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## Reallocation of Price Risk among Cooperative Members

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*Abstract: The purpose of this paper is to explore the theoretical possibility of reallocation of price risk among members of processing cooperatives in the Danish hog and dairy sectors. Based on the observation that no effective price risk management institutions exist for Danish hog and dairy farmers, possible explanations for this are discussed and the possibility of cooperatives to reallocate risk among members is analyzed. Use of futures to hedge individual farmer price risk is absent, which may be due to prohibitively high basis risk. Farmers are exposed to the cooperative price. Endowing members with proportional forward contracts and organizing the exchange of these contracts via a double auction mechanism will reallocate risk, realizing gains depending on member heterogeneity and transaction costs. Most research on risk transfer focuses on vertical reallocations of risk in the value chain, whereas this paper explores the possibility of horizontal risk transfer.*





## 1. Reallocation of Price Risk among Cooperative Members

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 behavior is counter intuitive as the expected behavior of risk adverse farmers with weak positive correlation between input and output would be to hedge symmetrically or not to hedge at all (Pennings and Wansink, 2004). The asymmetric behavior may however be explained by interactions with 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 producers and processors in producer cooperatives is limited to risk sharing between producer product groups and the risks absorption of the cooperative equity buffer. This paper challenges this statement by suggesting that grouping of members according to their cost of carrying risk<sup>1</sup> rather than their product attributes may be a source of social gain. 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.

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<sup>1</sup> Following Chavas (2011) the term cost of risk is used to represent Arrow-Pratt risk premium. This is done to distinguish the cost of risk from the price  $z$  paid for reduction of risk, labelled the risk premium in this paper. The cost of risk refers to both capacity to bear risk and the attitude towards risk; that is the willingness and ability to carry risk.



The paper is structured as follows: Section 2 gives some background on hedging and why it may not have been widespread in Denmark. Section 3 provides an introduction to the characteristics of the marketing of Danish livestock products via the dominant marketing cooperatives. Section 4 argues for the potential heterogeneity of cooperative members in their attitude towards risk management, and discusses the potential gain from the reallocation of risk. Section 5 discusses why this reallocation may not be handled via futures markets. Section 6 represents the main body of the work and extends a model by Collins (1997) to illustrate the potential for reallocating risk via the transfer of forward contracted delivery among cooperative members. The section also discusses the assumptions of the model. Section 7 provides some concluding remarks.

## **2. Background on risk management in Danish agriculture**

In the 1970s, Danish agriculture was still characterized by fairly diversified farms and low leverage. During the 1980s, increasing specialization and leverage in the sector could be related to the price support regime in the EU's common agricultural policy. This can be interpreted as a meso-level effect of the balancing of business and financial risk (Gabriel and Baker, 1980). In the 1990s and 2000s, price support was substituted by income support, thereby reintroducing the potential for increased 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 (OECD, 2009; Turvey and Baker, 1989, 1990). However, it is less well 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 (Collins, 1997; Garcia and Leuthold, 2004; Pennings and Garcia, 2004; Pennings and Leuthold, 2000; Turvey and Baker, 1989, 1990), who see the motivation for hedging and risk management as a desire to avoid financial failure which is related to, but different from, a desire to reduce income variability. The literature suggests heterogeneity in willingness to pay for hedging. While this literature focuses on the financial aspects of hedging behavior, only Turvey and Baker (1990) stress and distinguish between liquidity aspects and capital structure aspects. A



focus on the possible impact of macro-economic 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), is not emphasized. In a leverage cycle framework (Geanakoplos, 2010), the credit reserves may, however, not be constant even though debt and assets are and thus the debt-to-asset ratio may not fully reflect the credit reserves. An increase in the access to credit for Danish agriculture in the late 1990s and 2000s is demonstrated by Pedersen and Olsen (2013). The crowding out effect of easy access to credit 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 crowded out the need for market-based risk management institutions disappear, although market-based risk management institutions may not appear instantly. The potential lack of risk management institutions may have significant social costs.

### **3. The marketing of milk and meat in Denmark**

Danish agriculture is dominated by two major processing and marketing cooperatives; Arla Foods in the dairy sector and Danish Crown in the pork (and beef) sector. These firms are in the top ten of Danish firms with regard to turnover and the top fifteen with regard to the number of employees.

