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Reallocation of price risk among members in marketing cooperatives

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Abstract

Marketing of milk and meat in Denmark is dominated by two large cooperatives, Arla Foods in the dairy sector and Danish Crown in the pork sector. Members in these cooperatives practically have no possibility for price risk management on their main product. Futures markets for dairy and pork are not utilised, and it is suggested that the reason is prohibitively large basis risk. The events following the global financial crisis suggest increased need for price risk management in Danish agriculture. Since futures markets do not seem to be a viable solution, the paper explores an alternative. Reallocation of price risk among members in marketing cooperatives. Endowing members with a forward contracted share of delivery, and allowing for transfer at a market price will lead to reallocation gains if member heterogeneity in cost of risk is great enough and transaction costs are low enough.

Keywords: futures, hedging, risk management, marketing cooperatives

JEL classification: G13, G32, Q13, D61, D8

1. INTRODUCTION

The main livestock sectors in Denmark, the hog and the dairy sectors are characterized by asymmetry in the contracting behaviour. 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 spot-price taking for milk and meat delivered to cooperative dairies and slaughterhouses. This asymmetric behaviour may be explained by related institutional domains such as agricultural policy, finance and organization. Recent changes in these domains suggest the need for changes in risk management institutions, the response may, however, be very challenging and not automatic (Aoki, 2001).

This paper explores the theoretical possibility of reallocation of price risk among members in marketing cooperatives. Endowing members with a forward contracted share of delivery, and allowing for transfer of this share at a market price will potentially lead to reallocation gains.

The paper is structured as follows: The next section gives some background on hedging and why it may not have been widespread in Denmark. The third section gives an introduction to the characteristics of marketing of Danish livestock products via the dominant marketing cooperatives. The fourth section argues for the potential heterogeneity of cooperative members in attitude towards risk management, and potential gain from reallocation of risk. The fifth section discusses why this reallocation may not be handled via futures markets. The sixth section holds the body of the work, extending a model by Collins (1997) to illustrate the potential for reallocating risk via transfer of forward contracted delivery among cooperative members. The section also discusses the assumptions of the model. Section seven provides concluding remarks.

2. BACKGROUND ON RISK MANAGEMENT

In the 1970s Danish agriculture was still characterized by fairly diversified farms and low leverage. During the 1980s increasing specialization and leverage could be related to the price support regime in EU common agricultural policy. This could be a meso level effect of the balancing of business and financial risk (Gabriel & Baker, 1980). In the 1990s and 2000s price support was substituted with income support, reintroducing the potential for some price risk. The reintroduction of price risk coincided with the build-up of the credit bubble which imploded in 2008 leading to the global financial crisis (GFC).

It is widely recognized that agricultural policy may have a crowding out effect on market based risk management institutions (Turvey & Baker, 1989; Turvey & Baker, 1990; OECD, 2009). It is less recognized that ease of access to credit, which may occur in the case of a credit bubble, may also crowd out market based risk management.

The connection between hedging and financial structure is however recognized by part of the literature (Turvey & Baker, 1989; Turvey, 1989; Turvey & Baker, 1990; Collins, 1997; Pennings & Leuthold, 2000; Pennings & Garcia, 2004; Garcia & Leuthold, 2004), that sees the motivation for hedging and risk management in a desire to avoid financial failure which is related too, but different from, a desire to reduce income variability. The literature suggests heterogeneity in willingness to pay for hedging. While this literature focus on the financial aspects of hedging behaviour, only Turvey and Baker (1990) stress and distinguish between liquidity aspects and capital structure aspects. Focus on possible impact of macroeconomic fluctuations of the business cycles on finance and its implications for hedging and risk management is generally absent. The importance of credit reserves, explicitly described in Gabriel and Baker (1980), are not emphasised. In a leverage cycle framework (Geanakoplos, 2009) the credit reserves may, however, not be constant even though debt and assets are, thus the debt-to-asset ratio may not fully reflect the credit reserves. An increase in the access to finance for Danish agriculture in the late 1990s and 2000s is demonstrated by Olsen and Pedersen (2011). The crowding out effect of easy access to finance on risk management institutions may have been substantial in this period. Post GFC changes in the financial environment and agricultural policy reform may lead to a situation of institutional vacuum, where the institutions that covered the need for market bases risk management institutions disappear, but market based risk management institutions do not appear instantly. The potential lack of risk management institutions may have significant social costs.

3. MARKETING OF MILK AND MEAT IN DENMARK

Danish agriculture is dominated by two major marketing cooperatives. Arla Foods in the dairy sector and Danish Crown in the pork (and beef) sector.

