

The Royal Veterinary and Agricultural University
Food and Resource Economic Institute



Unit of Economics Working Papers 2001/4

Contract Production of Green Peas.

Henrik Ballebye Olesen

Contract Production of Green Peas

Henrik B. Olesen

Department of Economics,
The Royal Veterinary and Agricultural University (KVL)

Abstract

This paper analyzes a contract between farmers and a large company in the Danish food industry, Danisco Foods. Production of green peas requires a very accurate coordination, which is obtained through centralized decision-making. The contract is based on a tournament system providing risk sharing between the farmers. General problems from the contract theory such as hold up, moral hazard, risk sharing and screening are analyzed. The paper illustrates the tradeoffs between these problems in design of contracts. By negotiating the contract through a pea-growers association, the farmers gain some bargaining power. Thus the farmers can ensure that Danisco Foods uses only one contract for all farmers. This paper analyzes the consequences of the farmers' strategy. Throughout the analysis several modifications of the contract is suggested in order to improve the incentives.

Keywords: contract theory, coordination, incentives, risk sharing.

1 Introduction

In recent years there has been an increase in the use of contract production in Danish agriculture. This development has made the understanding of contract production more topical. It is therefore interesting to take a deeper look into a specific contract in order to analyze how different problems general to agricultural production contracts have been solved. This paper is part of a larger survey of the contract production in Danish agriculture¹. The aim of the survey is to provide guidelines for design of contracts in agricultural production and to develop economic analysis of the existing contracts.

The contract between Danisco Foods and farmers concerning the production of green peas has evolved through many years of experience. The major motivation behind the contract for pea production is the need to control the timing of harvesting.

The contract has to solve two fundamental problems. The first problem is what the literature refers to as *moral hazard*. The problem exists because the actions taken by the farmer are unobservable to

¹ The Norma and Frode Jacobsen Foundation sponsor the project.

Danisco Foods, so that the farmer chooses actions to maximize his own utility without considering the effects on Danisco Foods. This creates a need for incentives motivating the farmers to provide effort in such a way that the return of Danisco Foods is maximized. Moral hazard is a problem due to the risk aversity of the farmers as well as to complexities of contract writing and costs of monitoring. If the farmers were not risk averse, the moral hazard issue could be solved by making the farmers residual claimants. The other problem is *screening*, i.e. the problem of designing a contract that attracts the farmers with high alternative income options without paying too much to farmers with low alternative income options.

The paper is organized as follows. Section 2 describes the background in the industry. Section 3 describes the most important regulations in the contract. Section 4 analyses how general challenges such as *moral hazard*, *risk sharing* and *screening* is solved in the contract, furthermore this section suggest several improvements of the contract. Section 5 concludes the paper.

2 Background²

Danisco Foods has been involved in green pea production for at least 50 years. Danisco Foods processes peas produced on 4,100 hectares, and is the sole processor of green peas in Denmark. The peas are processed in two factories owned by Danisco Foods. The green peas are sold in different mixes of frozen vegetables to supermarket chains in Denmark and other European countries. There is a very small export of bulk. Danisco Foods experiences competition from foreign companies, mainly because about 60 per cent of the production is exported, but also because other companies sell in the Danish market. The impression within the industry is that the competition is tough due to over-capacity on the European market for frozen peas.

The timing of the harvesting is extremely important to the final outcome. If the peas are harvested too late, they will be too ripe to be used as green peas, whereas if they are harvested too soon, the yield is too low. This means that the harvesting must be done within an interval of 24 hours. Once the peas have been harvested they must be frozen within 4 hours to remain fresh.

These factors require a very accurate planning, since the harvesting must be coordinated according to the capacity in the factory, the capacity of the harvesting machines, transportation time and the ripeness of the peas. To obtain an efficient harvesting process, the decision-making is centralized. This implies that Danisco Foods controls all decisions made during the harvesting period. In order to plan the harvesting, the sowing must also be done in the right order. To ensure this, the individual sowing time of each field is also decided by Danisco Foods. The main motivation behind the contract is the issue of timing the harvesting.

For most farmers the contract production is a one-year relationship, since farmers can easily change their production plans and exclude peas from their production. Furthermore, peas can only be grown

² The description in this section is mainly based on an interview of the Senior Field Manager at Danisco Foods referred to as (Sørensen, 1998). Another important source is an interview of the Board and Secretary of The Growers Association (Growers Association, 1998). This paper describes the situation before Danisco Ltd. sold Danisco Foods in 2000.

on the same area once every six years due to biological factors. For these reason the contract is a one-year contract where the terms are adjusted every year. However, some farmers produce peas on contract year after year in different fields.

The producers are organized in The Growers Association. This is, however, a quite weak organization, since it has no means to enforce discipline. Danisco Foods has a large number of potential growers. If the association made a threat that no grower would sign the contract, Danisco Foods would be able to either go elsewhere or start signing contracts with the growers on an individual basis. This actually happened in 1996, when the association rejected the contract (Growers Association, 1998). Danisco Foods is the only buyer of green peas from Danish farmers and thus holds almost all the bargaining power.

Danisco Foods considers the existence of The Growers Association an advantage, because it reduces the transaction cost (it is cheaper to write just one contract). A large part of the farmers are not able to see through the contract, these farmers only sign the contract because they have confidence in their negotiators. This means that the acceptance of the contract from The Growers Association is as a necessary blue stamping of the contract. Having the contract rejected by the Association would be bad publicity for the firm. Furthermore the relation with The Growers Association shifts the contract relationship towards more long-term commitment³. These factors give the Growers Association some bargaining power which is used to reduce Danisco Foods' flexibility in contract design, and thereby the possibilities for Danisco Foods to discriminate between farmers of different types⁴. This issue is analyzed in section 5.

2.1 Chronology

The chronology of the process is:

- Negotiation between The Growers Association and Danisco Foods
- Farmers communicate the size of the areas they want to allocate to contract production of peas to Danisco Foods – this is not legally binding.
- Contract is completed based on negotiation between Danisco Foods and The Growers Association.
- Danisco Foods sends out the standard contract on a “take-it-or-leave-it” basis to each farmer
- Farmers decide to sign or to reject the contract, and select the area for pea production
- Danisco Foods inspects the fields offered by the farmers and chooses their contractees based on the inspection
- Danisco Foods decides on the production plan, i.e. who, where and when
- Farmers make soil preparations and complete the sowing

³ A long-term relationship reduces the risk of opportunism, see Williamson (1985).

⁴ The growers argue for the use of only one contract from a fairness point of view, demanding ex ante equal treatment of all farmers.

- Farmers are divided into groups
- Farmers provide plant protection
- Danisco Foods harvest the crop
- Payment

3 The contract⁵

The farmer provides the land and is responsible for the soil preparations, the sowing and the plant protection during the growing season. Danisco Foods decides the timing of sowing, provides advisory service, and accomplish the harvesting. Danisco Foods does not only decide when the sowing must be done but also which varieties to use and how much seed to use.

In order to control the amount of seed used, Danisco Foods charges a very high price for using too much. For the farmer Danisco Foods is his only access to seed. These two factors control the quantity of seed effectively.