These two cooperatives have near monopsony power in the Danish markets for milk and meat. 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 organizations, there remain concerns over the effects of concentration in the industry.” The mergers which led 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 that 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. In addition to 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 especially contracted credence attributes such as organic or grass-milk. Similarly, the farm-gate price of hogs is based on weight and quality parameters and especially contracted credence attributes such as UK special pigs, free-range pigs, etc.

The Arla Foods payment scheme is based on a basic commodity value which is a linear function of the fat and protein content of the milk delivered and a constant term. This is the stated price that Arla Food changes on a regular basis according to current market and business conditions. Quality bonuses or penalties are added / subtracted as a percentage of the basic commodity value for somatic cell count, bacterial count and spore count. On top of this a fixed payment for willingness to accept independent determination of when Arla Foods collects the milk from the farm and a quantity payment based on the yearly delivery from the farm is paid as an adjustment of the difference in the costs of collecting the milk due to quantity and logistical flexibility. For organic producers a fixed premium is paid per kg. A minor fixed membership fee is paid by the farmer. On top of this the farmer receives a supplementary payment based on resolution of the board of representatives in proportion to the amount of business conducted with the cooperative (Arla Foods, 2013).

The Danish Crown payment scheme is based on a basic price per kg slaughtered weight in the weight class from 70.0 to 89.9 kg with a meat percent of 61%. More lean hog get premiums while more fat hogs get penalties. For hogs in other weight class's alternate prices apply. Danish Crown has a number of different logistical models adapted to the different production modes of the members. For different credence attributes a number of special payments apply, the different models are; 'Antonius', 'UK-pigs', 'EU-heavy pigs', 'Male pigs', 'Bornholm pigs', 'Free range pigs' and 'Organic pigs'. Like Arla Foods the farmer receives a supplementary payment based on resolution of the board of representatives in proportion to the amount of business conducted with the cooperative (Danish Crown, 2013)



There are clear price differentiation schemes on the 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 criticized for reducing competition (Bogetoft and 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 differentiated on, however, is the acceptable volatility of the base price. Danish hog and dairy farmers have no effective way of adjusting their hog or milk price risk exposure.

The substantial price risk that Danish farmers are exposed to is illustrated in Figure 1, note the change in milk price characteristic in 2007. Before 2007 milk price was declining but fairly stable, after 2007 more price variation is seen.

*Figure 1 here.*

#### **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, pp. 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 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 Dutch hog sector is very similar to the Danish hog sector, although the marketing traditions and the use of hog futures are important differences. Pennings and Leuthold (2000) analyze the following characteristics; perceived performance of futures as



effective hedging tools, entrepreneurial freedom, perceived risk exposure, risk attitude, market orientation and the 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 were significant drivers for hedging activity. There were, 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. 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 Danish 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.

## **5. 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 (Berg and Kramer, 2008) for milk and pork, and hedging in these markets are subject to considerable basis risk (Meuwissen, van Asseldonk and Huirne, 2008). A 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).

In the case of the hedging of farm-gate milk or hog prices, 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 and Leuthold, 2004, p. 242). The semi-processing of livestock commodities, transforming non-storable commodities to storable commodities, is an extension of this delivery cost line of reasoning. 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 and Leuthold, 2004, pp. 242-243). The “delivery” costs may, however, include considerable transformation costs from non-storable to storable.

The Danish marketing cooperatives are going much further in adding value to commodities, which add to the basis risk from the farmer/cooperative member’s point of view, if commodity prices are hedged via semi-processed commodities futures and physical delivery is to cooperatives, which add substantially more value to the average product via processing and marketing. The cooperatives down-stream contracting and risk management behavior 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 futures price.

The distinction between the 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. However, the relevant risk of concern to the Danish dairy or hog farmer is the aggregate of business and market risk of the respective market and marketing cooperative. A futures market for the transfer of commodity price risk on milk or pork would realistically be



based on the physical delivery to local processing facilities. 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 close connection between cooperative business risk and market 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 cooperatives and members makes an effective hedge of, e.g. milk via synthetic combination of SMP and butter futures very difficult, if not impossible. The marketing cooperative may, 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 the physical delivery of milk to Arla Foods, is the case of the controversy following the Danish newspaper Jyllands-Posten's publishing of cartoons of the Islamic prophet Muhammad in 2005. The controversy affected Danish exports 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 a 3 % price cut in the 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 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. Possible agency problems may exist, arising from a conflict of interest between owners and the 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) realized that, much the same as in 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, although a high quality hedge at an attractive price will be preferred if it is possible.