These two cooperatives have near monopsony power in the Danish markets for milk and meats. As pointed out by Hobbs (2001, p.27) this leads to "the unusual situation where, despite the fact that the processing and downstream supply-chain activities are performed by farmer-owned organisations, there remain concerns over the effects of concentration in the industry." Mergers leading to the formation of the current cooperatives were subject to a number of conditions, including that they partially relinquished their exclusive supply requirement for members and the notice for leaving the cooperative was shortened.

Within both cooperatives there are base price schemes with quoted prices for current spot deliveries to the cooperatives and end-of-year patronage payments based on a split of the residual claims among patronage payments, retained earnings on personal member accounts and retained earnings for collective equity build up in the cooperative. On top of the base price schemes there are general quality schemes and market-specific contracts.

The farm-gate price of milk is based on fat and protein content, quality, logistics and specially contracted credence attributes such as organic or grass-milk. Similarly the farm-gate price of hogs is based on weight and quality parameters and specially contracted credence attributes such as UK special pigs, free range pigs etc.

There are clear price differentiation schemes on physical attributes of the products and supplement payments for special contracted products, such as organic production, that often involve changes in on-farm production processes and specific investments. Although criticised for reducing competition (Bogetoft & Olesen, 2007), Danish cooperatives have shown that they can manage price differentiation among members on a number of product attributes. One thing they are not differentiating on, however, is the acceptable volatility of the base price. Danish hog and dairy farmers have no effective way to adjust their hog or milk price risk exposure. One minor exception is the Danish Crown "Kontrakt Alt Ind Alt Ud" which is a contract option designed for all in all out producers giving them the option of a three week average price, instead of the quoted week price for their (infrequent) deliveries. This contract option is limited to members who deliver pigs a maximum of 17 times a year (DC Ejerservice).

4. 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, p.398) and three ways of doing this is 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 that face a high cost of risk… …, such mechanisms can reduce the aggregate cost of risk" (Chavas, 2011, pp.398-99). Chavas (2011) implicitly stress the importance of heterogeneity and explicitly stress the potential for reallocating risk.

Pennings and Leuthold (2000) and Pennings and Garcia (2004) explicitly stress the heterogeneity in hedging behaviour using structural equation modelling to analyse behavioural characteristics of Dutch hog farmers. A sector which by and large is very similar to the Danish hog sector, although the marketing tradition and the use of hog futures are important differences. Pennings and Leuthold (2000) analyse the following characteristics: perceived performance of futures as effective hedging tools, entrepreneurial freedom, perceived risk exposure, risk attitude, market orientation and level of understanding of futures as a financial instrument. To test for heterogeneity the sample was segmented in two. Across the two segments all characteristics except the level of understanding was significant drivers for hedging activity. There was however differences between characteristics leading the use of futures across the two segments. The study shows heterogeneity in the drivers for the use of futures in a sector very similar to the Danish hog sector. Assuming heterogeneity in the attitude towards risk management instruments among Danish hog farmers seems fair.

Collins (1997) present 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.

5. THE PROBLEM WITH FUTURES MARKETS – BASIS RISK

Futures markets could potentially solve the problem of, individual cooperative member, commodity price risk adjustment. There may however exist liquidity problems in existing futures markets for milk and pork. An even more fundamental problem is however the substantial basis risk that emerge 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).

In the case of hedging of farm-gate milk or hog price, derived prices of semi-processed products, trade on futures exchanges, for example skim milk powder (SMP) and butter can be used. Combining futures in these two products could hedge milk price, but errors in relative weights could add to a broadly defined basis risk.

"Theory predicts that as maturity approaches, cash and futures prices must converge and the basis approaches zero, except for delivery costs" (Garcia & Leuthold, 2004, p.242). Semi-processing of livestock commodities is taking this a step further, transforming non-storable commodity to storable commodities. Even for non-storables "[p]rices are still expected to converge at maturity, and the futures price for non-storables is considered a market-expected cash price for a future time" (Garcia & Leuthold, 2004, pp.242-43). The "delivery" costs may however include transformation costs from non-storable to storable.

The Danish marketing cooperatives are however going much further in adding value to commodities, this adds to basis from the farmer / cooperative member point of view, if commodity prices are hedged via semi-processed commodities futures, and physical delivery is done to cooperatives that go further in adding value via processing and marketing. The cooperatives down-stream contracting and risk management behaviour may also have an impact on the broad definition of basis risk. If cooperatives have significant contract production down-stream, their earnings will not necessarily be fully reflected in the commodity spot cash price, unless their down-stream contracting was hedged via an effective futures market.

