From this condition, and after inserting Z_w in Eq. (19) into Eq. (17), the wholesaler's fixed compensation is derived as

$$\beta_w = \overline{W}_w + d_w + \overline{W}_p + d_p - \alpha_w^2\alpha_p / c_p + 0.5c_w\alpha_p^2\alpha_w^2 / c_p^2 + 0.5\alpha_p^2\alpha_w^2 / c_p$$

$$- 0.5\mu_F^2 / \rho_p\sigma_F^2 + 0.5\rho_p\alpha_p^2\alpha_w^2 S + \mu_F\alpha_w\sigma_{\varepsilon F} / \sigma_F^2 - 0.5\mu_F^2 / \rho_w\sigma_F^2$$

$$+ 0.5\rho_w(1-\alpha_p)^2\alpha_w^2 S$$

(21)

Next, we substitute Eq. (19) in Eq. (18) to obtain the following expression for the producer's revenue-sharing parameter α_p in his/her contract with the wholesaler:

$$\alpha_p = [1 + c_p\rho_w S] / [1 + c_w / c_p + c_p(\rho_p + \rho_w)S]$$

(22)

We now turn to the objective function of the risk-neutral retailer. From equations Eq. (1), Eq. (3), Eq. (6), Eq. (14) and Eq. (21) the risk-neutral retailer maximizes the expectation of profits as follows:

$$Max_{\alpha_w}\{\alpha_p\alpha_w / c_p - \overline{W}_w - d_w - \overline{W}_p - d_p - 0.5c_w\alpha_p^2\alpha_w^2 / c_p^2$$

$$- 0.5\alpha_p^2\alpha_w^2 / c_p + 0.5\mu_F^2 / \rho_p\sigma_F^2 - 0.5\rho_p\alpha_p^2\alpha_w^2 S - \mu_F\alpha_w\sigma_{\varepsilon F} / \sigma_F^2$$

$$+ 0.5\mu_F^2 / \rho_w\sigma_F^2 - 0.5\rho_w(1-\alpha_p)^2\alpha_w^2 S\}$$

(23)

for which the first-order condition yields:

$$\alpha_w = [1 - c_p \mu_F \sigma_{\varepsilon F} / \alpha_p \sigma_F^2] /$$
$$[c_w \alpha_p / c_p + \alpha_p + c_p \rho_p \alpha_p S + c_p \rho_w (1 - \alpha_p)^2 S / \alpha_p] \tag{24}$$

Recall from the linear contract for the wholesaler, as presented in Eq. (1) that the revenue-sharing parameter is given by α_w. In the contract for the producer the revenue-sharing parameter is $\alpha_p \alpha_w$. Consequently, if α_p is a constant parameter, then both revenue-sharing parameters may still be time varying through α_w. In line with this notion and for purpose of empirical testing to be discussed in the next two sections, we consider α_w, β_w, β_p, ρ_w, ρ_p, Z_w and Z_p as unknown variables to be solved by the equations Eq. (14) – Eq. (16), Eq. (19), Eq. (21), Eq. (22) and Eq. (24). In what follows, we first discuss the derivation of the solutions for ρ_w and ρ_p.

Rewriting Eq. (22) yields the following expression for the producer's risk parameter:

$$\rho_p = \rho_w (1 - \alpha_p) / \alpha_p + (1 - \alpha_p - \alpha_p c_w / c_p) / \alpha_p c_p S \tag{25}$$

Next, substituting α_w in Eq. (14) and ρ_p in Eq. (25) into Eq. (24), we obtain the wholesaler's risk parameter as follows:

$$\rho_w = [(\sigma_F^2 \alpha_p - \sigma_F^2 c_p e - c_p \mu_F \sigma_{\varepsilon F}) \alpha_p] / [(1 - \alpha_p) c_p^2 e \sigma_F^2 S] \tag{26}$$

