REALLOCATION OF PRICE RISK AMONG COOPERARTIVE MEMBERS

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Abstract

Currently there is practically no active output price hedging in the Danish livestock sector. This may be because their, until recently, was very little need for hedging, as Danish farmer had (a perception of) very large credit reserves up to the GFC. After the GFC the need for price risk management has increased, as an institutional vacuum has emerged, where no new risk coping mechanisms are in place after the credit reserves disappeared. Price hedging via futures may problematic when physical delivery is to a cooperative, as the cooperative specific business risk which is carried by the members, will translate into basis risk in a futures hedging arrangement. This paper explores the possibility of risk reallocation among cooperative members as an alternative risk management institution. Based on deduction and extension of a model by Collins (1997) it is found that given adequate member heterogeneity in the cost of carrying risk and given low enough transaction costs there are, potentially substantial, gains from reallocation of risk among cooperative members.

Keywords: futures, hedging, reallocation gains, risk management, cooperatives, mechanism design

1. Introduction

The main livestock sectors in Denmark, the hog and the dairy sectors, are characterized by asymmetry in the contracting behavior. On the input side, forward contracting and substantial self-sufficiency rates of grain or feed from the arable side of the farm are traditionally dominant. On the output side, there is tradition for the spot-price marketing of milk and meat delivered to cooperative dairies and slaughterhouses. This asymmetric behavior may be explained by related institutional domains such as agricultural policy, finance and organization. Recent changes in these domains suggest the need for adaptive changes in risk management institutions. However, this response may be very challenging and not automatic (Aoki, 2001).

According to Bogetoft and Olsen (2004), risk sharing between members in agricultural cooperatives is limited to risk sharing between producer product groups and risks the absorption of the equity buffer. This paper challenges this statement by suggesting the grouping of members according to their cost of carrying risk rather that their product attributes. By introducing mechanisms that reallocate risk from the individuals faced with a high cost of risk to individuals with a low cost of risk, the aggregate cost of risk can be reduced (Chavas, 2011).

Most research on hedging explores the vertical reallocation of risk in the value chain, the use of forward contracting, commodity futures and options being the main vehicles for the reallocation (Garcia and Leuthold, 2004). This paper explores the possibility of horizontal risk transfer among cooperative members. Endowing members with a forward contracted share of delivery, and organizing the transfer of this share via an auction mechanism at a market price will potentially lead to the reallocation gains.

2. Member heterogeneity in risk exposure, appetite and management needs

Recent work by Chavas (2011) stresses the interaction between uncertainty and externalities in efficiency analysis of the agricultural sector. Using a certainty equivalent approach, the Coasian efficiency evaluation is extended to include risk allocation. It is stated that "an efficient allocation should try to reduce the aggregate cost of risk" (Chavas, 2011, pp. 398) and three ways of doing this are mentioned. First, risk exposure can be reduced. Second, when exposure involves externalities, it can be managed by coordination schemes using contracts or policy. Third, "the aggregate cost of risk […] can be reduced through risk-transfer mechanisms. By redistributing the risk away from the individuals who face a high cost of risk […], such mechanisms can reduce the aggregate cost of risk" (Chavas, 2011, pp. 398-399). Chavas (2011) implicitly stresses the importance of heterogeneity and explicitly stresses the potential for reallocating risk.

Pennings and Leuthold (2000) and Pennings and Garcia (2004) explicitly stress the heterogeneity in hedging behavior using structural equation modeling to analyze the behavioral characteristics of Dutch hog farmers. The study shows heterogeneity in the drivers for the use of futures. In the USA, the use of price risk management is widespread in both the dairy and hog sectors and in Ireland the cooperative dairy Glanbia has forward contracted part of its production with members, linking member supply-side forward contracts to specific business partner contracts on the demand side (Keane, 2012). This illustrates demand for price risk management instruments in the dairy sector. Assuming heterogeneity in the attitude towards risk management instruments among hog and dairy farmers seems fair.

Collins (1997) presents a model where heterogeneity in cost structure, profitability and financial structure affect the likelihood of financial failure and motivate different levels of hedging via futures contracts.