The distinction between market price risk and business risk is important, but not necessarily obvious. The "market price" for milk or pork in Denmark is greatly affected by the success or failure of the processing and marketing activities of the respective marketing cooperative. A potential global or European futures market price for milk or pork would be, if not independent, then very weakly dependent, on the success or failure of the processing and marketing activities of the dominant marketing cooperative on the Danish market.

Global or European market price risk is what could potentially be transferred via a futures exchange, the relevant risk of concern to the Danish dairy or hog farmer is however the aggregate of business and market risk of the respective market and marketing cooperative. A futures market for transfer of commodity price risk on milk or pork would realistically be based on physical delivery to local processing facility. As Arla Foods and Danish Crown have near monopsony in Denmark, it is very hard to avoid exposure to processing and marketing business risk for Danish dairy and hog farmers. As explained above, the tight connection between cooperative business risk and markets risk means that market risk is very hard to avoid or adjust for Danish livestock farmers.

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 cooperative and member makes an effective hedge of say, milk via synthetic combination SMP and butter futures very difficult, if not impossible. The marketing cooperative will however not be very willing to disclose this information for strategic competition related reasons.

Example of risk, unrelated to market risk: The case of Arla Foods in the cartoon controversy

One example of specific business risk, which would not have been hedged in the case of use of futures market contracts and physical delivery of milk to Arla Foods is the case of the controversy following the Danish newspaper Jyllands-Posten published cartoons of the Islamic prophet Muhammad in 2005. The controversy affected the Danish export to the Middle East, notably the significant export of dairy products. The estimated loss for Arla Foods was 460 million DKK (Pedersen, 2010) equivalent to a price fall for the residual claimants of 0,075

DKK / kg member delivered milk in 2006 (Arla Foods, 2007) or more than 3% price cut to farm-gate price in 2006. Business risk like this are not transferable on a futures market, but may possibly be transferred among cooperative members.

The pricing behaviour 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 hedging of cooperative member price risk. Possible agency problems may exist, from conflict of interest between owns and management of the cooperative. These problems are beyond the scope of this paper.

A number of potential problems with the use of futures hedging to reduce the cost of risk are identified. It should be noted however that even early literature on the topic by Working (1953), realised that, like insurance, the chief risk management function of hedging is to protect "against serious, crippling, loss. Carrying insurance against small losses that occur frequently is ordinarily poor business" (Working, 1953, p.339). The cost of hedging must be weighed against the benefit of hedging. A lower quality hedge, with high basis risk, may be attractive if it comes at a discount compared to a high quality hedge, but if possible a high quality hedge at an attractive price will be preferred.

6. POTENTIAL FOR REALLOCATION OF PRICE RISK AMONG COOPERATIVE MEMBERS

Futures markets on agricultural commodities may hold some potential for risk management and price stabilization. Basis risk related to the difference between the cooperative spot commodity price and the futures marked product may be one reason for the absent use of futures in the livestock products in Denmark, whereas the use of grain futures are common.

Marketing cooperatives may have some unutilized potential for differentiation of price risk exposure between cooperative members. By forward contracting different percentages of commodity turnover with cooperative members, the aggregate price risk of the cooperative will be redistributed between cooperative members.

Elaborating on the Collins (1997) model framework it is shown that cooperative member heterogeneity, in usual factor motivating hedging, will yield potential gains from trade, redistributing risk from members with high cost of risk to members with low cost of risk, as suggested more generally by Chavas (2011).

One usual explanation of hedging is 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.494-95) 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 acceptable probability of financial failure.

Following Collins (1997) the model of terminal equity is:

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

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

2) $$\max \bar{E}_1 = \int_{-\infty}^{\infty} E_1 g(E_1) dE_1$$
$$\text{s.t.} \int_{-\infty}^{d} g(E_1) dE_1 \leq \alpha$$

Expected terminal equity is

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

and

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

The relevant situations are where $\bar{p}_c > p_h$ and there is a trade-off between expected terminal equity and reduction of 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

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

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 realisation of (b) and E_a representing the terminal equity under realisation of (a).

The probability that a terminal equity level is less than the disaster level is

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

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

Assume 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 less than some disaster level is less than the acceptable risk of financial failure. If this is the case, it will be shown that the ability to redistribute price risk among heterogeneous members will increase utility. Usually stated goals by cooperatives are to maximise the commodity price received by members, an example of this is in Jeppesen and Jørgensen (2012), this may differ from the assumed goal above. Whether the stated goal of maximum price is due to communicational convenience or not, goals that maximise integrated profit and thus takes the on farm costs into account seem more relevant (Bogetoft & Olesen, 2000). Following Chavas (2011) the on-farm costs ought to include the cost of risk.