## **6. Potential for reallocation of price risk among cooperative members**

### *6.1. The model*

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 can be redistributed among cooperative members.

Elaborating on the Collins (1997) model framework shows that cooperative member heterogeneity, in the usual factors which motivate hedging, yields potential gains from trade, thereby 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  $\alpha$ ” which is the individual’s acceptable probability of financial failure. Following Collins (1997), the model of terminal equity of the individual farmer is:

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

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. For simplicity the possibility of capital gains and losses are ignored.

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

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

Where  $\alpha$  is the acceptable risk of terminal equity below the individual disaster level, reflecting the individual cost of risk. Expected terminal equity is:

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

and

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

The relevant situations are where,  $\bar{p}_c$ , the expected spot cash price is above the forward price of hedged output ( $\bar{p}_c > p_h$ ) or an equivalent situation where 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:

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

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:

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

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 assuming zero transaction cost. The commonly stated goal of cooperatives is to maximize the commodity price received by their 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 (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:

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

where  $H = 0$ , by tradition. That is, the cooperative payment to the member is proportional to the amount of business the member has with the cooperative. As a member the farmer is an owner of the cooperative and entitled to the residual claims, which is a proportion of what is left after all prior claims are satisfied (costs of running the cooperative).

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:

$$\begin{aligned} & \left[ p_h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{low}}{Y_{coop}} \right] + \left[ p_h \bar{H} \frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{medium}}{Y_{coop}} \right] \\ & + \left[ p_h \bar{H} \frac{Y_{high}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{high}}{Y_{coop}} \right] = [p_h \bar{H} + \tilde{p}_c (1 - \bar{H})] Y_{coop} \end{aligned} \quad (8)$$

This endowment is equivalent of a pre-commitment to increase the aggregate prior claims and reduce the residual claims, as well as reducing the quantity over which the residual claims will be proportionally divided. Notice that the average price and the variation in average price are unchanged for all segments. However, marginal price ( $\tilde{p}_c$ ) volatility ( $\sigma_c$ ) is increased.

Assume for convenience that the forward price is equal to the expected spot cash price,  $p_h = \bar{p}_c$ . As stated above the relevant situation is where ( $\bar{p}_c > p_h$ ) or an 'equivalent situation' where there is a trade-off between expected terminal equity and a reduction in the risk of financial failure.

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  $z \bar{H} \frac{Y_{low}}{Y_{coop}}$  for an increase in the forward contracted quantity by  $\bar{H} \frac{Y_{low}}{Y_{coop}}$ . Similarly,

cooperative members with a low cost of risk would presumably be willing to reduce the forward contracted quantity by  $h\bar{H} \frac{Y_{low}}{Y_{coop}}$  in return for pecuniary compensation  $zh\bar{H} \frac{Y_{low}}{Y_{coop}}$ , where  $h$  is the share of the endowed fixed price quantity that the low cost of risk members will be willing to sell at the price  $z$ .

This is such an ‘equivalent situation’ and a trade-off between expected terminal equity and a reduction in the risk of financial failure is created. High cost of risk members can be in a financial position where they don’t have the capacity to bear risk or they can have high cost of risk because of a high level of risk aversion. Likewise, the low cost of risk members can be in a strong financial position with moderate risk aversion, or they may be in a weaker financial position but have a low level of risk aversion, in both cases they have to be both willing and able to take on increased risk exposure in return for adequate compensation.

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:

$$\begin{aligned}
 & \left[ p_h \bar{H} \frac{Y_{low}}{Y_{coop}} - p_h h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h \bar{H} \frac{Y_{low}}{Y_{coop}} + zh \bar{H} \frac{Y_{low}}{Y_{coop}} \right] \\
 & + \left[ p_h \bar{H} \frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{medium}}{Y_{coop}} \right] \\
 & + \left[ p_h \bar{H} \frac{Y_{high}}{Y_{coop}} + p_h h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h \bar{H} \frac{Y_{low}}{Y_{coop}} - zh \bar{H} \frac{Y_{low}}{Y_{coop}} \right] \\
 & = [p_h \bar{H} + \tilde{p}_c (1 - \bar{H})] Y_{coop}
 \end{aligned} \tag{9}$$