3. The problem with futures markets – basis risk

Futures markets could potentially solve the problem of commodity price risk adjustment for the individual cooperative member. There may, however, be liquidity problems in existing futures markets for milk and pork. An even more fundamental problem is the substantial basis risk that emerges from the fact that even if futures markets could transfer market price risk effectively, farmers, as cooperative members, are exposed to business risk in the dairy or meat processing and marketing business. This is a broad definition of the basis risk concept, but a useful one. A narrow definition of basis risk is the difference between the spot cash price and the futures price (Hull, 2002).

The difference between futures market risk and the aggregate of cooperative business and market risk is a key element of the basis risk involved in synthetic futures based hedging. Information asymmetries about processing costs and marketing contract and risk management status between cooperatives and members make an effective hedge very difficult, if not impossible. The marketing cooperative may, however, not be very willing to disclose this information for strategic competition related reasons.

The pricing behavior of cooperatives may be affected by investment and finance considerations. The members are the residual claimants, but residual earnings may be retained in the cooperative for investment purposes or for reduction of debt. Thus strategic considerations concerning finance and possible credit constraints, as well as variation in investment opportunities for the cooperative, will affect the aggregate of the cooperative spot cash price and the end of year patronage payment. This may affect the difference between the cooperative price and the futures price, as well as the predictability of this difference, which will increase the difficulty of use of commodity futures for the hedging of cooperative members' price risk.

4. Potential for reallocation of price risk among cooperative members

4.1. The model

Elaborating on the Collins (1997) model framework shows that cooperative member heterogeneity, in the usual factors which motivate hedging, yields potential gains from trade, by redistributing risk from members with a high cost of risk to members with a low cost of risk, as suggested more generally by Chavas (2011). One usual explanation for hedging is the reallocation of risk vertically in the supply chain. The idea suggested here is to utilize the potential gain from reallocation of risk horizontally in the supply chain, that is, reallocation among cooperative members with heterogeneous cost of risk.

As stated in Collins (1997, pp. 494-495), the "realistic objective of a single-period model is to maximize the expected effect of this period's operations on the firm's terminal equity [...] subject to the constraint that the chance that terminal equity is less than some disaster level (d) is less than α" which is the individual's acceptable probability of financial failure. Following Collins (1997), the model of terminal equity is:

$$\tilde{E}_1 = E_0 + [p_h H + \tilde{p}_c(1 - H)]Y - kY - iD - F \tag{1}$$

Where $\tilde{E}_1$ is the terminal equity, E_0 is the initial equity, p_h is the forward price of hedged output, H is the hedge ratio, $\tilde{p}_c$ is the stochastic cash price of the unhedged output, Y is output, k is variable costs, i is the interest rate paid on debt, D is debt and F is fixed costs. Given stochastic cash price of output, terminal equity is a stochastic function of not only realized cash price and the quantity hedged, but also the financial leverage of the firm.

Let g (E_1) be the probability density function for terminal equity. The objective function is:

$$\max \bar{E}_1 = \int_{-\infty}^{\infty} E_1 g(E_1) dE_1$$

$$\text{s.t.} \int_{-\infty}^{d} g(E_1) dE_1 \leq \alpha \tag{2}$$

Expected terminal equity is:

$$\bar{E}_1 = E_0 + [p_h H + \bar{p}_c(1 - H)]Y - kY - iD - F \tag{3}$$

and

$$\frac{\partial \bar{E}_1}{\partial H} = p_h - \bar{p}_c \tag{4}$$

The relevant situations are where, $\bar{p}_c$, the expected spot cash price is above the forward price of hedged output $(\bar{p}_c > p_h)$ and there is a trade-off between expected terminal equity and a reduction in the risk of financial failure.

Following Collins (1997), suppose for simplicity that the price $\tilde{p}_c$ is uniformly distributed between the worst possible price (a) and the best possible price (b). The uniform density function is defined as:

$$f(p_c) = \frac{1}{b-a}, a \leq p_c \leq b; 0 \ otherwise \tag{5}$$

Further, following Collins (1997), given $f(p_c)$, the probability density function for terminal equity $g(E_1)$ is uniformly distributed with E_b representing the terminal equity under realization of (b) and E_a representing the terminal equity under realization of (a). The probability that a terminal equity level will be less than the disaster level is:

$$\int_{-\infty}^{d} g(E_1)dE_1 = \frac{d - E_a}{E_b - E_a}, \ E_a < d < E_b \tag{6}$$

Now suppose this model reflects the Danish situation for the marketing of milk and hogs. Because of near monopsony and prohibitive basis risk for futures markets, there are no effective hedging tools and $H = 0$. All cooperative members receive the same stochastic price $\tilde{p}_c$ for a given output, which reflects the residual claims in the cooperative.

