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Payment Schemes based on Seed Quality

Incentives for the Swedish farmer

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Abstract

Payment and bonus schemes based on seed quality used by the Swedish agriculture cooperative Lantmännen is evaluated. Results from a farm and region/time fixed effect model show that the linear payment scheme for pulses (peas and beans) has approximately 15 percentage points lower quality compared to that used for grains when a common quality measure constructed for this research is used. Germination capacity is reduced by five percentage points and the probability of reaching the desired water content level is 20 percent lower for pulses compared to grains. The result for bonus schemes are inconclusive, but show signs of endogeneity from matching.

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1. Introduction

This paper examines how quality varies as a result of payments schemes. The setting is the Swedish market for seeds where payments to the farmers are not only based solely on quantity but additionally determined by results from laboratory analyses on certain product quality parameters. This study answers the following questions: “If seed quality differs between a linear payment scheme and a discontinuous payment scheme and if bonus schemes for varieties of higher value to the buyer gives the farmer an incentive to deliver higher quality?” along with “if a higher premium for reaching desired water content increases the probability of doing so?”. This study is conducted in cooperation with Lantmännen, one of the largest agricultural cooperatives in Europe. The payments schemes investigated are those used by their seed unit. The dataset consists of laboratory test results on seed deliveries ranging from the years 2014 to 2018. Approximately 600 different farmers and their nearly 18000 deliveries of seeds to Lantmännen consisting of grains, peas and beans are used to answer the research questions.

By constructing a common quality measure and using preexisting standards on germination capacity and water content, a fixed effect model is used to estimate the impacts of the different payment schemes. Results show that the linear payment scheme for pulses (peas and beans) leads to approximately 15 percentage points drop in quality compared to that used for grains when the common quality measure is used. Germination capacity is reduced by 5 percentage points and the probability of reaching the desired water content is 20 percent lower for pulses. The result for the bonus schemes are inconclusive, possibly explained by the lack of data. This information is useful for Lantmännen or other seed buyers to evaluate their current payment schemes. Lantmännen may want to improve quality and reduce costs efficiently and this study aims to assist them with making decisions when drawing contracts in the future.

The outline of this paper is as follows: A background on the seed market, quality parameters and incentives schemes is followed by a general presentation of theory on contracts and moral hazards. Next, a literature review on the topics of contracts and moral hazard with focus on performance of payment schemes and applications of these in an agricultural setting. Then an overview and summary statistics of the data used in this research is presented. The model and method is presented before the estimation results. The result is followed by a discussion and finally conclusions and suggestions for further research.

2. Seed market, quality parameters & incentives schemes

As in any business operation, contracts between buyer and seller in the agricultural industry play an important role for both parties. Farmers are interested in securing the price for the whole or a part of the harvest, while the buyers want to ensure deliveries of a certain magnitude and quality. Different incentive schemes can be included in the contracts to ensure the preferred product reaches the buyers. A common farming practice is to grow crops intended for food and feed in conjunction with those intended for seeds. Seeds are the embryo of plants and in the context of this study, used as the input in coming years farming, hence the crop is grown for this purpose and yields are not intended for the food industry even if it is edible.

The production of seeds serves many purposes. Among them are to secure the required inputs for production in the coming seasons and additionally, to breed and increase the stock of new crop varieties. Because the production of seeds play an important role in food security and samples of new breeds being highly valuable, regulations have been established to reduce the risks. Examples of risks include weed spreading and avoiding the degradation of crop varieties. The European Union assumes responsibility in regulating the marketing of plant reproductive material of agricultural, vegetable, forest, fruit, ornamental species and vines. Trade with these products may only be performed with EU certified products. The focus of this study will be solely on seeds used in the agricultural business.

Tests are performed on seeds before it receives its certification enabling it to be marketed within the EU. The procedure of these tests is determined by International Seed Testing Association. Prior to harvest, farms are inspected to ensure that seed production is done at locations that meet certain criteria such as historical prevalence of weeds and proximity to other crops. The growing crop is also inspected and the amount of weed and foreign plants is recorded. If the requirements are met, the seed can be delivered for further analysis. A sample is collected from each delivery and controlled for content of seeds of other species, germination capacity, hard seeds and weight of pure seeds. The presence of high risk weeds is also examined (Jordbruksverket, 2017).