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



$$\bar{E}_{low_1} = E_{low_0} + \left[ p_h \bar{H} \frac{Y_{low}}{Y_{coop}} - p_h h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h \bar{H} \frac{Y_{low}}{Y_{coop}} + z h \bar{H} \frac{Y_{low}}{Y_{coop}} \right] - k Y_{low} - i D_{low} - F_{low} \quad (10 a)$$

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

$$\bar{E}_{high_1} = E_{high_0} + \left[ p_h \bar{H} \frac{Y_{high}}{Y_{coop}} + p_h h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h \bar{H} \frac{Y_{low}}{Y_{coop}} - z h \bar{H} \frac{Y_{low}}{Y_{coop}} \right] - k Y_{high} - i D_{high} - F_{high} \quad (10 c)$$

As pointed out above, the heterogeneity in factors which affect hedging behavior can take many forms (Pennings and Garcia, 2004; Pennings and Leuthold, 2000). 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:

$$\begin{aligned} \max \bar{E}_{i_1} &= \int_{-\infty}^{\infty} E_{i_1} g(E_{i_1}) dE_{i_1} \\ \text{s. t. } \int_{-\infty}^d g(E_{i_1}) dE_{i_1} &\leq \alpha_i, \text{ where } i \in \{low, medium, high\} \end{aligned} \quad (11)$$

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  $z h \bar{H} \frac{Y_{low}}{Y_{coop}}$ .

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.



## AGRICULTURE IN AN INTERCONNECTED WORLD

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  $\alpha_{low} > \alpha_{medium} > \alpha_{high}$ .

*Figure 2a and 2b here.*

As illustrated in Figure 2 a, the condition for equation (11) is not satisfied for the high cost of risk segment, since the probability of financial failure is above  $\alpha_{high}$ , 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 2 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. This claim builds on the following reasoning; endowing members with a non-zero but low positive  $\bar{H}$  changes nothing, neither the expected terminal equity nor the variation in terminal equity. Nobody is worse off. Now if  $h > 0$  this means that someone made a voluntary market transaction, and this means that someone is better off, making it a Pareto improvement. These assumptions, however, need further discussion.

### 6.2 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  $\tau$  in the following way:

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

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

$$\begin{aligned}
 \bar{E}_{low_1} = \\
 E_{low_0} + \left[ p_h \bar{H} \frac{Y_{low}}{Y_{coop}} - p_h h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c h \bar{H} \frac{Y_{low}}{Y_{coop}} + zh \bar{H} \frac{Y_{low}}{Y_{coop}} - \frac{\tau}{2} h \bar{H} \frac{Y_{low}}{Y_{coop}} \right] \tag{13 a} \\
 -kY_{low} - iD_{low} - F_{low}
 \end{aligned}$$

$$\begin{aligned}
 \bar{E}_{medium_1} = \\
 E_{medium_0} + \left[ p_h \bar{H} \frac{Y_{medium}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{medium}}{Y_{coop}} \right] \tag{13 b} \\
 -kY_{medium} - iD_{medium} - F_{medium}
 \end{aligned}$$





$$\bar{E}_{high_1} =$$

$$E_{high_0} + \left[ p_h \bar{H} \frac{Y_{high}}{Y_{coop}} + p_h h \bar{H} \frac{Y_{low}}{Y_{coop}} + \tilde{p}_c (1 - \bar{H}) \frac{Y_{high}}{Y_{coop}} - \tilde{p}_c h \bar{H} \frac{Y_{low}}{Y_{coop}} - z h \bar{H} \frac{Y_{low}}{Y_{coop}} - \frac{\tau}{2} h \bar{H} \frac{Y_{low}}{Y_{coop}} \right] \quad (13 \text{ c})$$

$$-kY_{high} - iD_{high} - F_{high}$$

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. The sugar beet contract exchange not only facilitated the efficient reallocation of contracts, it did so whilst keeping bid and ask information confidential through use of secure multiparty computation (SMC) technology (Bogetoft and Nielsen, 2012).