If the goal of the marketing cooperative is to maximize the individual member's terminal equity subject to the constraint that the probability of terminal equity is less than some disaster level, which is less than the acceptable risk of financial failure, the ability to redistribute price risk among heterogeneous members will increase utility. The commonly stated goal of cooperatives is to maximize the commodity price received by their members. Whether the stated goal of maximum price is due to communicational convenience (as maximizing integrated profit may be a difficult concept to communicate) or otherwise, goals that maximize integrated profit and thus take the on-farm costs into account seem more relevant (Bogetoft and Olesen, 2000). Following Chavas (2011), the on-farm costs ought to include the cost of risk.

Suppose the marketing cooperative has three member segments, one with a low cost of risk, one with a medium cost of risk and one with a high cost of risk. Total quantity marketed through the cooperative is $Y_{coop} = Y_{low} + Y_{medium} + Y_{high}$ where the subscripts low, medium and high represent the three member segments.

The residual claims in the cooperative are:

$$[p_h H + \tilde{p}_c(1 - H)]Y_{coop} \tag{7}$$

where $H = 0$, by tradition. But suppose members were endowed with an equal and positive forward price and an equally positive and proportional forward priced quantity, $\bar{H}$. Equation (7) could be extended to:

$$\left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}}\right] + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}}\right] - [p_h\bar{H} + \tilde{p}_c(1-\bar{H})]Y_{coop} \tag{8}$$

Notice that the average price and the variation in average price are unchanged for all segments. However, marginal price ($\tilde{p}_c$) volatility (σ_c) is increased. Assume for convenience that the forward price is equal to the expected spot cash price, $p_h = \bar{p}_c$.

Now suppose cooperative members were allowed to exchange $\bar{H}Y_{coop}$ among each other at a market price z. Cooperative members with a high cost of risk would presumably be willing to pay zhY_{coop} for an increase in the forward contracted quantity by hY_{coop}. Similarly, cooperative members with a low cost of risk would presumably be willing to reduce the forward contracted quantity by hY_{coop} in return for pecuniary compensation zhY_{coop}.

The cooperative members with a medium cost of risk would be unwilling to pay z for a marginal increase in the forward contracted quantity, and unwilling to receive z for a marginal reduction in the forward contracted quantity. They would be unaffected at the average price volatility level, but would be affected by an increase in variation at the marginal price ($\tilde{p}_c$) level. Equation (8) could be extended to:

$$\left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c hY_{coop} + zhY_{coop}\right] + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c hY_{coop} - zhY_{coop}\right] = [p_h\bar{H} + \tilde{p}_c(1-\bar{H})]Y_{coop} \quad (9)$$

The expected terminal equity for cooperative members with a low, medium and high cost of risk, respectively, is:

$$\bar{E}_{low_1} = E_{low_0} + \left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c hY_{coop} + zhY_{coop}\right] - kY_{low} - iD_{low} - F_{low} \quad (10a)$$

$$\bar{E}_{medium_1} = E_{medium_0} + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] - kY_{medium} - iD_{medium} - F_{medium} \quad (10b)$$

$$\bar{E}_{high_1} = E_{high_0} + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c hY_{coop} - zhY_{coop}\right] - kY_{high} - iD_{high} - F_{high} \quad (10c)$$

As pointed out above, the heterogeneity in factors which affect hedging behavior can take many forms (Pennings and Leuthold, 2000; Pennings and Garcia, 2004). Assume these factors are condensed in the cost of risk (Chavas, 2011) and assume, without loss of generality, that the cost of risk is inversely reflected in the level of acceptable probability of financial failure $\alpha_{low} > \alpha_{medium} > \alpha_{high}$ holding the disaster level equal for all members at the point of financial failure where $\tilde{E}_1$ is zero, $d_{low} = d_{medium} = d_{high} = 0$.

The objective function of the three segments could be stated as:

$$\max \bar{E}_{i\_1} = \int_{-\infty}^{\infty} E_{i\_1} g(E_{i\_1}) dE_{i\_1}$$
$$\text{s.t.} \int_{-\infty}^{d} g(E_{i\_1}) dE_{i\_1} \leq \alpha_i \text{, where } i \in \{low, mediun, high\} \tag{11}$$

This means that members with a low cost of risk *ceteris paribus* will accept a higher probability of financial failure than members with a high cost of risk, against compensation of zhY_{coop}. Members with a high cost of risk will accept a lower expected terminal equity, $\bar{E}_{high\_1}$, in return for a lower probability of financial failure.