Subsequently, substituting ρ_w in Eq. (26) into Eq. (25) we obtain the risk parameter for the producer:

$$\rho_p = [\sigma_F^2 \alpha_p^2 - 2\sigma_F^2 \alpha_p c_p e - \alpha_p c_p \mu_F \sigma_{\varepsilon F} + c_p e \sigma_F^2 - \alpha_p c_w e \sigma_F^2] /$$
$$[\alpha_p c_p^2 e \sigma_F^2 S] \tag{27}$$

To assess the importance of the risk parameters for the performance of the marketing channel, we perform some simulations, in order to obtain the agency (coordination) costs (*AC*) of the whole marketing channel as the difference between the first-best optimal solution and the second-best optimal solution, as follows:

$$AC = E(\pi_r^* + \pi_w^* + \pi_p^*) - E(\pi_r + \pi_w + \pi_p) \tag{28}$$

Agency (coordination) costs may include ex ante information search costs associated with adverse selection (hidden information) problems and/or ex post monitoring and enforcement costs associated with moral hazard problems. These costs are believed to be the main reasons for which the marketing channel cannot achieve the first best optimal solution. We examine the role of incentives in reducing coordination costs of the marketing channel *with* and *without* the use of the futures markets. The terms 'first-best solution' and 'first-best situation' are used interchangeably. They refer to a situation where all MCMs are assumed to be risk neutral. Similarly, the terms 'second-best situation' and 'second-best solution' are used interchangeably. In this case, risk aversion is assumed for producers and wholesalers. The second-best situation is viewed from two perspectives: *with* and *without futures trade*.

In what follows, we describe how we performed the simulations aimed at obtaining the coordination costs of the marketing channel. The first-best optimal solution of the marketing channel, $E(\pi_r^* + \pi_w^* + \pi_p^*)$, is obtained by setting $\rho_w = \rho_p = 0$. These restrictions imply that the futures market is also eliminated in the model: $Z_p = Z_w = \mu_F = \sigma_{\varepsilon F} = 0$. From this condition, and considering c_w, c_p, d_w, d_p, σ^2, $\overline{W}_w$ and $\overline{W}_p$ as given, from Eq. (20) it follows that $S = \sigma_F^2$. Hence, Eq. (22) yields $\alpha_p = c_p/(c_p + c_w)$, and Eq. (24) then shows that $\alpha_w = 1$, so that $e = 1/(c_p + c_w)$, according to Eq. (14). Next, we can perform simulations in order to obtain β_p and β_w by using Eq. (16) and Eq. (21), respectively. Thus, to obtain the first-best expressions for β_p and β_w, we substitute the first-best expressions for S, α_p, α_w, and e, outlined above into Eq. (16) and Eq. (21). Finally, we can derive the first-best and second-best expectations of profits and variances of the profits of the respective MCMs along the lines of Eq. (1) – Eq. (12). To derive the estimates of the expectation of first-best optimal profits for MCMs we substitute the first- best optimal expressions of the variables outlined above into the respective expectations of profits of the MCMs. However, to derive the estimates of the expectation of the second-best optimal profits for MCMs, we substitute where appropriate the variables: α_p in Eq. (22), α_w in Eq. (24), ρ_w in Eq. (26), ρ_p in Eq. (27), β_p in Eq. (16), β_w in Eq. (21) into the respective expectations of profits of the MCMs. Now that all MCMs are risk-neutral, the futures market has become superfluous and the principal can give full incentive to the agent, as the principal is no longer constrained by the optimal trade-off, according to which higher incentive intensity (incentive parameters) can only be established at the cost of a higher risk premium. The second-best optimal solution for the marketing channel, $E(\pi_r + \pi_w + \pi_p)$, is obtained when producers and wholesalers are risk averse. Subsequently, we can determine the coordination costs when MCMs cannot trade futures contracts, but are as risk averse as they were when they could trade on the futures market. This is done by setting $\sigma_{\varepsilon F} = \mu_F = 0$, and considering the empirical values of ρ_w and ρ_p obtained from Eq. (26) and Eq. (27) respectively, before imposing these restrictions as given. This analysis enables us to compare the coordination costs of the marketing channel *with* and *without* futures trade by MCMs.