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

The residual claims in the cooperative are

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

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

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

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

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

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

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

Expected terminal equity for low, medium and high cost of risk cooperative members, respectively, is

10 a)
$$\bar{E}_{low\_1} = E_{low\_0} + \left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c hY_{coop} + zhY_{coop}\right] - kY_{low} - iD_{low} - F_{low}$$

10 b)
$$\bar{E}_{medium\_1} = E_{medium\_0} + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] - kY_{medium} - iD_{medium} - F_{medium}$$

10 c)
$$\bar{E}_{high\_1} = E_{high\_0} + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h hY_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c hY_{coop} - zhY_{coop}\right] - kY_{high} - iD_{high} - F_{high}$$

As pointed out above the heterogeneity in factors affecting hedging behaviour can take many forms (Pennings & Leuthold, 2000; Pennings & 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 tolerance probability level $\alpha_{low} > \alpha_{medium} > \alpha_{high}$ 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

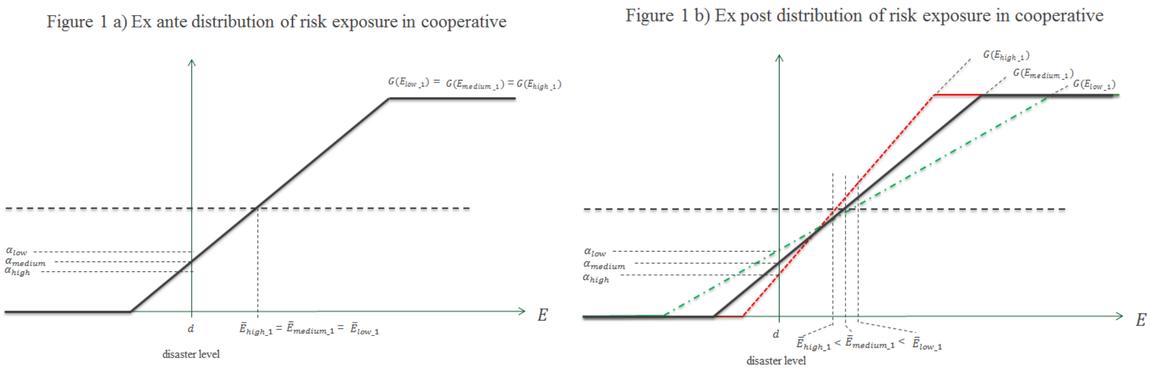
11)
$$\max \bar{E}_{i\_1} = \int_{-\infty}^{\infty} E_{i\_1} g(E_{i\_1}) dE_{i\_1}$$
$$\text{s.t.} \int_{-\infty}^{d} g(E_{i\_1}) dE_{i\_1} \leq \alpha_i, where\ i \in \{low, mediun, high\}$$

This means that members with low cost of risk ceteris paribus will accept a higher probability of financial failure than members with high cost of risk, against compensation of zhY_{coop}. Members with 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, to obtained an ex post situation where risk is adjusted to the level where 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. $G(E_{i\_1})$ denote the cumulative distribution function of terminal equity of segment i.

Figure 1 a) and b). Cumulative distribution function of terminal equity



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 aggregate utility without any one being worse off. This constitutes a Pareto improvement. These assumptions do however need further discussion.

6.1. Transaction costs

An actual endowment of $\bar{H} > 0$ and 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 negligible or covered in more than full by direct transaction fees paid by participating segments, there could still be room for Pareto improvement. In this case non-participating member will no longer be unaffected but 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, times $\frac{Y_{medium}}{Y_{coop}}$. Modern electronic market platforms have relatively low direct transaction costs, why assuming variable transaction costs, although simplifying reality, seems fair.

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

12)
$$\left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h h Y_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h Y_{coop} + zhY_{coop} - \frac{t}{2}hY_{coop}\right] + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h h Y_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h Y_{coop} - zhY_{coop} - \frac{t}{2}hY_{coop}\right] = [p_h\bar{H} + \tilde{p}_c(1-\bar{H}) - th]Y_{coop}$$

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

13 a)
$$\bar{E}_{low\_1} = E_{low\_0} + \left[p_h\bar{H}\frac{Y_{low}}{Y_{coop}} - p_h h Y_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h Y_{coop} + zhY_{coop} - \frac{t}{2}hY_{coop}\right] - kY_{low} - iD_{low} - F_{low}$$

13 b)
$$\bar{E}_{medium\_1} = E_{medium\_0} + \left[p_h\bar{H}\frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c(1-\bar{H})\frac{Y_{medium}}{Y_{coop}}\right] - kY_{medium} - iD_{medium} - F_{medium}$$

13 c)
$$\bar{E}_{high\_1} = E_{high\_0} + \left[p_h\bar{H}\frac{Y_{high}}{Y_{coop}} + p_h h Y_{coop} + \tilde{p}_c(1-\bar{H})\frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h Y_{coop} - zhY_{coop} - \frac{t}{2}hY_{coop}\right] - kY_{high} - iD_{high} - F_{high}$$

If transaction costs are sufficiently low, there will still be potential for Pareto improvements by enabling 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.