In principal the reallocation of risk suggested above could be done by cooperative members betting on the cooperative pay-out bilaterally. However, as Danisco and the Danish Sugar Beet Growers Association realized when they implemented their contract exchange, bilateral bargaining involves considerable searching and matching costs and is associated with strategic behavior. Mechanism design and implementation are pivotal in order to obtain the reallocation gains (Bogetoft and Nielsen, 2012). Organization of a forward contract exchange by cooperatives may significantly increase the gains derived from the reallocation of price risk. Not only will searching and matching costs be reduced, counterparty risk, involved in a bilateral betting scenario, will also be reduced by having the cooperative act as a clearing house, thereby shifting counterparty risk from a member to member issue, to a member to cooperative issue. Reduced



counterparty risk is a feature of exchange-traded derivatives such as futures and options as opposed to negotiated contracts. In this way the concept of futures (standardized contracts) and forwards (negotiated contracts) converge, as the forward contracts exchanged are standardized, but cooperative specific, with exchange being restricted to cooperative members.

### *6.3. 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  $\bar{H}$  are specified in advance for the cooperative's fiscal year, stating  $p_h$  as the expected average price and the individual member endowment  $\bar{H}_i$  to be based on the individual member's preceding year's delivery to the cooperative.



Suppose the 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  $\sigma_c$ . 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 (Gowdy, 2004) as a function of the risk reallocation possibility.

If delivery of  $Y_{coop}$  declines as a consequence of low  $\tilde{p}_c$ , the cooperative may be able to mitigate this effect by sourcing input from 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 a 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 the possibility of leaving the cooperative. However, members who cease production, as mentioned above, will 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 incentivized to react to average benefit. This may not be equal to marginal benefit, and



maximizing integrated profit may be difficult because of difficulty in equating marginal cost and marginal benefit, which is called the quantity control problem. In New Generation Cooperatives (NGC), this problem is mitigated through contract production. NGCs are usually characterized by closed membership and transferrable delivery rights (Bogetoft and Olesen, 2000). In some sense the suggested endowment and reallocation of forward contracted prices is similar to the operation of NGCs, although the model differs from NGCs in the sense that membership is not closed and the endowment of forward contracting is only short term.

As mentioned, the level of endowment of forward contracts,  $\bar{H}$ , to cooperative members is zero by tradition. Increasing this level and reallocating the contracts among members via a double auction will most likely yield reallocation gains. Increasing the level of  $\bar{H}$  too much will, however, reintroduce risk in the form of counterparty risk. In case of a high level of  $\bar{H}$  the risk that the cooperative will be unable to pay  $p_h$  for the contracted quantity may be introduced. A balance between the potential reallocation gains on the one hand, and the increase in counterparty risk on the other, will determine the optimal level of  $\bar{H}$ . This analysis is beyond the scope of this study. A suggested level of  $\bar{H}$  around 20 % of  $Y_{coop}$  seems to be low enough to avoid the risk of being unable to pay  $p_h$ , driving the cooperative into bankruptcy, while yielding a significant potential for reallocation gains.

Tying the individual endowment of  $\bar{H}$  to the preceding year's delivery will introduce a second order effect on commodity price. Revenue from commodities delivered to the cooperative will not only be in the form of  $p_h$  or  $\tilde{p}_c$  but also in the form of,  $z_{year\ two} \bar{H}_{year\ two} Y_{year\ one}$ , the value of endowment of forward contracting the following year. Assume for illustration that the risk premium  $z$  is 5 % of the expected spot cash price and that the endowment of  $\bar{H}$  is 20% of the previous year's delivery, the second order price effect will be a 1 % increase in the expected price.

Bak-Pedersen and Neergaard-Petersen (2003) suggest a model with many similar aspects targeting new (young) entrants to the hog sector. They suggest a five year contract based on the average price of the previous five years. The main difference between the model presented in this paper and the Bak-Neergaard-model is that the suggested contracts here would be one year



contracts based on expected price. Other important differences are: a) all members have the same access to the contract; b) the risk premium paid for reducing price risk via contract is determined by an auction mechanism and not by fiat; c) all members are endowed with a contract quantity in equal proportion to the previous delivery, which means that members who do not participate in the auction will experience minimal change in their risk exposure if they have stable production, and; d) the Bak-Neergaard-model suggests that the cooperative should carry the liquidity burden associated with risk, while the liquidity burden is transferred to the residual claimants in the model presented here.

The importance of the financial framework conditions are recognized by Bak-Pedersen and Neergaard-Petersen (2003) and they conclude that the value of their contract model is reduced by favorable access to credit at the time, but that future adverse developments in the financial markets may increase the relevance of the model. This is important insight and the actual development in the post financial crisis world may very well increase the potential value of risk reallocation among cooperative members.