Assume that $g(E_{low\_1}) = g(E_{medium\_1}) = g(E_{high\_1})$ ex ante, before endowment of $\bar{H}$ and transfer of risk. The only thing separating the three segments is $\alpha_{low} > \alpha_{medium} > \alpha_{high}$.

As illustrated in Figure 1a, the condition for equation (11) is not satisfied for the high cost of risk segment, since the probability of financial failure is above α_{high}, the acceptable level of financial failure. Given the endowment of $\bar{H}$ it is possible to transfer risk among members in exchange for pecuniary compensation and obtain an ex post situation (Figure 1 b) in which risk is adjusted to the level where the probability of financial failure is equal to the acceptable level, for each segment. Expected terminal equity will shift from $\bar{E}_{low\_1} = \bar{E}_{medium\_1} = \bar{E}_{high\_1}$ in the ex ante situation to $\bar{E}_{low\_1} > \bar{E}_{medium\_1} > \bar{E}_{high\_1}$ in the ex post situation. $G(E_{i\_1})$ denotes the cumulative distribution function of terminal equity of segment *i*.

Assuming that $\frac{\partial Y}{\partial \sigma_c} = 0$, that $h > 0$ and zero transaction costs, a change in the traditional endowment of $\bar{H} = 0$ to $\bar{H} > 0$ will increase the aggregate utility without anyone being worse off. This constitutes a Pareto improvement. These assumptions, however, need further discussion.

Figure 1a. Cumulative distribution function of terminal equity, ex ante

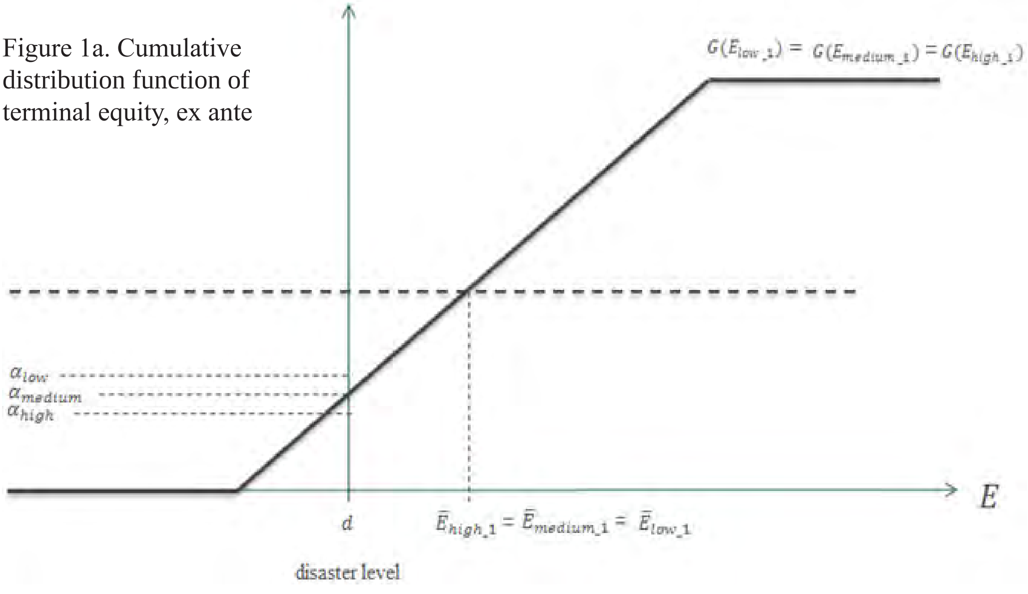
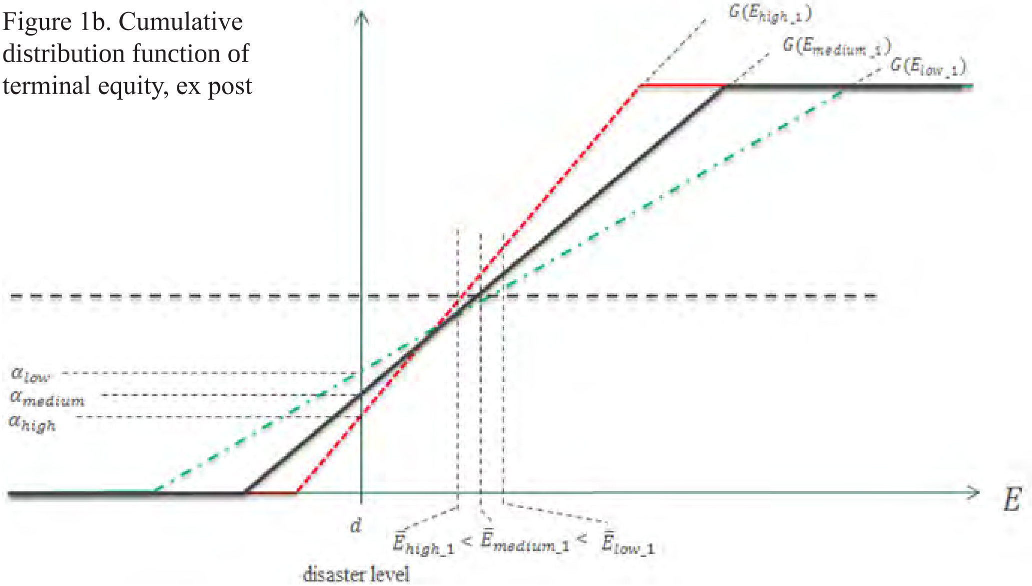