To provide documentation to customers that, for a limited time before harvesting, there has been no use of pesticides on the peas, Danisco Foods requests the farmers to keep a log of their work.

Danisco Foods has the right to decide that a farmer must try out a new variety on a small area. In these cases the farmer is paid according to the regular payment scheme, but with a guarantee that he will get at least the same payment per hectare for the new variety as he obtains for the ordinary variety on the rest of his land. I.e. the payment follows an option structure⁶ with weaker incentives to the farmers, which may lead to conflicts of interest. However, Danisco Foods has never experienced any problems with farmers sowing new variety on the poorest land or undertaking an otherwise more risky production of a new variety.

Danisco Foods can refuse to accept peas from a farmer if, due to shirk, the peas cannot be used in production. Except from damages caused by hail⁷, the peas are never refused for reasons outside the influence of the farmers⁸.

The payment is determined in two steps. First the payment on factory level is determined, i.e. the total bill Danisco Foods must pay the farmers. Danisco Foods pays 1.40 DKK/kg. for the first 5500

⁵ The division of obligations described in the following is based on Danisco Foods (1998) and Growers Association (1998).

⁶ The payment to the farmer only depends on output if the yield on the new variety exceeds a certain level. This corresponds to the payment of a financial option.

⁷ Most of the farmers have already insured their entire crop against damages from hail.

⁸ This corresponds to what in the contract theory is known as *moving support*, since both sides agree that peas never are rejected due to bad luck. The idea is that shirking can be avoided at no cost, if the punishment is harsh enough and if it is possible to detect shirking without any miscarriage of justice (Salanié, 1997).

kg./hectare and 0.55 DKK/kg. for the remaining quantity. The farmers are guaranteed a minimum of 4800 DKK per hectare. The payment on factory level can be illustrated like this:

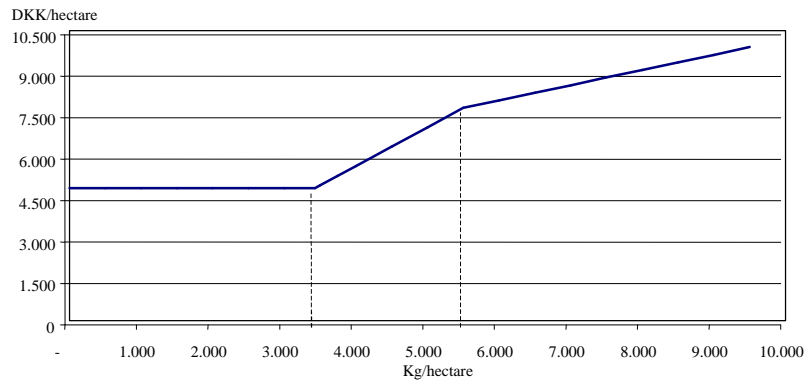


Figure Error! Unknown switch argument. The factory payment

The farmers are divided into groups according to the variety sowed and the time of sowing. This means that farmers in the same group experience the same growing conditions. The average payment is the same in all groups. In each group the total payment is shared proportionally to the farmers production. And with a minimum payment of 4800 DKK per hectare, the individual farmer is facing a linear price scheme⁹. The following figure shows the payment scheme towards a farmer in three different groups, given an average production on factory level of 7500 kg. per hectare.

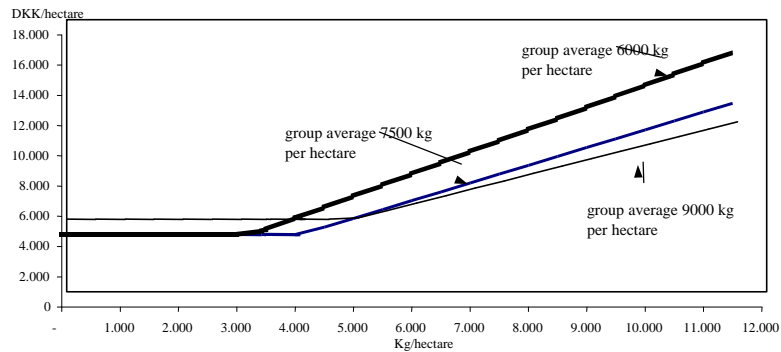


Figure Error! Unknown switch argument. The payment to a farmer

As shown in the figure, the average production in the group is very important to the farmer. This makes the division of the groups an interesting issue, which will be discussed later.

If Danisco Foods is unable to harvest the peas at the right time, the company has the right to decide which areas will not be harvested as green peas but at full ripeness. The payment to the farmer is

⁹ In this graph the effect of an increase in the production of one farmer on the total factory payment and on the average production in his group is not included.

not affected by this decision, i.e. Danisco Foods bears all risk derived from timing in the harvesting period.

The contract specifies that conflicts are to be solved by an arbitrator.

4 Analysis of the contract

The following provides an analysis of how different general challenges such as *coordination*, *hold-up*, *risk sharing*, *moral hazard* and *screening* are solved in the contract.

4.1 Coordination

The production of green peas requires precise coordination of the different levels in the production. In this contract the coordination is reached through a very centralized decision-making, where Danisco Foods decides:

- Who to accept as producers
- The variety
- The amount of seed
- The timing of sowing and harvesting
- The production standards

The programmability of the farmer's tasks is quite high, and the areas are inspected 3-4 times during the growing season. This gives Danisco Foods a high degree of control over the entire production process.

4.2 Hold-up

Danisco Foods has made very specific investments in this production, including investments in the factories and in the harvesting equipment. In a different context this could lead to hold-up problems, but since Danisco Foods has so many potential contractees, there is no real risk of hold-up.

The growers do not make any investments. There are no requirements for special machines or any special training, since peas is a very easy crop to grow. This eliminates the risk of Danisco Foods holding up the farmers.

4.3 Risk sharing

Risk sharing between the parties is in general an important issue in contract design. The general idea in agency theory is that the principal (Danisco Foods) has a weaker risk aversion than the agent (the farmer). In the present case, Danisco Foods is risk averse (Sørensen, 1998). However, several arguments suggest that insurance against risk is cheaper for Danisco Foods than it is for the farmers. Firstly, Danisco Foods has six other product lines and therefore a high diversification. Secondly, Danisco Foods is only one division of a larger corporation Danisco A/S, thus giving the owners

opportunity to diversify their investments on the capital market. It is difficult for the farmers to diversify due to correlation between the yields of different crops, and their opportunities of diversification through capital investments are also limited. Thus, it is to be expected that it is cheaper for Danisco Foods to bear the risk than it is for the farmers.

In dividing the risk between Danisco Foods and the farmers there is a trade-off between optimal risk sharing, i.e. placing the entire risk on the party who can handle risk the cheapest, and the provision of incentives. An optimal risk sharing would be to pay the farmers a fixed wage, but this will not motivate the farmers to provide effort.

4.3.1 Sources of risk

In the analysis of risk sharing it is important to look at the types of risk in the production chain. One major distinction is between general and individual risk.

Following the division in Holmström (1982) the production risk can be separated into general production risk and idiosyncratic risk. In the production of green peas the general production risk is the risk caused by weather conditions, general vermin attacks etc. The idiosyncratic risk is associated with those risk factors that affect the farmers differently such as plant disease, weeds etc.