3. Empirical application and Results

We apply the model to the Dutch potato industry. Every year, some eight million tons of potatoes are produced in the Netherlands, mainly on family farms. About half are ware potatoes, approximately 20 percent are seed potatoes, and the remaining 30 percent are potatoes grown for starch (NIVAP Holland, 2002). We focus on ware potatoes, as the prices of this type of potato exhibit the highest volatility estimates. It is therefore considered a more risky product than the other types of potatoes (Smidts, 1990). As far as the ware-potato trade in the Netherlands is concerned, there is very little interference in the operation of a free market and hence 'outside' involvement is at a minimum (*e.g.*, Young, 1977; ZLTO & LLTB, 2002). Most ware potatoes are sold to wholesalers and most of the wholesale trade has become concentrated in relatively few hands, as the major users, particularly the large retailers,

processors and export markets, demand large quantities with tight specifications which only the larger wholesalers can meet. Because of this development in the market, the need has arisen to procure potatoes before harvest. In this respect, the potato futures contract of the Euronext Commodity Amsterdam Exchange plays a price discovery role (see Kuiper *et al.*, 2002).

For the empirical analysis, Statistics Netherlands provided us with annual data over the period 1971 – 2003, for the following variables: the farm, export (i.e., wholesale) and retail prices (Euro/kg) of ware potatoes, all deflated by the consumer price index (1990 = 1.00), area planted (1000 ha), yield per hectare (100 kg/ha), and rent price of land (Euro/ha), deflated by the consumer price index. Furthermore, we obtained the futures price of potato from the Euronext Amsterdam Commodity Exchange over the period 1971-2003. We used the futures price (Euro/kg) for delivery in April of year t quoted as the closing price of the first trading day of April in year $t - 1$ to represent $F_{t,t}$; to represent $F_{t,t-1}$, we used the futures price (Euro/kg) for delivery in April of year $t + 1$ quoted as the closing price of the first trading day of November (when most potatoes are sold by the farmers) in year t. Both $F_{t,t-1}$ and $F_{t,t}$ are also deflated by the consumer price index. From these time series, we obtain the following variables of interest. First, all prices, spot and futures, are deflated by the consumer price index. The output quantity q_t (million tons) in year t is computed as the yield per hectare times the area planted. We compute the conditional expectation of the consumer (retail) price, p_t, and denote it as $\hat{E}(p_t|I_{t-1})$, assuming that the information set I_{t-1} is common to all MCMs. Using data on yield per hectare and the number of hectares planted, the estimate of the expected output $E(q_t|I_{t-1})$, denoted as $\hat{E}(q_t|I_{t-1})$, is obtained by the product of area planted and expected yield per hectare, where the expected yield per hectare is assumed to follow an autonomous positive linear time trend. Next, we turn to the estimation of $E(p_t q_t|I_{t-1})$. For this, note that $p_t q_t$ = $E(p_t|I_{t-1})E(q_t|I_{t-1}) + E(p_t|I_{t-1})\varepsilon_{qt} + \varepsilon_{pt}E(q_t|I_{t-1}) + \varepsilon_{pt}\varepsilon_{qt}$, where $\varepsilon_{pt} = p_t - E(p_t|I_{t-1})$ and $\varepsilon_{qt} = q_t - E(q_t|I_{t-1})$ are the unexpected components of p_t and q_t, respectively, and $\varepsilon_{pt}\varepsilon_{qt}$ represents the covariance of p_t and q_t, which we may expect to be negative. Consequently, $E(p_t q_t|I_{t-1})$ = $E(p_t|I_{t-1})E(q_t|I_{t-1}) + E(\varepsilon_{pt}\varepsilon_{qt}|I_{t-1})$. Now, to estimate $E(p_t q_t|I_{t-1})$ we simply regress $p_t q_t$ on a constant and $\hat{E}(p_t|I_{t-1})\hat{E}(q_t|I_{t-1})$. In this way, $\hat{E}(p_t|I_{t-1})\hat{E}(q_t|I_{t-1})$ extracts all the information of interest out of $\varepsilon_{pt}\varepsilon_{qt}$ since the regression residuals are orthogonal to $\hat{E}(p_t|I_{t-1})\hat{E}(q_t|I_{t-1})$. Hence, the fit of the regression is denoted as $\hat{E}(p_t q_t|I_{t-1})$, the expected output value at retail level. Next, the estimate of ε_t denoted as $\hat{\varepsilon}_t$ is obtained by subtracting $\hat{E}(p_t q_t|I_{t-1})$ from $p_t q_t$. The estimate of σ_ε^2 (*i.e.* the variance of the random retail value) denoted as $\hat{\sigma}_\varepsilon^2$ is simply computed as the fit of a regression of ε_t^2 on a constant. The rent price of land times the area planted (divided by 10^6) is used as a proxy for $\overline{W}_{pt}$ (the producer's reservation wage). Lastly, we set $\overline{W}_{wt}$ (the wholesaler's reservation wage) equal to zero and used linear models with a constant and linear trend to estimate d_w and d_p.