Figure 1b. Cumulative distribution function of terminal equity, ex post



4.2. Transaction costs

An actual endowment of $\bar{H} > 0$ and the subsequent exchange of forward contracting rights will incur some direct transaction costs. The cost structure of direct transaction costs will presumably have some fixed element related to setup costs, etc. If these are assumed to be negligible or covered more than fully by direct transaction fees paid by participating segments, there could still be room for Pareto improvement. In this case, non-participating members will no longer be unaffected but will receive part of the redistribution gains, that is the transaction fees paid by participating members less the part of direct transaction costs covered by the cooperative multiplied by $\frac{Y_{medium}}{Y_{coop}}$. Modern electronic market platforms have relatively low direct transaction costs, which is why assuming variable transaction costs, although a simplification of reality seems fair.

The model could be extended to cover variable transaction costs τ in the following way:

$$\begin{aligned}&\left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c hY_{coop} + zhY_{coop}\right.\\&\quad\left.-\frac{\tau}{2}hY_{coop}\right] + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right]\\&\quad+\left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c hY_{coop} - zhY_{coop}\right.\\&\quad\left.-\frac{\tau}{2}hY_{coop}\right] = [p_h\bar{H} + \tilde{p}_c(1-\bar{H}) - th]Y_{coop}\end{aligned} \tag{12}$$

Expected terminal equity for cooperative members with a low, medium and high cost of risk, respectively, would be:

$$\bar{E}_{low_1} = E_{low_0} + \left[p_h \bar{H} \frac{Y_{low}}{Y_{coop}} - p_h h Y_{coop} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h Y_{coop} + z h Y_{coop} - \frac{\tau}{2} h Y_{coop}\right] - k Y_{low} - i D_{low} - F_{low} \quad (13a)$$

$$\bar{E}_{medium_1} = E_{medium_0} + \left[p_h \bar{H} \frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{medium}}{Y_{coop}}\right] - k Y_{medium} - i D_{medium} - F_{medium} \quad (13b)$$

$$\bar{E}_{high_1} = E_{high_0} + \left[p_h \bar{H} \frac{Y_{high}}{Y_{coop}} + p_h h Y_{coop} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h Y_{coop} - z h Y_{coop} - \frac{\tau}{2} h Y_{coop}\right] - k Y_{high} - i D_{high} - F_{high} \quad (13c)$$

If transaction costs are sufficiently low, there will still be potential for Pareto improvements by enabling the reallocation of price risk.

Assuming zero setup costs means zero costs if $h = 0$, this is of course a simplifying assumption. But given the turnover of the cooperatives in question, assuming the fixed setup costs of a price risk reallocation scheme to be negligible seems a fair simplifying assumption.