In this production, not all farmers experience the same general production risk, since the time of sowing and the variety of peas determine the output. This means that the general risk is primarily comparable only between farmers in the same group.

If it is cheaper for the company to bear the risk than it is for the farmers, the company should take all risk except some fraction of the idiosyncratic risk, which the farmer must bear for incentive reasons (Holmström, 1982).

4.3.2 Risk borne by Danisco Foods

The payment from Danisco Foods to the farmers is independent of marketing possibilities, i.e. the company bears all price risk¹⁰. From the beginning of the harvesting period Danisco Foods bears all risk associated with the production, since the company faces the loss if an area is not harvested as green peas but at full ripeness. With these decisions being outside the influence of the farmers, this is exactly what the contract theory predicts, since there is no trade-off between risk sharing and incentives.

As earlier mentioned, the farmers are guaranteed a minimum payment of 4,800 DKK per hectare, implying that Danisco Foods bears the general production risk of very low yields. The second break in the factory-payment curve implies that Danisco Foods bears some additional part of the general production risk, since variations in the output on the last part of the payment curve only have a

¹⁰ One can argue that the farmers bear some marketing risk, since their contracts will not be renewed if the production is no longer profitable to Danisco Foods.

minor effect on the payment (see figure 1)¹¹. If the farmers had to take all the general production risk, the factory payment would be determined by a constant price per kg. On the other hand, if the factory payment were independent of the output, Danisco Foods would bear all general production risk. The later system would correspond to the payment scheme in the American broiler production (Knoeber and Thurman, 1995).

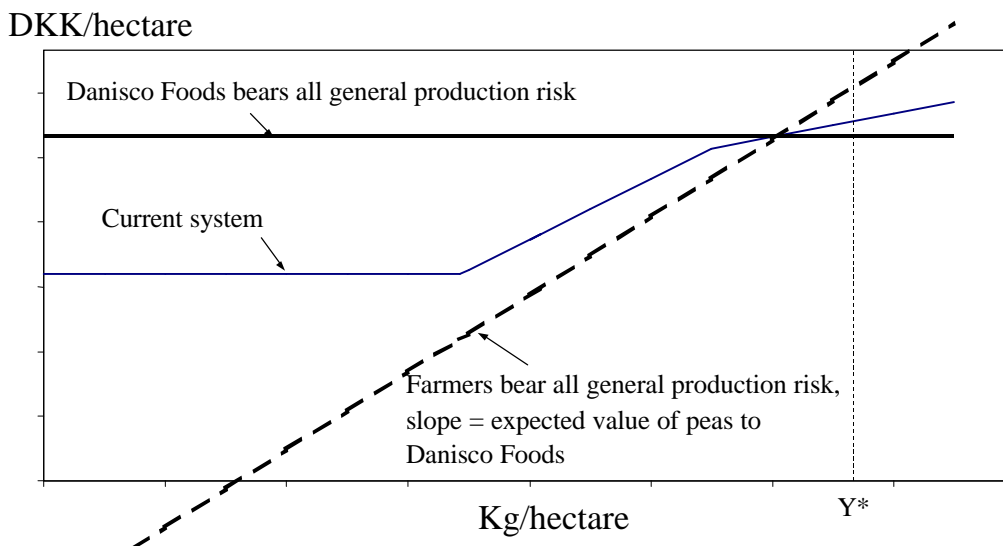


Figure 3 Different ways to deal with common risk by variations in factory payment

If the risk is borne cheapest by Danisco Foods, the system with the flat payment would dominate the payment scheme in the present contract since the company will gain from insuring producers against the general production risk, thus obtaining the farmers risk premium. The figure shows how the payment for the expected production Y^* is lower the more risk Danisco Foods bears, since this reduces the risk premium to the farmers. This is one of the important arguments in favor of using tournaments in broiler contracts (Knoeber, 1989).

If the general production risk is severe, it may cause financial problems for the integrator to bear general production risk in bad years. This problem is analyzed by Tsoulouhas and Vukina (1999). They explain the coexistence of contracts based on relative performance evaluation and contracts based on fixed performance standards in different agricultural industries, using the argument of integrator bankruptcy. They argue that farmers do not accept contracts, if the payments provided cannot be recovered from the firms' revenue and liquidation value in bad years. The empirical evidence supports this, since tournaments are not used in industries with high common risk. The problem of possible bankruptcy may explain the actual contract between Danisco Foods and the farmers.

¹¹ The kink in the payment scheme can alternatively be explained from a coordination point of view, since it gives weaker incentives to the farmers in good seasons. If the marginal value of the peas produced decreases in the quantity produced, it is reasonable to reduce the level of effort if the production is already high.

There is a conflict of interest between the farmers and Danisco Foods regarding the production planning. Overall, Danisco Foods wants the harvesting period to be as long as possible in order to utilize the capacity at the factory. For this reason Danisco Foods wants to have some farmers sowing very early and some sowing very late even though this results in lower yields. Contrary to this, the farmers want to choose the sowing time such that the yields are maximized and do not take the factory capacity problems into consideration. If Danisco Foods tells one group of farmers to sow at a bad time, the total payment to farmers decreases. This means that Danisco Foods pays only part of the costs caused by production planning (i.e. the time of sowing and the variety of seed). This in turn implies that Danisco Foods does not have incentives to plan the production in a way that maximizes the total vertical profit. A flat payment scheme would place all costs of production planning on Danisco Foods, thus eliminating the conflict of interest between Danisco Foods and the farmers regarding the time of sowing¹². Since the loss caused by sowing at a bad time is shared between all farmers, the individual farmer has very little incentive to object to decisions made by Danisco Foods. Thus Danisco Foods can implement a production plan without too much protest.

If Danisco Foods were to take all common risk, it may lead to conflict with the Danish agricultural law. The Danish agricultural law requires that the risk of production is taken by the farmer (Wulf and Jørgensen, 1995)¹³. This means that even the present contract may not be legal, since the individual farmer does not bear all the production risk¹⁴. The legal aspects of the contract will not be analyzed further.

4.3.3 Risk shared among all farmers

The part of risk not borne by Danisco Foods is either shared between all farmers via pooling or borne by the individual farmer. As mentioned, Danisco Foods bears only part of the common production risk, since the factory payment is not constant. This leaves a fraction of the common production risk to the farmers. The farmers bear not only part of the common risk such as a dry season, but also a fraction of that risk, which is only common to the farmers within one group, such as bad weather at the time of sowing. This comes from the fact that a low production in one group lowers the factory payment, but the farmers in the low yielding group receive the same average payment as the other groups.

New varieties are introduced in a way that causes no additional risk to the individual farmer, since Danisco Foods guarantees at least the same payment per hectare as for the ordinary varieties. However the total payment from Danisco Foods to the farmers will decrease if a new variety has very low yields, since the total production will drop. This means that Danisco Foods is both giving and taking, if a new variety has low yields. The net effect can be both positive and negative.

¹² There may still exist some conflict of interest if the variability is affected by the time of sowing.

¹³ The argument is that arrangements where the farmers do not bear the full production risk is considered a rental arrangement.