If the minimum requirements are met, seeds get certified and can enter the European market. However, buyers such as Lantmännen tend to pay a price premium for certified seeds of superior quality. The quality parameters are linked to those used for certification were for example grains are valued on the basis of presence of foreign seeds, with zero awarding the highest premium with a price deduction from the base price for each additional foreign seed. Seeds of pulses are instead valued by germination capacity with a higher percentage being awarded the most. The payment structure for the quality parameters are presented in a matrix for the farmer before the contract is signed. Some species considered to be extra valuable gives an extra price premium which is added either when a certain quality standard is met or directly at the base price.

3. Contracts & Moral Hazard

The practical implication for a seed buyer to monitor the work done at a farm level has given rise to asymmetric information. The relationship between the farmer and the seed buyer could be viewed as a principal agent problem where the seed buyer acts as the principal and the farmer as the agent. By modifying Mirrlees (1976) models on uncertainty, Holmström (1979) built his theory on moral hazard when observing the agent's action is not possible. His main findings are presented in this section.

3.1 Moral Hazard

The principal's payoff depends on the agent's action; however, the principal can only observe the outcome. Therefore, the principal wants to come up with a contract consisting of an incentive scheme based on the agent's constraint arising from its optimizing behavior. Because the asymmetric information arises after the contract is signed, it becomes a Moral Hazard problem where the output is assumed to be dependent on the agent's action and chance, hence the agent can affect the probability distribution of output by taking certain actions. But the principal cannot observe the actions; hence, the payment to the agent is only dependent on output. Under partial information the principles expected profit and the agents expected utility are given by (1) and (2) respectively.

$$\sum_{i=1}^{n}(x_i - s_i)\pi_{ij} \qquad (1)$$

$$\sum_{i=1}^{n} u(s_i)\pi_{ij} - c_j \qquad (2)$$

Where x_i is the observed output i, s_i the payment for output i and π_{ij} the probability of output i if action j is taken. The agent's utility of payment $u(s_i)$ is assumed to be in the form of Von Neumann–Morgenstern utility function and c_j is the cost for the agent to take the action j. The participation constrain (3) ensures that the agent will take part of the scheme with the expected utility being higher than a base level utility $\bar{u}$ from not participating, while the incentive compatibility constraint (4) makes the agent take the principal's desired action j over action k.

$$\sum_{i=1}^{n} u(s_i)\pi_{ij} - c_j > \bar{u} \qquad (3)$$

$$\sum_{i=1}^{n} u(s_i)\pi_{ij} - c_j > \sum_{i=1}^{n} u(s_i)\pi_{ik} - c_k \qquad (4)$$

The maximizing problem for the principal is therefore given by (1) subject to (3) and (4). Taking the first order conditions, the expression can be simplified to (5) were Λ is the shadow price of the participation constraint the ɥ the shadow price of the incentive compatibility constraint.

$$\frac{1}{u\prime(s_i)} = \Lambda + ɥ(1 - \frac{\pi_{ik}}{\pi_{ij}}) \qquad (5)$$

It is reasonable to assume that $\Lambda > 0$, but if $ɥ = 0$ it can be shown that if the action preferred by the principal also is the low cost action for the agent there is no need for an incentive scheme, thus if for example pride is of great importance to the farmer, higher payment for quality should not change the actions taken.

4. Literature review

The following chapter begins with highlighting important literature on the subject of contracts and moral hazard in general and focuses in onto applications of this in agricultural economics. The chapter concludes with views on what affects crop quality.

4.1 The optimal contract

Holmström & Milgrom (1987) emphasizes that real world contracts are seldom refined as predicted by theory due to their complexities. By using basic assumptions of the principal's and agent's preferences they show that the first best solution is to pay the agent a fixed wage with the exception of a very low output, in which a low wage would be paid instead. However, they argue that this model performs very poorly if the assumptions are not met. Alternatively, the authors show that an incentive scheme based on output with linear payments leads to a more desirable effort over time. If the principal agent relationship is extended over time, randomness can be neglected if the desired effort is put in every time and compensation can be based on average performance instead as long as it is close to the desired level, Sappington (1991) argues. By doing so, the risk can be completely shifted from the agent to the principal. However this may induce the Ratchet effect, giving the agent low incentives to exceed previous year's performance even if it could be accomplished with low effort (Bevan & Hood, 2006). Herweg, Müller & Weinschenk (2010) found that the simple lump sum bonus scheme is preferred if the agent's risk preferences is driven by loss aversion. A payment scheme with multiple levels increases the uncertainty for the agent, where a realized low payment will be compared to higher possible payments causing an experience of loss, reducing expected utility leading to a demand for higher average payments.