In reality, the cost structure of a risk reallocation mechanism is likely to involve relatively high fixed cost (setup costs) compared to negligible variable costs. The setup costs will, however, most likely be relatively low compared to the reallocation gain. Experiences from the introduction of a sugar beet contract exchange in Denmark in 2008 among farmers are good and the cost of running an exchange like this is negligible compared to the economic size of the cooperatives in question.

4.3. Quantity effect of increased volatility of marginal price

In the analysis above it was assumed that change in the volatility of price has no effect on output, $\frac{\partial Y}{\partial \sigma_c} = 0$. This assumption may be strong which is why the effect of relaxation is discussed as it may influence the model outcome. As Turvey (1989) points out, production and marketing issues are often treated independently, although they are inherently integrated parts of one decision problem.

As classical theory dictates, the short run production will be maintained as long as marginal revenue is greater than or equal to marginal cost, $\tilde{p}_c \geq k$. In the long run all costs will have to be covered. The question is how long is the long run? How flexible is the cost structure at the individual farm level and on the cooperative wide level.

The time horizon of the suggested endowment of forward contracts to cooperative members is a key variable. The contract horizon length is assumed to be positively related to the value of hedging. Very short contracts will approach a no contract situation, while longer contracts will improve cash flow predictability for members with an above average hedge ratio within the contract period. Members, having sold part of their forward contract endowment to other members, will have a below average hedge ratio. The price of accepting increased price volatility, for members with below average hedge ratio, will increase with the length of the time horizon of forward contracts. The optimal length of such contracts is beyond the scope of this paper, although a pragmatic suggestion for the time horizon of the forward contract could be that the hedged price p_h and quantity endowment $\overline{H}$ are specified in advance for the cooperative's fiscal year, stating p_h as the expected average price and the individual member endowment $\overline{H}_i$ to be based on the individual member's preceding year's delivery to the cooperative.

Suppose forward contract is specified as above, then the short run will become the cooperative's fiscal year. The volatility of the unhedged price $\tilde{p}_c$ will increase and will affect the production quantity in cases where $\tilde{p}_c < k$ with k representing the within year flexible costs. In general, the cost structure of modern Danish livestock production is relatively fixed and cases where $\tilde{p}_c < k$ will presumably be seldom. However, across the members of the cooperative, there will likely be a distribution of production technologies at work. Older production facilities that are near the end of their productive lifespan, may be shut down early in cases where $\tilde{p}_c$ is low. Similarly, these facilities may be kept in production for a while longer in cases where $\tilde{p}_c$ is high. This sort of dynamic will most likely have some effect on the total production Y_{coop} and $\frac{\partial Y}{\partial \sigma_c} \neq 0$ and thus have an impact $[p_h H + \tilde{p}_c(1-H)]Y_{coop}$ and an accelerating impact on σ_c. The cooperative average price will be affected at some level and the above-mentioned impact on non-participating members will be understated. Pareto improvements will be less likely, as the possibility that non-participating members will not be automatically compensated will increase. There will, however, still be significant potential for improvement of the weaker Kaldor-Hicks efficiency measure as a function of the risk reallocation possibility (Gowdy, 2004).

5. Conclusions

The potential gain from the reallocation of risk among cooperative members will depend upon the distribution of cooperative member attitudes towards, and perceptions of, risk, their alternative risk mitigation possibilities and differences in financial structure and possibly the macroeconomic environment. Given sufficiently low transaction costs and sufficiently high heterogeneity of members, the potential gains would be positive. It is the author's belief that the potential is great in the current post GFC environment, although it is not static, as alternative ways of mitigating risk evolve dynamically and the potential will be conditioned on the present alternatives at any given time.

Until recently, institutions may have been in place that crowded out the need for price risk transfer away from some of the livestock producers in Denmark. These institutions may be changing drastically and the ability to transfer price risk may be becoming valuable. Traditionally, commodity futures are thought of as vehicles for the transfer of price risk vertically in the value chain. Here endowment and the transfer of forward contracts among cooperative members is suggested to extract the potential gains from the horizontal reallocation of risk.

Research questions like; what is the optimal endowment of $\overline{H}$? what is the optimal forward price p_h? and what is the potential gain from the reallocation of risk? are still open questions. However, it seems likely that advances in electronic market platforms and market design could reduce transaction costs to a sufficiently low level, where this type of reallocation could be a source of social gain. Price risk management tools could potentially alleviate some of the financial constraints that Danish agriculture is experiencing in the aftermath of the GFC.

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