¹⁴ The contract protects the farmer from production risk in several ways. Danisco Foods bears all the risk of harvesting, and the risk of a bad sowing time etc. is shifted from the individual farmer to all farmers (see next section).

4.3.4 Risk borne by the individual farmer

Another source of risk is the division of farmers into groups, since the payment to the individual farmer depends on the performance of the other farmers in his group. The payment to a farmer is therefore determined by how the groups are divided. If we look at the farmer in figure 2 with same yield as the average for all farmers (7,500 kg. per hectare), his payment will vary from 7,300 to 11,000 DKK per hectare as the average production in his group varies from 6,000 to 9,000 kg per hectare. This shows that from a risk perspective the division into groups is important. The group division is not arbitrary, but determined by which variety the farmer grows. This means that most of the difference in yields across the groups is common to all farmers within one group (i.e. the fraction of deviation caused by difference in yields for different varieties). The larger the groups, the smaller the risk from group division¹⁵ due to the law of large numbers.

The payment on farm level is dependent on idiosyncratic risks in order to provide the farmer incentives to perform.

The farmer bears the risk of severe weed problems that occur only if the farmer shirks on the plant protection. This is supported by the argument of *moving support* from the contract theory (see note 8).

4.4 Moral hazard

The production of peas involves a large number of production decisions. This makes it difficult to specify and monitor the tasks of the farmers. It is therefore important to provide incentives for the farmers to perform in such a way that their hidden action maximizes the profit of Danisco Foods. Possibilities for opportunistic behavior exist on both sides.

4.4.1 Opportunistic behavior from Danisco Foods

The negotiation process makes it important for Danisco Foods to maintain a good relationship with The Growers Association. This limits Danisco Foods possibilities to exploit market power.

In a year where Danisco Foods foresees very bad marketing conditions, the company would be interested in reducing the quantity. The contract in principle gives Danisco Foods certain ways to do this. The company can reject more peas and blame it on e.g. weed, but the arbitrator institution and the importance of the relationship with The Growers Association minimizes such behavior. Another possibility would be to harvest a larger part of the peas at ripeness instead of as green peas. This approach is very expensive, since the value of ripe peas is much lower than the payment to the farmers. Thus, using time of harvest as an instrument in controlling the quantity is too expensive. This means that on the side of Danisco Foods the contract does not give rise to moral hazard.

¹⁵ I.e. risk caused by the production level in the group.

4.4.2 Opportunistic behavior from the farmers

Low effort on the farmer's side is a fundamental moral hazard issue in this contract. Since it is impossible to specify and monitor the task of the farmers, an incentive contract is used as governance structure.

The farmers are quite limited in their set of possible production decisions. This means that in reality they are unable to affect the quality of the peas, since Danisco Foods decides the variety, the amount of seed and the production standards. For this reason quality is not a moral hazard issue in the production.

A problem in the use of tournaments is that the agents have incentives to collude in providing low effort. This problem is solved in two ways. Firstly, the farmer cannot know with whom to collude until after he has provided most of his effort, since the groups are not divided until after the sowing. Secondly, the groups change from year to year i.e. the farmers do not get to know each other. The disadvantage of not knowing the group before signing the contract is that the farmer can have only a very uncertain expectation concerning his payment, because he does not know whether he ends up in a group with high or low average yield.

4.5 Screening

The farmers have to be compensated for their effort and the land they provide. The farmers are paid according to their production, regardless of whether a high production is a result of high effort or high soil quality. When calculating which soil types Danisco Foods wants to contract upon, the company considers all cost, i.e. the payment to farmers as well as the production cost. One example of such considerations is that good soil with high yields gives relatively cheaper harvesting and better timing (the fixed cost of harvesting an area – transportation cost of machinery to the area etc. is apportioned to a larger quantity). Such considerations suggest that it is most profitable for Danisco Foods to sign contracts with the farmers holding the best soil even though they have a higher reservation value¹⁶ (Sørensen, 1998). It is therefore in the interest of Danisco Foods to design a contract rewarding the farmers with good soil to at least compensate their potential profit in production of other crops.

The total area contracted for is limited by the factory capacity. In an efficient setting, Danisco Foods will sign contracts on the areas with the largest difference between marginal value of the area to Danisco Foods and the reservation value. Danisco Foods does have contracts on the best soil. This fact allows us to infer that the difference between the reservation value and the value to Danisco Foods is increasing in soil quality (Sørensen, 1998).

The following figures analyze how soil quality affects the payment under the present contract and under modified contracts. We assume that the production follows the simple structure without risk $y_i = a_i + s_i$, where y_i is the output for farmer i , a_i is his level of effort and s_i his soil quality¹⁷.

¹⁶ The reservation value is the income the farmer can obtain in an alternative production.

¹⁷ The soil quality does not follow ordinary measures of soil quality, it is a measure normalized for our purpose.

Furthermore we suppress the effort a in the figure by graphing the output for a soil type at the optimal level of effort. We assume that the soil quality is uniformly distributed. Since the payment per hectare is given by the yield times the price per kg. in the group¹⁸, the payment is, under our assumptions, linear in soil quality. Every year Danisco Foods rejects some farmers, with low quality soil, who want to contract. This is because the payment to farmers with low quality soil is above their reservation value. It is hardest for Danisco Foods to attract the farmers with the best soils. We can infer from this information, that the reservation value must be convex in soil quality¹⁹.

Under these assumptions the problem can be illustrated like this:

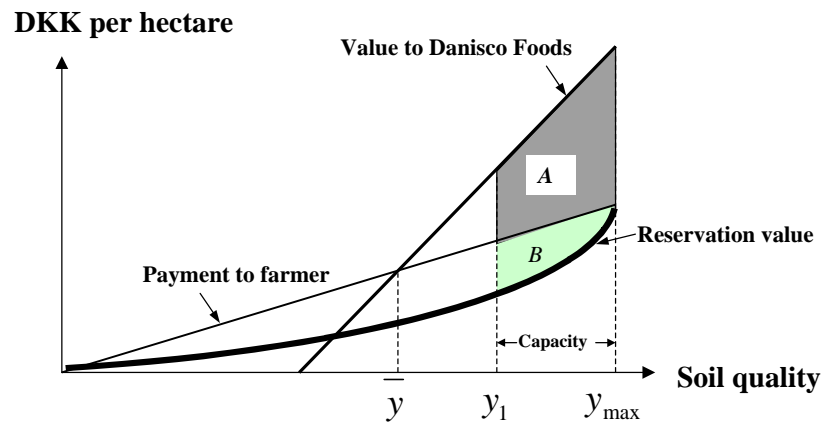


Figure 4 The payment to different soil types in the present contract

where B is the information rent to the farmers and A is the profit to Danisco Foods.

According to the figure, it will be most profitable for Danisco Foods to utilize the capacity by signing contracts upon the soil types between y_1 and y_{\max} . If Danisco Foods offers payment as shown in the graph, all farmers are interested in a contract. However, Danisco Foods prefers soil types above y_1 and is not at all interested in soil types below \bar{y} . Danisco Foods has many years of experience in the industry and has a reasonable knowledge of the soil type based on the geographical location of the area. For this reason it is fair to assume that the company is able to detect and reject the types below y_1 . This means that the problem of screening in this contact does not come from *hidden information* as in the standard adverse selection problems, but is caused by the limitation of having only one contract, i.e. a contract independent of soil types.