Bogetoft and Olesen (2000, 2002, 2004, 2007) have performed rigorous analyses of contracting in Danish agriculture. Their main frame of analysis is producer / processor contracting and one of the main issues is the conflict between motivation of optimal effort and optimal risk sharing. Examples of risk related to effort can be quality aspects or animal health issues. Processors may be better able to carry the cost of risk associated with stochastic processes related to these issues, although the cost of risk may be significantly reduced by the producer's optimal effort. In these cases, motivational problems may exist.

*Figure 3 here.*

With regard to price risk and price risk transfer, the motivational problems that preoccupied Bogetoft and Olesen (2004) are not major problems if hedge ratios are moderate. Price risk transfer via hedging reduces the variation of average price received around the hedged price subject to the increased variation of the price of unhedged production and the hedge ratio. Classical production theory predicts that production quantity is motivated, not by the average price, but by the marginal price, which is the price of the unhedged production. Increasing





production to the level where marginal costs are equal to marginal revenue is unaffected by hedging at moderate levels from the individual farmer's point of view. Figure 3 illustrates differences in forward contracted price, average price and marginal (unhedged) price with the differences in the slope of the total revenue curve.

Forward contracting parts 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 opposed to average benefit. The above-mentioned effect on non-participating members may be positive as better price signals may increase integrated profit. Pareto improvement may, however, still be too strong an efficiency criterion, 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 members' 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's point of view than from the farm's 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. Conclusion

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, all reflected in the members individual cost of risk. 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.

“Necessity is the mother of invention” (Ester Boserup cf. Rogers, Jalal, & Boyd, 2008, p. 20) the question is whether necessity is also 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 transferring 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 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  $\bar{H}$ ? 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.

As noted, the potential (net) gain will depend on the heterogeneity of the cooperative members (gross gain potential) and the transaction costs involved in reaping the gross gain potential. The estimation of the gross gain potential, e.g. the cost of carrying risk, is an open research area. Zheng *et al.* (2008) analyze the potential welfare loss from reducing the choice of marketing arrangements for agents with a heterogeneous risk preference in the U.S. hog industry. This approach may provide a useful way of estimating the potential gain from increasing the choice of marketing arrangements among agents with a heterogeneous risk preference.



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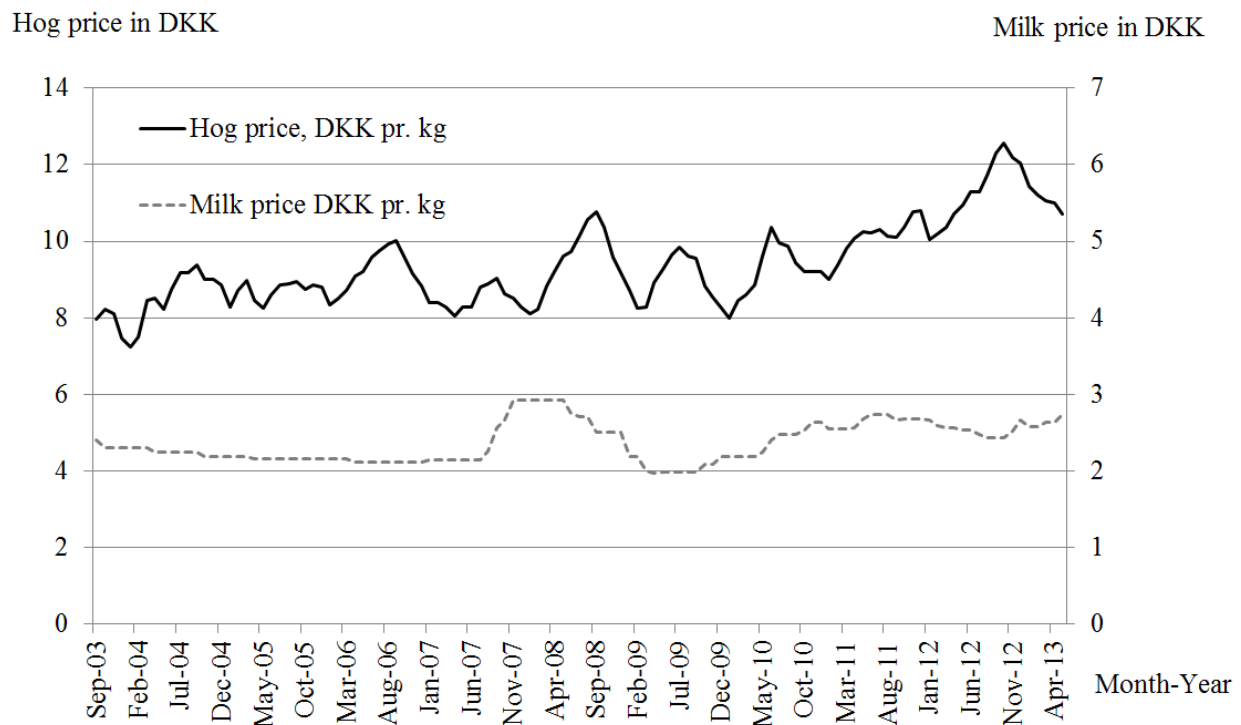