4.2 Contracts and moral hazard in Agriculture

The need and performance of production contracts in agriculture have been discussed in the literature fairly extensively. Kelley (1994) argues that accessibility to markets is one factor for the farmer, but also risk management, for example guaranteed price eliminates the risk from volatile markets. The author further discusses that some risks may arise, such as failure to meet the contract standards resulting in the loss of premium prices. Allen & Lueck (1992) investigate how riskiness of a crop affects contract choice and found no such correlation, concluding that risk sharing is not important for contract choice. Ackerberg & Botticini (2002) address the problem of endogeneity in the matching between agent and contractor that may be present in Allen and Lueck's study and found that when controlling for endogenous matching, risk sharing is indeed important in the choice of contract.

The moral hazard issue in agricultural contracts is discussed by Goodhue (1999) where it may arise when product quality is affected by grower decisions. By controlling input decisions the incentive payments can be reduced Goodhue argues. It is also argued that due to the business structure, farmers are likely to be risk averse, hence income variability is costly. Hennessy & Moschini (2001) confirm in their review that there is evidence of farmers being risk averse and that preferences probably follow a diminishing absolute risk aversion (DARA) utility function. Horowitz & Lichtenberg (1993) investigate the presence of moral hazard when farmers have crop insurance. Their findings exhibit that farmers with insurance spend more on fertilizer and pesticides than those who are uninsured, suggesting that these are risk-increasing inputs. However their findings are considered contrary by Smith & Goodwin (1996), who shows that insurance lead to less chemical input. Coble et al. (1997) investigated the input decisions of crop insured wheat farmers and found evidence that moral hazard occurs in bad years but no significant effect in favorable years.

Unfortunately, the research on role of quality parameters in agricultural contracts is not as extensive. Hueth & Ligon (1999) investigate contracts based on quality in tomato farming and show that in a joint venture agreement, the agent faces 47 percent of the price risk. In poultry, other contractual forms exist. Payment schemes based on broiler chicken growers performance relative to other growers is researched by Knoeber & Thurman (1995). Due to the structure of these contracts, production and price risk is partly shifted from the grower to the integrator companies, but they conclude that price risk (84 percent) is still the main contributor of risk to the grower. The agreed upon contract between the principal and agent in an agricultural setting is one method for the farmer to handle risk. To handle quantity and quality risk emerging from the stochastic output, farmers may use the discussed financial instruments such as hedging and insurance, but also diversification. Hanson et al. (2004) found that organic farmers in Wisconsin had re-introduced livestock, making it possible to use crops as feed instead in the event of loss in crop quality and value. MacLeod & Moller (2006) found that since the 1960's, agriculture in New Zealand has primarily intensified immensely, but also diversified into other sectors such as forestry and deer farming. Barnes *et al.*(2015) show that diversified agricultural businesses in Sweden and Scotland achieve a higher viability than those who elect to specialize.

4.3 Factors affecting quality

The output's dependence on stochastic factors makes agricultural production unique. The production variability comes from factors such as weather and pests and can vary from regions and different farms (Just & Pope, 2001). Problems from characterizing technically efficient decisions comes from tracking the impact of any input at a specific time during the growing season on the final harvest when random events occur continuously during the same period (ibid.). From this methodical concerns are raised when performing estimations, such as use of aggregate data and availability of inter seasonal input choices.