The figure above shows that since Danisco Foods is unable to make efficient discrimination towards the farmers, the farmers obtain the profit in area B . Danisco Foods could discriminate by changing

¹⁸ We also assume that the individual farmer do not affect the price per kg. in his group.

¹⁹ The explanation for this is that the soil quality has relatively more effect on the yield of alternative crops than on the production of peas. Formally the argument requires that the reservation value of land without any potential yield is zero and that the second order derivative has the same sign everywhere. The appendix contains an example of production functions leading to convex reservation value.

the payment into an affine payment, in which the farmers receive a fixed premium for the quality of the soil. This would increase the profit to Danisco Foods, area A. The following figure shows such a contract.

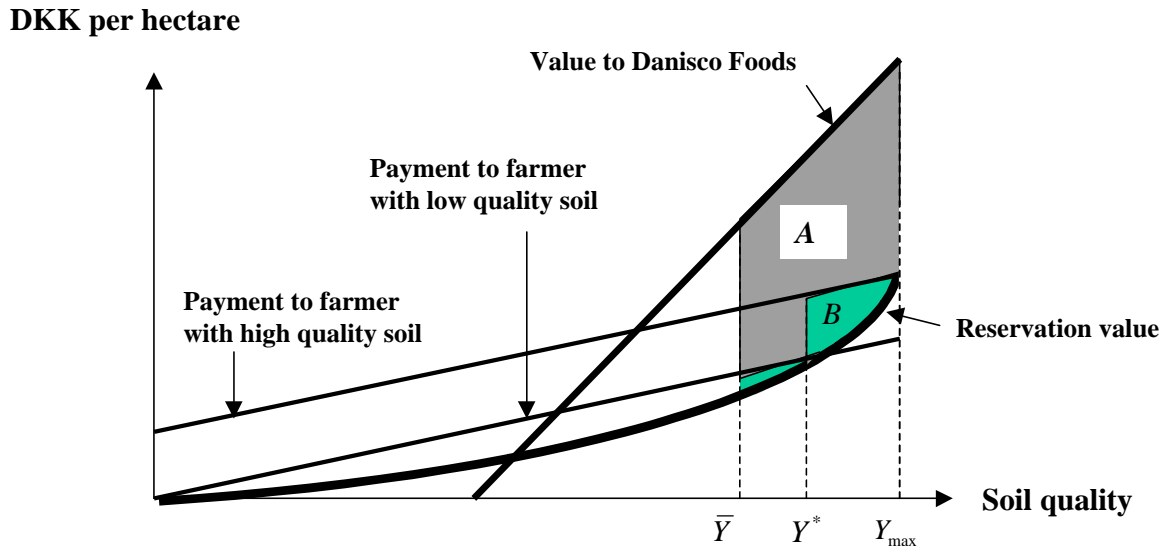


Figure 5 Differentiated payment to soil types based on bonuses

As illustrated in the figure above, offering a constant price per kilo combined with a bonus to soil types above Y^* increases the profit to Danisco Foods (area A in the figure) and reduces the profits to the producers (area B)²⁰. The contract suggested in the figure above is not a self-selection device, where the farmer himself chooses which contract he prefers, but a system where Danisco Foods offers each farmer just one contract. The figure below shows a set of contracts fulfilling the individual rationality constraint. The difference between the figures is that in the latter the price is used to discriminate, whereas the discrimination in the first figure is created by bonuses alone.

²⁰ The payment per kilo in the affine payment in the figure is lower than the originally payment, which reduces the incentives. The information rent to farmers could also be reduced by using the originally payment per kilo in figure 4 to high quality soil combined with a negative bonus to low quality soil.

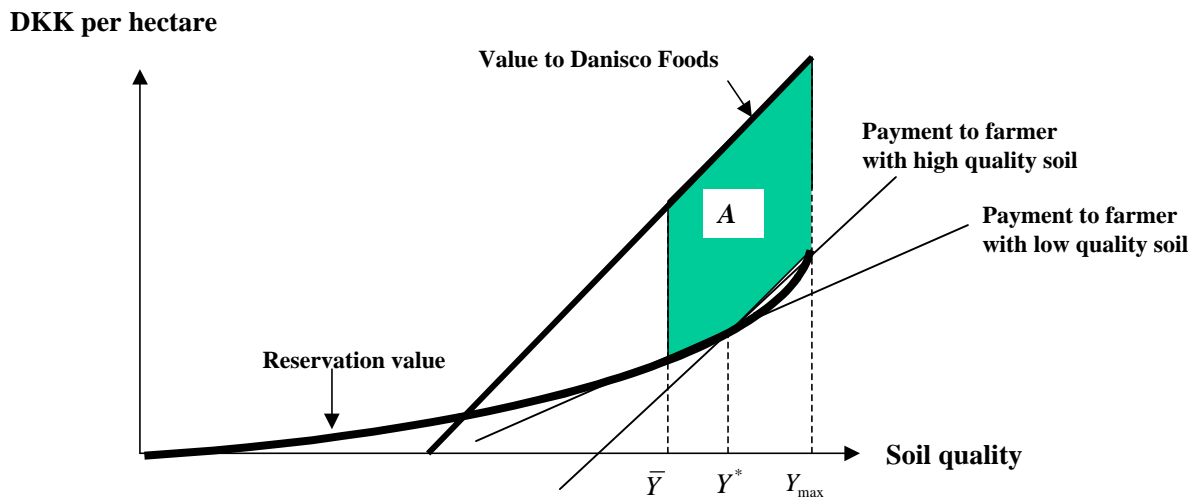


Figure 6 Differentiated payment to soil types based on different prices²¹

The analysis shows the dilemma for Danisco Foods. If the company wants to contract upon the best soils, and in order to do so pay these farmers a high price, farmers with lower yields will benefit by receiving a payment that exceeds their reservation value (since the company is restricted to only one contract). This is similar to the problem of the company raising the payment to obtain the advantages of large areas per farmer (to reduce transportation of the harvesting machines) and thereby increasing the benefit of all other farmers. It would be beneficial for Danisco Foods to discriminate the farmers by using bonuses for high quality soil, large areas per farm and location near the factory. However, the farmers resist this because it would remove their profits. This result corresponds to the actual negotiation process, where The Growers Association has blocked the use of bonus payment to farmers with large areas (Growers Association, 1998).

The payment per kg. in the group is determined by the factory payment and the average yield in the group. This causes a serious problem, since the soil-quality within one group tends to be positively correlated, since the groups are divided according to the harvesting route, so that the farmers in one group are from the same area. The consequence is that the payment per hectare to farmers in a group with high quality land is close to factory payment per hectare, because of a low price per kilo in the group²². Thus, the way in which the groups are divided causes these farmers to profit more from growing other crops. If Danisco Foods still wants to contract upon the best soils, the factory payment will have to be raised. This turns out to be too costly for the company, and as a result there has not been any contracts during the past few years in a certain area with very good soil (Sørensen, 1998).