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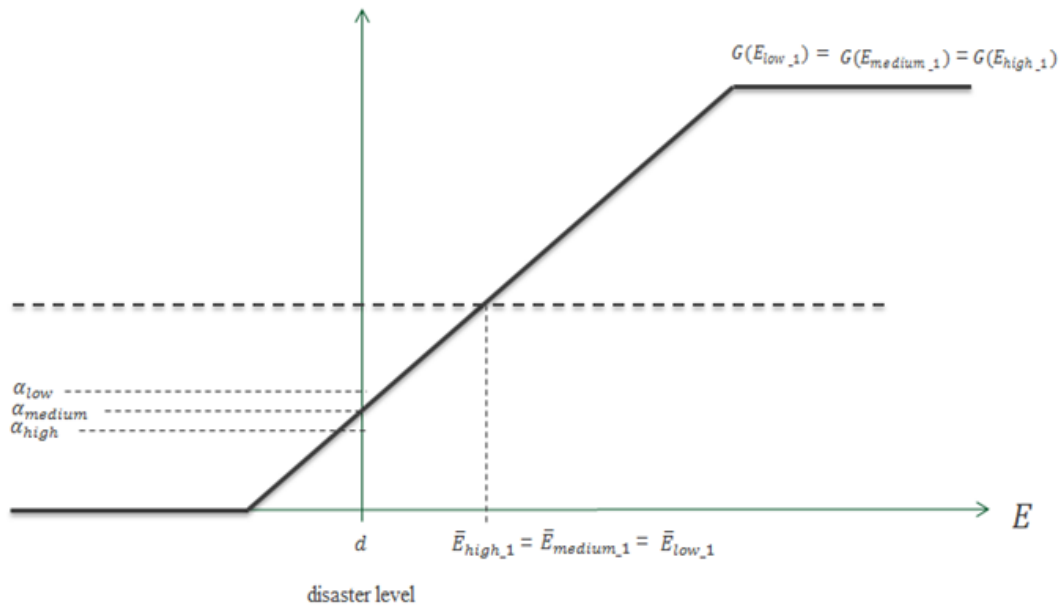
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## Figures