Note that, in contrast to the modeling framework, where the variables are assumed static, the variables become time varying during the estimation process, as we used time-series data. Hence the subscript t is imposed on the variables.

Finally, having data on $\overline{W}_{pt}$ and $\overline{W}_{wt}$ as well, we are only left with the estimation of c_p, c_w, d_p, d_w, and α_p, the unknown parameters in the model. In order to estimate these parameters, we need to derive estimation equations. According to Eq. (14), we can substitute $c_p e$ for $\alpha_p \alpha_w$ into Eq. (2) and into Eq. (16) to obtain, after substituting for β_p,

$$W_{pt} - \overline{W}_{pt} = d_p + c_p e_t x_t - 0.5 c_p e_t^2 + c_p e_t \hat{\mu}_F \hat{\sigma}_{\varepsilon F} / \hat{\sigma}_F^2$$
$$- 0.5 \hat{\mu}_F^2 / \hat{\sigma}_F^2 \rho_{pt} + 0.5 c_p^2 e_t^2 \rho_{pt} \hat{S} \qquad (29)$$

Similarly, substituting $c_p e / \alpha_p$ for α_w in Eq. (24), and then substituting for α_w and β_w in Eq. (1), yields:

$$W_{wt} - \overline{W}_{wt} - \overline{W}_{pt} = d_p + d_w + c_p e_t x_t / \alpha_p - c_p e_t^2 / \alpha_p + 0.5(c_p + c_w)e_t^2$$
$$- 0.5 \hat{\mu}_F^2 / \hat{\sigma}_F^2 \rho_{pt} + 0.5 c_p^2 e_t^2 \rho_{pt} \hat{S} + \hat{\mu}_F \hat{\sigma}_{\varepsilon F} c_p e_t / \hat{\sigma}_F^2 \alpha_p - 0.5 \hat{\mu}_F^2 / \hat{\sigma}_F^2 \rho_{wt}$$
$$+ 0.5[(1 - \alpha_p) / \alpha_p]^2 c_p^2 e_t^2 \rho_{wt} \hat{S} \qquad (30)$$