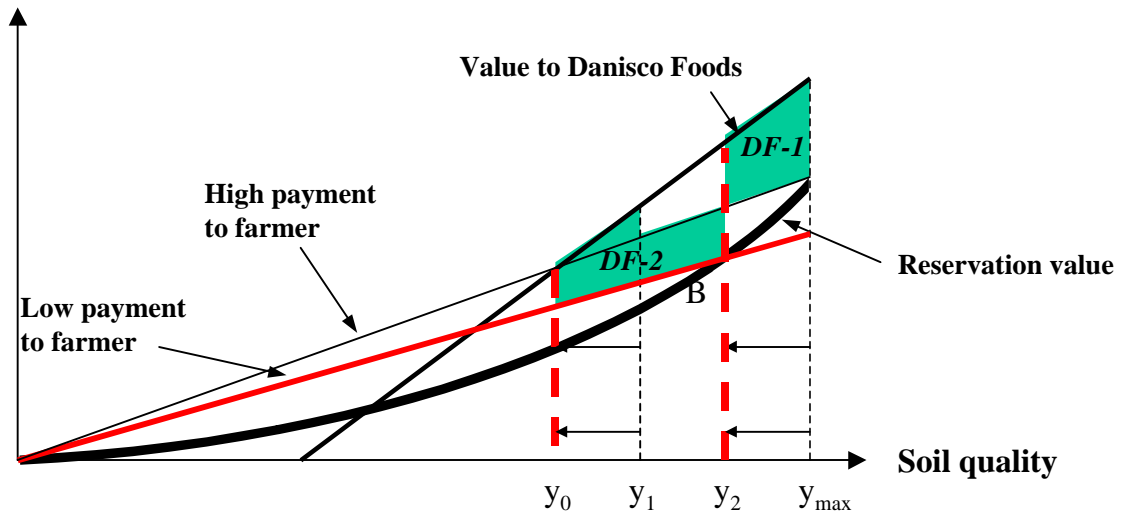
If the payment were dependent on information about the soil type, the contract could be improved in yet two other ways. Firstly, the current contract design may lead to a deadweight loss. In the figure below the total profit of Danisco Foods increases (Danisco Foods loses $DF-1$ but gains $DF-$

²¹ This approach may influence the level of input, meaning that the rescaling of soil type may not be valid, because the assumption $a_i = \bar{a}$ may be broken.

²² In figure 4 this corresponds to a concave payment scheme from Danisco Foods.

2) if Danisco Foods lowers the payment to the farmers. Lowering the price to the farmers means that the contract is no longer acceptable for the best soils (between y_2 and y_{\max}), thus Danisco Foods will contact on the soils between y_0 and y_2 . Lowering the payment to the farmers is however not socially optimal, since the total profit of farmers and Danisco Foods is reduced. The problem is even more serious if the soil types are not uniformly distributed as assumed in figure 4, since a payment aimed at a small area of very high soil quality benefits all other soil types.

DKK per hectare



Figur 7 Deadweight loss due to uniform payment scheme

The second way for information about soil quality to improve the contract is through more exact information about the effort. The idea is that the output level conditioned on the soil type contains more information about the effort, which makes the implementation less costly (Holmström, 1979).

The information about soil quality may not be verifiable. In a situation where the company has committed to a constant total payment²³ to the farmers, the non-verifiable information is not an issue, since Danisco Foods has no incentives to misrepresent the information, see Bogetoft (1994) for a general analysis of the use of non-verifiable information in contracts.

Given these advantages of conditioning the payment on the soil type, the Coasian Theorem suggests, that the parties would reach a Pareto optimal agreement through negotiation and divide the benefits via side payments. One reason why the Coasian Theorem may not hold is that the farmers negotiating the present contract may not be accepted as growers in a contract based on soil types. It may not be possible for Danisco Foods to compensate these farmers via side payments, which causes the negotiations to break down.

²³ Danisco Foods could commit to categorizing e.g. 50 per cent of the area as high quality.

4.6 How should the groups be divided?

The payment scheme makes the division of groups very important. As mentioned, the price scheme is not totally linear toward the farmers, since an increase in the production of one farmer has two second order effects. Firstly, a higher production raises the payment on factory level and thereby the payment to the groups. Secondly, a higher production lowers the payment per kg. in the group.

The payment from Danisco Foods is independent of group division, but the incentives and allocation of the payment depends on the formation of the groups²⁴. Danisco Foods is interested in fields as large as possible, since this reduces the transportation time of the harvesting machines. In this matter the incentives does not support the interests of Danisco Foods, because the incentives are weaker the larger the area of the farmer. Since a farmer by producing more lowers the payment per kg. in the group due to a higher average production, the individual farmer affects the group average more the smaller the group is. I. e. the larger the group, the more high-powered the incentives to the individual farmer. This, of course, affects farmers with large productions (due to large areas or high yields) the most. Thus, the incentives are lower the larger the farm size or the higher the yields. These results are shown in the appendix.

The effects of group size on the incentive structure as well as the effect on risk caused by production level within the group (see section 4.3.4) give arguments for large groups, which is in line with the policy of the company. However, the farmers are still divided into a considerable number of groups. There are two reasons for this. First, the farmers are divided into groups based on which variety of seed they have. In this way, comparing low yielding varieties to high yielding varieties is avoided. This is basically a fairness argument. This argument does not by itself explain the groupdivision, since this objective could be reached by using different premiums based on experimental results to the different varieties²⁵. The second motivation for dividing into more groups is to obtain a more precise measure of the common uncertainty in each group, since farmers sowing at different times are affected differently by the weather conditions. This means that the division of groups should be done according to the trade-off between strong incentives and precise measures of common uncertainty.

4.7 Modification of the payment scheme

It is unfortunate if incentives are very dependent on the groupsize and are weaker for larger producers. Usually, Relative Performance Evaluation is made by comparing the output of one agent with the average of other agents who face the same common uncertainty, i.e. the agents own output is not included in the average used for comparison (Schleifer, 1985). In the appendix it is shown that

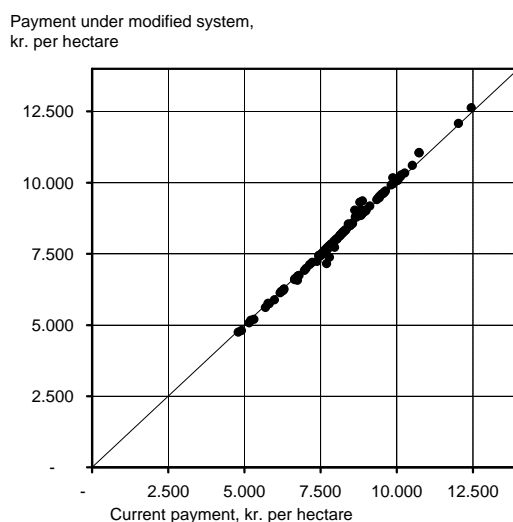
²⁴ If Danisco Foods use the group division as a discrimination mechanism rewarding growers with high reservation value, Danisco Foods can attract all growers using a lower factory payment. In this case the factory payment depends on the division of groups.

²⁵ This approach has actually been tried out by Danisco Foods by offering different prices to the varieties. The prices were determined before the signing of the contracts. This system was abandoned because it resulted in too much variation in the payment (Sørensen, 1998).