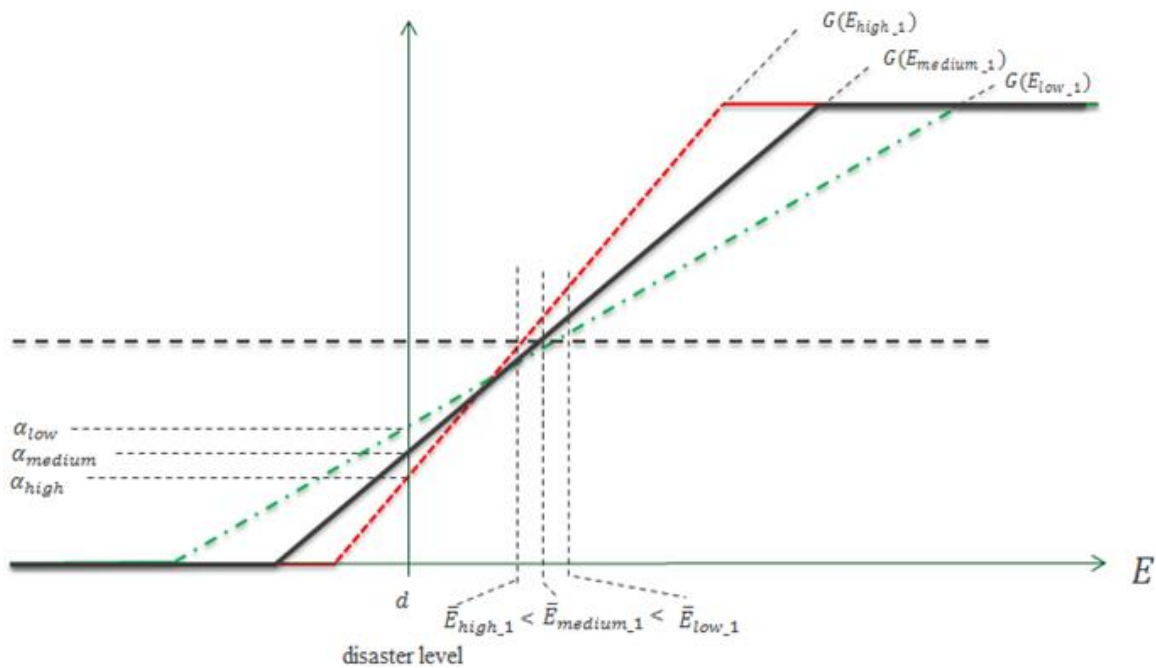


**Figure 1:** Monthly milk and hog price from Sep-2003 to May-2013. Source: FarmtalOnline (2013)



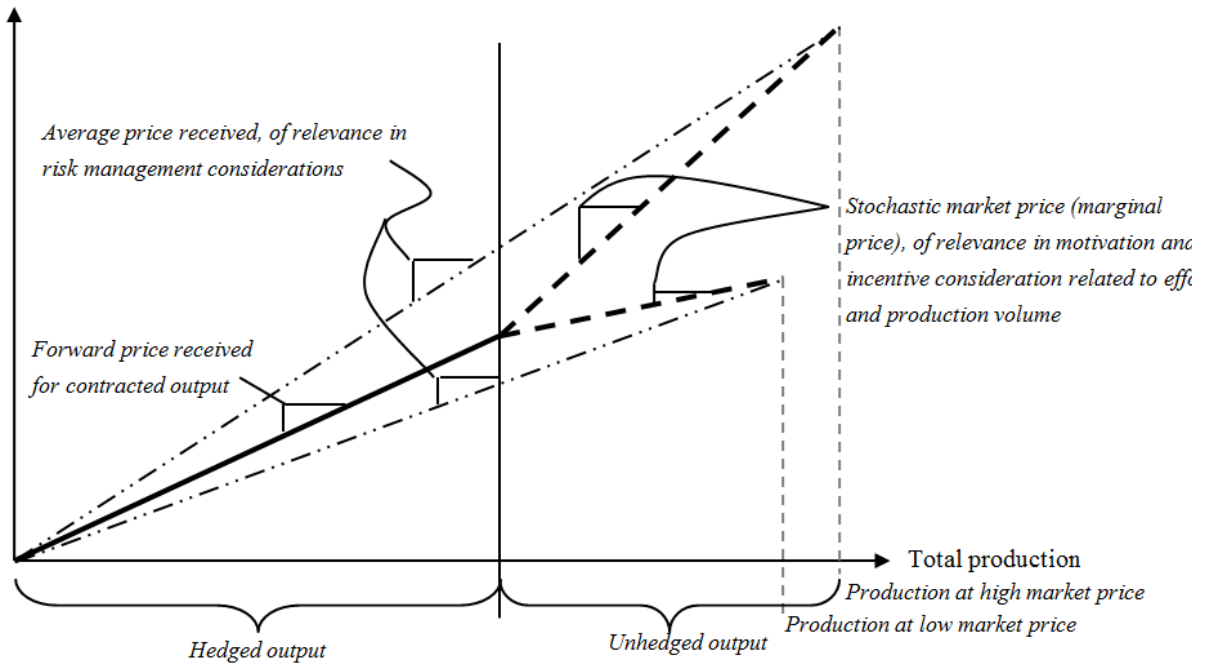


**Figure 2 a):** Cumulative distribution function of terminal equity, ex ante



**Figure 2 b):** Cumulative distribution function of terminal equity, ex post

Total revenue



**Figure 3:** Price risk exposure for farmers using forward contracts