After substituting Eq. (26) and Eq. (27) for ρ_w and ρ_p, respectively, into Eq. (29) and Eq. (30), and modeling the deterministic terms d_p and d_w as linear trends, giving $d_{pt} = d_{p0} + d_{p1}t$ and $d_{wt} = d_{w0} + d_{w1}t$, we can estimate the unknown parameters α_p, c_p, c_w, d_{p0}, d_{p1}, d_{w0}, and d_{p1} in the two-equation system, by using Full Information Maximum Likelihood (FIML). The FIML estimates of the unknown parameters α_p, c_p, c_w, d_{p0}, d_{p1}, d_{w0}, and d_{p1} in Eq. (29) and Eq. (30) are 0.581, 0.261, 0.485, 0.276, -0.007, -0.107, 0.000 respectively. The estimate for α_p is significant and conforms to the expected constraints $0 < \alpha_p < 1$. The estimates of the marginal cost terms c_p and c_w are positive and significant as well. For both the producers and wholesalers, we obtain the negative slope of the trend terms, d_{p1} and d_{w1} in the cost function. However, only the trend term of the producers turned out significant, indicating technological advances in agricultural production. Having obtained the estimates of the above-mentioned parameters, we now perform simulations in order to obtain the estimates of the following variables: $\alpha_{wt}, \alpha_p \alpha_{wt}, \rho_{pt}, \rho_{wt}, \beta_{pt}$, and β_{wt}. The simulation procedure has been explained above in the last paragraph of section 2.

The estimates of the incentive parameters for producers $(\alpha_p \alpha_{wt})$ *with* and *without* futures market are compared with the first-best situation (i.e., when producers and wholesalers are risk neutral) and are shown in Figure1. This situation shows the case where all MCMs are assumed to be risk neutral. In the second-best situation, risk aversion is assumed for producers and wholesalers. The second-best situation is viewed from two perspectives: *with* and *without*

futures trade. The estimates of incentive intensity are higher for the case with futures trade than for the case without as higher incentives are associated with higher risks and hence channel members need to trade futures to reduce the risk. *With futures trade*, the incentive intensity of producers increased from 0.24 in 1971 to 0.31 in 2003, whereas, *without futures trade*, it increased from 0.14 in 1971 to 0.25 in 2003. As expected, most incentives can be given in case of risk-neutrality, although, remarkably, around 2000, where the three graphs converge, incentive intensity hardly seems to be affected by the risk aversion of the producers. This result is consistent with the increase in the incentives in the potato contracts in 2000. In 1999, potato production was adversely affected by the flood that occurred in 1998. To motivate the producers to increase production, they were given more incentives by wholesalers and processors in the potato contract in 2000. Hence, the incentive levels converge with the first-best levels. This result may indicate an improvement of coordination among wholesalers and producers.
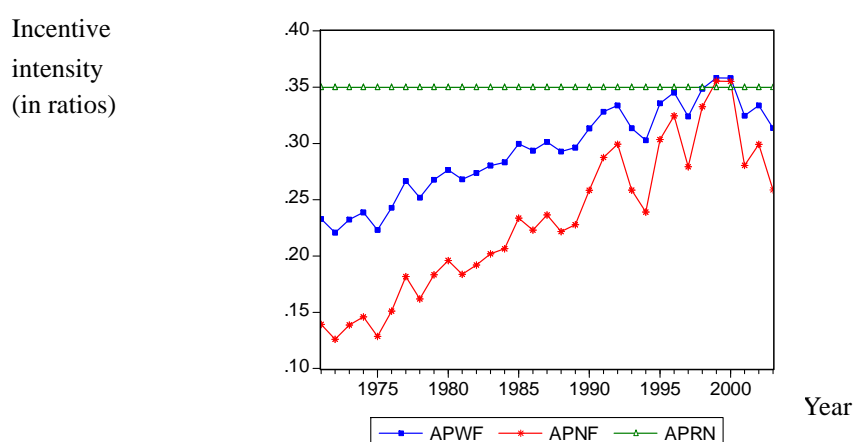
Figure 1. Producers' incentive intensity $(\alpha_p \alpha_{wt})$ with futures (APWF), without futures (APNF), and under risk neutrality (i.e., first-best situation) (APRN)

Similarly, the estimates of the incentive intensity from retailers to wholesalers (α_{wt}) *with* and *without* futures market are compared with the first-best situation and are shown in Figure 2. The incentive intensity for wholesalers increased from 0.40 in 1971 to 0.62 in 2000, *with* futures trade, and increased from 0.22 in 1971 to 0.50 in 2000, *without* futures trade.