(under the assumption that the payment from Danisco Foods is constant²⁶) such a modification will mean that:

- The payment per kg. to a farmer is independent of his yield
- The incentives are independent of group size
- The incentives are independent of farm size.

The effect of such a modification in the payment scheme is analyzed on the basis of data for the 111 farmers supplying Danisco Foods in 1996. A comparison between the actual payment and the payment the farmers would obtain, were their own production not included in the group average, shows that the modification of the payment scheme has only minor effects on the payment to the farmers²⁷. The largest deviation between the payments in the two systems is 7 per cent. In figure 8 the payment the farmers would obtain in a modified system (vertical axis) is plotted against the current payment (horizontal axis). The figure shows that in general the farmers receiving the highest payment per hectare would gain and the opposite holds for farmers with low payment per hectare.



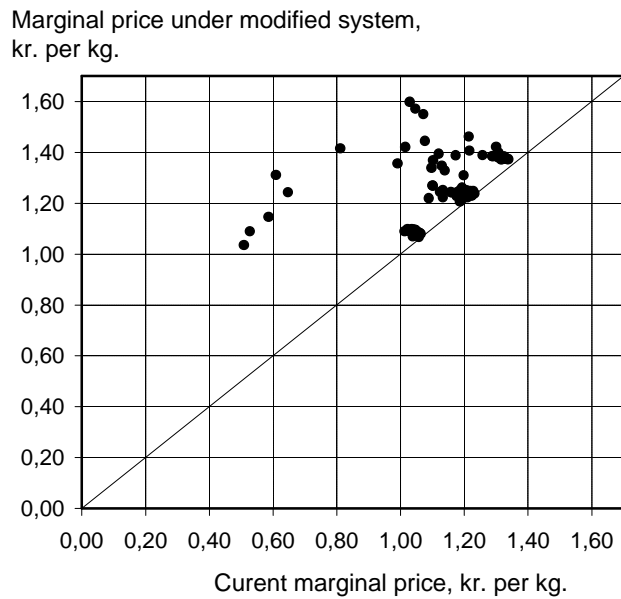
Figur 8 The payment to farmers under current and modified system.

Even though the payments to the farmers remain almost unchanged, a modification of the payment scheme would lead to a large increase in the incentives. Figure 9 shows the current marginal income²⁸ plotted against the marginal income in the modified system. The largest increase of incentives is 115 per cent and is obtained by a farmer in a small group. The incentives increase for all farmers, even though the effect in larger groups is minor.

²⁶ See the discussion on page 6 of optimal risk sharing.

²⁷ Changes in level of production may alter this; the analysis is based on the old production levels.

²⁸ The marginal income is the increase in payment from an increase in production of 1 kg. per hectare



Figur 9 The incentives under current and modified system

The total payment to farmers is 0.25 per cent higher in the modified system than in the current system. This is caused by positive correlation between farm size and yields. This shows that the large farms would have stronger incentives than small farms under the modified contract, which is in line with the interest of Danisco Foods due to lower harvesting cost on large areas. The disadvantage of the modified system is that the payment to the individual farmer becomes more sensitive to variation in the yields of other producers.

5 Conclusion

The major motivation behind the contract is the issue of coordinating the production in the harvesting period. This crucial coordination is obtained through centralized decision-making, where Danisco Foods makes all major decisions regarding the production.

There are no hold-up problems in the contract. Danisco Foods do have some specific investments, but the growers have very little bargaining power and are unable to hold up Danisco Foods. There are no specific investments on the growers' side.

The payment to the individual farmer is determined through tournaments. However, this does not cause any problems of collusion, since the farmers do not know with whom to collude until after the sowing when most of their work is done.

There is a high programmability of the farmers' tasks. This implies that Danisco Foods can ensure some level of effort via monitoring. The use of incentives to motivate the farmers to provide effort plays a very important role.

The payment to the farmers is determined in two steps. First, the total payment from Danisco Foods to all farmers is determined, based on the actual average yield per hectare. Secondly, the farmers are divided into groups according to the time of sowing. The average payment per hectare is the same in all groups. In each group the payment is divided proportionally to the quantity of peas supplied by each farmer.

Danisco Foods bears all the price risk but only a small part of the production risk. From a theoretical point of view this seems to be disadvantageous, since several arguments point towards Danisco Foods being the cheapest risk bearer. In order to shift all general production risk towards Danisco Foods it is suggested that the total payment from Danisco Foods to farmers is made independent of the actual production level. This corresponds to the system used in American broiler contracts. The advantage of this risk sharing is that Danisco Foods can obtain the risk premium from the farmers by insuring them against general production risk. Another advantage of a fixed total payment is that it minimizes conflicts of interest between the farmers and Danisco Foods regarding the production plan.

It would be beneficial for Danisco Foods to discriminate between farmers by offering different contracts based on soil types. The present system does not use any bonuses, as a result of The Growers Association bargaining power. This reduces the profit of Danisco Foods and may lead to deadweight losses.

By dividing the farmers into groups and paying them according to the group's average price per kg., the contract actually uses Relative Performance Evaluation. When the average production in the group is calculated, all farmers in the group are included. This paper shows that the incentives would improve if the average production to which the farmers were compared did not include the farmer in question. Calculation on actual data for 1996 shows that this, for some farmers, would increase the incentives by more than 100 per cent.

6 Appendix

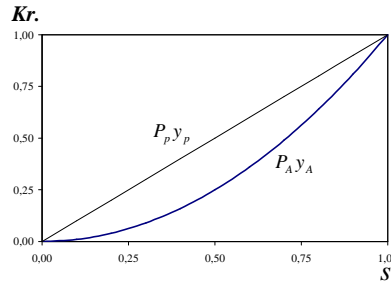
6.1 Convex reservation value

We look at the simple production function for peas: $y_p = s$, s is the soil quality and y is the production level. The production function for the alternative crop is $y_A = s^2$. We look at the interval $0 \leq s \leq 1$, and the price of the alternative crop is $P_A = 1$. Danisco Foods is aiming at the lowest price on peas P_p satisfying:

$$\begin{aligned}
 &P_p y_p \geq P_A y_A \text{ for all } s \\
 &\Updownarrow \\
 &P_p s \geq s^2 \\
 &\Updownarrow \\
 &P_p \geq s \Rightarrow P_p = s
 \end{aligned}$$

If Danisco Foods wants to contract upon all soil types, it must choose $P_p = 1$.

In this example the reservation value is convex:



6.2 The contract

Let x_i denote the area on farm $i=1, \dots, N$, and let q_i be the total production on farm i . We analyze the incentives for a farmer i in group J , $J \subseteq N$. The total factory payment F is given by:

$$F = \begin{cases} 4800 \sum_{i \in N} x_i & \text{for average production below 3429 kg. per hectare} \\ 1,4 \sum_{i \in N} q_i & \text{for average production between 3429 and 5500 kg. per hectare} \\ 7700 \sum_{i \in N} x_i + 0,55 \sum_{i \in N} (q_i - 5500x_i) & \text{for average production above 5500 kg. per hectare} \end{cases}$$

The payment per kg in group J is:

$$p_J = \frac{\sum_{i \in J} x_i}{\sum_{i \in N} x_i} \frac{F}{\sum_{i \in J} q_i} = \frac{X_J}{X_N} \frac{F}{Q_J}$$

where X_J denotes the total area in group J , X_N the total area for all farmers and Q_J is the total production in group J .