6.2. Quantity effect of increased volatility of marginal price

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

As traditional 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 member 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, 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 cost of accepting increased price volatility, for members with below average hedge ratio, will increase with the time horizon length of forward contracts. The optimal length of such contracts is beyond the scope of this paper, for now a pragmatic suggestion for forward contract length specification could be that the hedged price p_h and quantity endowment $\overline{H}$ is specified in advance for the cooperatives fiscal year, stating p_h as the expected average price and the individual member endowment $\overline{H}_i$ to be based on the individual members preceding year delivery to the cooperative.

Suppose forward contract is specified as above, the short run becomes the cooperative fiscal year. The volatility of the unhedged price $\tilde{p}_c$ will increase and will affect production quantity in cases where $\tilde{p}_c < k$ and k represent 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 member will be understated. The potential for Pareto improvements will be lower, as it is possible that someone will be worse off. There will however still be significant potential for improvement of the weaker Kaldor-Hicks efficiency measure as a function of the risk reallocation possibility.

If delivery of Y_{coop} fall as a consequence of low $\tilde{p}_c$, the cooperative may be able to mitigate this effect by sourcing input outside the group of members. This may be a realistic strategy in cases where general market price downturn drives $\tilde{p}_c$ to a low level. In cases where the lower $\tilde{p}_c$ is related to business specific factors, this may not be possible. As mentioned earlier, mergers leading to the formation of the current cooperatives were subject to a number of conditions, including that they partially relinquished their exclusive supply requirement for members. Members are however still required to deliver the substantial part of their production to the cooperative within the year, and are only able to leave the cooperative, without penalty, with due notice effective at the end of the year. Side-trading is therefore limited, if the length of forward contracting endowments is aligned with possibility of leaving the cooperative. Members ceasing production, as mentioned above, will however not be restricted.

Because of the proportional payment schemes cooperatives traditionally have inherent incentive problems in the sense that they signal average benefit to the member, and the member is incentivised to react to average benefit. This may not be equal to marginal benefit, and maximising integrated profit may be difficult because of difficulty equating marginal cost and marginal benefit, this is called the quantity control problem. In New Generation Cooperatives

(NGC) this problem is mitigated though contract production. NGCs are usually characterised by closed membership and transferrable delivery rights (Bogetoft & Olesen, 2000). In some sense the suggested endowment and reallocation of forward contracted prices is similar to the operation of NGC, however the model differs from NGCs in the sense that membership is not closed and the endowment of forward contracting is only short therm.

Forward contracting part of production will to some extent mitigate the quantity control problem, in the sense that the cooperative via $\tilde{p}_c$ sends a stronger signal of marginal benefit as oppose to average benefit. The above mentioned effect on non-participating members may be positive as it may increase integrated profit, Pareto improvement may however still be too strong an efficiency criteria, because the distribution of effects may potentially put some groups in a situation where they are worse off, ex post.

Today cooperative management do not receive any signals on the acceptable risk taking in the processing and marketing business except for the signals sent via the member democratic organization. An internal market price for forward contracts may improve the ability to signal the farm-level cost of risk to cooperative management in a more efficient way. This may help coordinate collective risk management. Basis risk on futures markets may be lower from the cooperative point of view than the farm level point of view as asymmetry in information on cooperative exposure may be substantial. Garcia and Leuthold (2004, p.261) pose the question "Will individual managers have to turn to locally based forward contracts offered by large processing firms who then have access to futures markets to manage their risk?" The question seems to suggest a fruitful line of reasoning.

7. CONCLUDING REMARKS

Potential gain from 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 authors belief that the potential is great in the current post GFC environment, the potential is however not static, as alternative ways of mitigating risk evolve dynamically and the potential will be conditioned on the present alternatives at any given time.

Ester Boserup cited for the expression "Necessity is the mother of invention" cf. (Rogers et al., 2008, p.20) as being the key point of her work, the question is whether necessity also is the mother of institutional innovation with regard to risk management in agriculture?

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