Incentive
intensity
(in ratios)
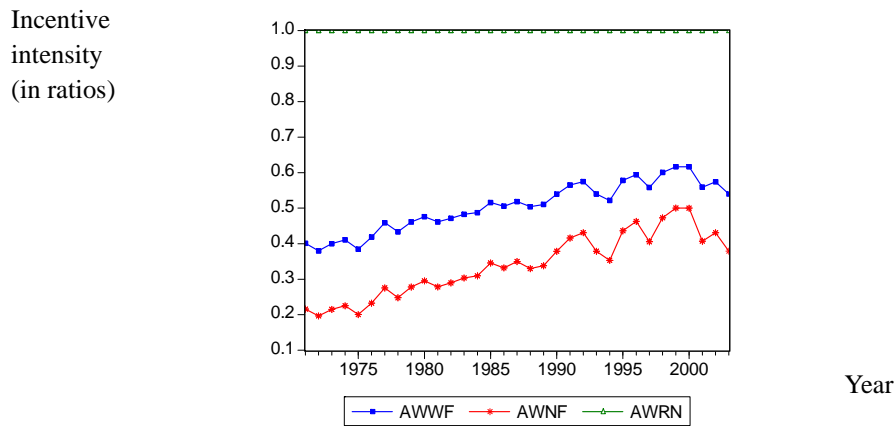
Figure 2 . Wholesalers' incentive intensity (α_{wt}) with futures (AWWF), without **f**utures (AWNF), and under risk neutrality (i.e., first-best situation) (AWRN)

In contrast to the incentive parameters that show positive trending patterns, the fixed compensations for producers (wholesalers), β_{pt} (β_{wt}), show negative trending patterns over the years (the fixed payments decreased to negative levels). The results suggest that farmers play a crucial role in the transformation process of the agri-food chain, as they seem forced to finance some of the activities required by marketing firms (i.e., wholesalers and retailers) to meet consumers' needs and demands in the increasingly saturated consumer food market, amidst growing competition and globalization. The fact that growers have become more involved in storing potatoes is a clear example of this development. Yet, another illustration of the above claim is that more and more varieties have been produced and marketed, in order to satisfy consumer needs in recent years.

The increase in incentive intensity, along with the decrease and negativity of the fixed compensation payments to producers and wholesalers has implications for financial risk allocation in the marketing channel. The computed variance of profits of producers in Eq. (11) and wholesalers in Eq. (12) shows slightly increasing trending patterns, both in the case *with* and *without* a futures market; whereas that of the retailers in Eq. (7) shows decreasing trending patterns that are quite pronounced, see Figure 3. The graphs in Figure 3 clearly show that, of all MCMs, the retailers assume most of the risk, as we expect them to do, being the only risk-neural MCMs. Interestingly, however, of all the MCMs, the risk-neutral retailers profit most from the presence of a futures market. In terms of risk reduction, even though the retailers do not use the futures market as a risk-management instrument, their profit risks becomes much lower, when the wholesalers and producers use the futures market to manage their risks.