The payment B to farmer t in group J is:

$$B_{Jt} = q_t p_J$$

The incentive, i.e. the marginal payment is:

$$\frac{dB_{Jt}}{dq_t} = p_J + \frac{dp_J}{dq_t} q_t$$

since $p_J = \frac{X_J}{X_N} \frac{F}{Q_J}$ we have:

$$\begin{aligned} \frac{dB_{jt}}{dq_t} &= p_J + \frac{X_J}{X_N} \frac{\frac{dF}{dq_t} Q_J - F}{Q_J^2} q_t = p_J + \frac{dF}{dq_t} \frac{X_J}{X_N} \frac{q_t}{Q_J} - \frac{X_J}{X_N} \frac{F}{Q_J} \frac{q_t}{Q_J} \\ &= p_J + \underbrace{\frac{dF}{dq_t} \frac{X_J}{X_N} \frac{q_t}{Q_J}}_{\text{share of increase in factory payment}} - \underbrace{p_J \frac{q_t}{Q_J}}_{\text{share of price reduction in group J}} \end{aligned}$$

The marginal payment is given by the payment per kg. in the group plus the share of the change in factory payment minus farmer t 's share of price reduction in the group. The latter because a farmer by raising his production also increases the total production of his group, and thereby lowers the price per kg. within the group.

The marginal factory payment is never higher than the average payment:

$$\begin{aligned} \frac{dF}{dq} \leq \frac{F}{\sum_{i \in N} q_i} &\Rightarrow \frac{dF}{dq} \leq \frac{F}{\sum_{i \in J} q_i} \Rightarrow \frac{dF}{dq} \frac{X_J}{X_N} \frac{q_t}{Q_J} \leq \frac{F}{Q_J} \frac{X_J}{X_N} \frac{q_t}{Q_J} \\ &\Downarrow \\ \frac{dF}{dq} \frac{X_J}{X_N} \frac{q_t}{Q_J} &\leq p_J \frac{q_t}{Q_J} \end{aligned}$$

This means that:

A) $\frac{dB_{jt}}{dq_t} \leq p_J$, i.e. the farmers face lower incentives than the average payment per kg in their group.

The actual curve is therefore below the curve in figure 2.

B) $\frac{dB_{jt}}{dq_t}$ decreases in q_t , i.e. the incentives are strongest for small producers.

Let $Q_{J \setminus t} = \sum_{i \in J} q_i - q_t$ be the production for all other producers in group J but producer t , and let y_t be the yield per hectare on farm t . Rewriting:

$$\frac{dF}{dq} \frac{X_J}{X_N} \frac{q_t}{Q_J} \leq p_J \frac{q_t}{Q_J} \Leftrightarrow \frac{dF}{dq} \frac{X_J}{X_N} \frac{y_t x_t}{Q_{J \setminus t} + y_t x_t} \leq p_J \frac{y_t x_t}{Q_{J \setminus t} + y_t x_t}$$

gives the results below, since $\frac{y_t x_t}{Q_{J \setminus t} + y_t x_t}$ increases in y_t .

C) $\frac{dB_{Jt}}{dq_t}$ decreases in y_t , i.e. the incentives are weaker the higher the yield

Assuming that all farmers have the same yield y per hectare, the incentive can be rewritten as:

$$\begin{aligned} \frac{dB_{Jt}}{dq_t} &= p_J + \frac{dF}{dq_t} \frac{X_J}{X_N} \frac{yx_t}{yX_J} - p_j \frac{yx_t}{yX_J} \\ &= \underbrace{p_J + \frac{dF}{dq_t} \frac{x_t}{X_N}}_{\text{independent of group size}} - p_j \frac{x_t}{X_J} \end{aligned}$$

This means:

D) $\frac{dB_{Jt}}{dq_t}$ increases in X_J , i.e. the incentives are stronger in large groups

6.3 Modified contract

We now consider a modification of the contract, where the individual farmer is excluded from the average in the group, when the price per kg is determined. I.e. we change the payment to farmer t in group J from:

$$B_{Jt} = \frac{X_J}{X_N} \underbrace{\frac{F}{Q_J}}_{p_J} q_t$$

to the payment in the modified contract:

$$\hat{B}_{Jt} = \frac{X_{J \setminus t}}{X_N} \underbrace{\frac{F}{Q_{J \setminus t}}}_{\hat{p}_{J \setminus t}} q_t$$

where $X_{J \setminus t} = \sum_{i \in J} x_i - x_t$.

The incentives in this contract is:

$$\frac{d\hat{B}_{Jt}}{dq_t} = \frac{X_{J\setminus t}}{X_N} \frac{F}{Q_{J\setminus t}} + \frac{X_{J\setminus t}}{X_N} \frac{1}{Q_{J\setminus t}} \frac{dF}{dq_t} q_t = \hat{p}_{J\setminus t} + \underbrace{\frac{X_{J\setminus t}}{X_N} \frac{q_t}{Q_{J\setminus t}} \frac{dF}{dq_t}}_{\text{share of increase in factory payment}}$$

since $\frac{X_{J\setminus t}}{X_N} \frac{F}{Q_{J\setminus t}}$ is independent of q_t .

A further modification of the contract, resulting in a constant payment from Danisco Foods (due to risk consideration, see page 8) i.e. $\frac{dF}{dq} = 0$, implies that the incentives $\frac{d\hat{B}_{Jt}}{dq_t} = \hat{p}_{J\setminus t}$ are independent

of

- The farmers own yield
- Farm size
- Group size.

Literature

Bogetoft, P. *Non-Cooperative planning theory*. Springer-Verlag, 1994.

Danisco Foods. *Kontraktvilkår for dyrkning af grønne ærter til Danisco Foods*. 1998.

Growers Association. *Interview of Pea Growers Association*. 1998.

Holmström, B. "Moral hazard and obserability." *The Bell Journal of Economics* (1979):74-91.

Holmström, B. "Moral Hazard in Teams." *The Bell Journal of Economics* (1982):324-340.

Knoeber, C.R. "A Real Game of Chicken: Contracts, Tournaments, and the Production of Broilers." *Journal of law Economics and Organization* 5(1989):271-292.

Knoeber, C.R. and W.N. Thurman. "'Don't Count your Chickens ...': Risk and Risk shifting in the Broiler Industry." *American Journal of Agricultural Economics* 77(1995):486-496.

Salanié, B. *The Economics of contracts, A Primer*. Cambridge. The MIT Press, 1997.

Schleifer, A. "A theory of yardstick competition." *Rand Journal of Economics* 16(1985):319-327.

Sørensen, Christian Stigaard, Senior Field Manager, Danisco Foods. *Personal Communication*. 1998.

Tsouluhas, T. and T. Vukina. "Integrator Contracts with Many Agents and Bankruptcy." *American Journal of Agricultural Economics* 81(1999):61-74.

Wulf, H. and C. Jørgensen. *Landbrugsloven i hovedtræk*. 1995.