Profit risk for producers,
wholesalers and retailers
(in billions €^2)
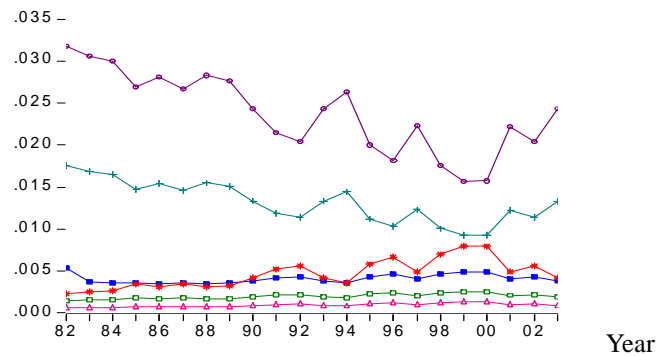
Figure 3. Variance of profits of wholesalers with futures (VPWWF) and without futures (VPWNF); variance of profits of producers with futures (VPPWF) and without futures (VPPNF); and variance of profits of retailers with futures (VPRWF) and without futures (VPRNF)

To assess coordination efficiency, we computed the coordination costs of the marketing channel involving producers, wholesalers, and retailers. Possibly, as a result of increases in the incentives to producers and wholesalers, the coordination costs of the marketing channel have generally decreased over time, both *with* and *without* futures trade. The coordination costs of the marketing channel *with* (*without*) futures trade decreased from about 0.09 billion euro (0.24 billion euro) in 1971 to 0.03 billion euro (0.014 billion euro) in 2002, see Figure 4. The coordination costs *with* futures are generally lower than *without*, complying with the role of futures markets in providing information regarding prices.

Coordination costs of the
 marketing channel
(in billion €)
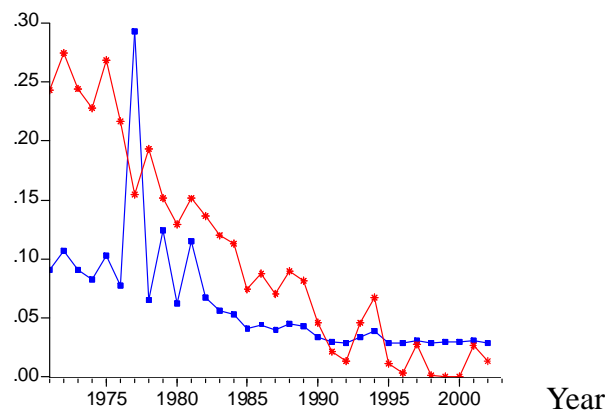
Figure 4. Coordination costs of the marketing channel with futures market
          (CCWF) and without futures markets (CCNF)

4.   Conclusions

We extend the widely-known two-stage, principal-agent model to a three-stage model involving producers, wholesalers, retailers and a futures markets, to assess risk, incentives, and coordination costs, in an agricultural marketing channel. The model allows risk-averse producers and wholesalers to trade in the futures market, in combination with their respective contractual relationships in the spot markets. We develop a procedure to determine the coordination costs of the marketing channel.

 The Dutch ware potato marketing channel has been used as the empirical setting for the research. The results show considerable improvement of coordination between wholesalers and producers as indicated by the convergence of the estimated second-best incentive-intensity levels for producers and first-best incentive-intensity values. Note that the producer's incentive intensity is paid by wholesalers. The coordination between retailers and wholesalers seems to be open to further improvement, although the benefits of these improvements will be minor for the marketing channel as a whole, as total channel profit has already come very close to the first-best profit that the channel would make if all its members were risk neutral. The coordination costs of the marketing channel are generally lower *with* futures trade than *without*. This demonstrates the role of futures markets in providing marketing-channel members with information regarding prices. Yet another striking result is that the computed variance of profits of producers and wholesalers shows slightly increasing trending patterns, both *with* and *without* a futures market, whereas that of the retailers shows decreasing trending patterns that are quite pronounced. These results indicate that the retailers assume most of the risk, as we expect them to do; being the single risk-neutral MCMs. Strikingly, the retailers' risk is much lower when wholesalers and producers trade in the futures markets to manage their

increasing risks. Retailers thus profit most from the futures market in terms of risk reduction, while they are not using it themselves.

5. References

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