Although estimations of agricultural techniques can be problematic, some can be said about how the seed quality is affected by external and internal factors. Internal factors are linked to farm management and techniques used. The presence of foreign seeds can be caused by remains from previous cropping in the field, seeds in the manure, contaminated machinery and leakage from drier. These factors can in great extent be handled through management, such as proper crop rotation, pesticide usage, cleaning and machinery maintenance. Internal factors affecting germination capacity are rough handling during and after harvest, storage time and high drying temperatures. Compared to foreign seeds, germination capacity is to a larger extent affected by external factors such as a too dry or too wet fall, seed water content, uneven crop, fungi pests and lodging. Water content is primarily determined by internal factors where on-site measuring equipment can indicate when drying should be continued or stopped. Unfortunately, due to the high costs of these instruments, farmers commonly elect to use low cost alternatives which result in seeds that are either too dry or too wet. Motivations for the grower to deliver high quality products differ, but the consensus in the industry is that larger growers in general tend to focus more on the financial aspects while smaller growers generally value the pride of delivering products of higher quality (Gillsjö, G. 2018, email, 7 Dec).

5. Data

The data exhibited in this research has been generously provided from Lantmännen therefore no formal publication has been used. It consists of laboratory test results on seed deliveries along with some limited information on the farmer. It’s unbalanced panel data ranging from 2014 to 2018. It is unbalanced in three ways: first that every delivery is specified to a certain date and naturally all producers don’t deliver at the same date; second, every batch gets tested and is of approximately the same size leading to big producers getting more observations each year; third, not all producers deliver every year within the data time range. The information on the producer is limited to an identification number, address, contracted quantity and delivered quantity along with the specific variety delivered. The laboratory test results consist of a wide range of measures where the quality indicators of interest are number of foreign seeds, germination capacity and water content. Germination capacity and water content is measured for both grain and pulses while foreign seeds are only measured for grains. Foreign seeds are a simple count in the form of integers ranging from 0 and up. Germination capacity is the number of seeds in a population able to complete germination while water content is the water content of the seed and both are given in percentages. The raw data consists of observations on all kinds of crop, and when limiting it to only grains and pulses the number of observations is circa 18000 distributed over barely 600 producers with missing values mainly for the measurement of foreign seeds. Observations on grain are highly over represented with only roughly 1700 observations being on pulses which is a reflection of the general agricultural production in Sweden. The sample is representative for the entire population since Lantmännen is the distributer for around 60 percent of all seed growers in Sweden. A summary of the data is shown in Table 1.

Table 1: Summary statistics. Notable is the fewer observations of foreign seeds compared to other variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Foreign Seeds	13.286	2.7	14.5	0	752
Germination Capacity	17.828	95.3	4.9	3	100
Water Content	17.615	13.3	1.5	0	28
Contracted Quantity	18.138	332158.4	457110.9	0	3900000

There are some limitations present in the data. It would be ideal that more detailed data on the individual farmer such as wealth and financial indicators and also income distribution over activities if diversified to get a precise measure of risk awareness. With external factors impacting quality being linked to weather, data on local weather condition may strengthen the set. For more complete results, foreign seeds should also be measured for pulses. The endogeneity issue discussed by Ackerberg and Botticini (2002) is likely present since only the growers associated with Lantmännen are in the data sample and when they are making the decision on varieties grown. Although balanced panel data would be preferred in this study, it is not possible in practice and furthermore a more even distribution between grains and pulses would require an additional country or more to be researched. A final comment could be made on the reliability of the data since it’s from an enterprise with financial interest in the test results, however tampering with results is a criminal act and control programs are in place to prevent this from happening.

6. Model & Method

The general model used for estimations is constructed based on what was learned in the literature review and represented by equation (6) where β_0 is the intercept and ε_{it} the error term.

$$Quality_{it} = \beta_0 + \beta_1 P_{it} + \beta_2 B_{it} + \beta_3 C_i + \beta_4 D_i + \beta_5 F_i + \beta_6 R_{it} + \varepsilon_{it} \tag{6}$$

The model uses $Quality_{it}$ as the dependent variable and represents the quality parameter of interest for the batch delivered by farmer i at time t. Three measures of quality is used: germination capacity, water content and a common measure between foreign seeds and germination capacity based on the payment received for the specific indicator. The last measure is constructed for this research and the principle for determining the value of $Quality_{it}$ is shown in Table 2. The reason for doing this is due to grains and pulses not being evaluated by the same measure.

Table 2: The construction of a common quality measure based on payment scheme. For example a delivery of grains with 1 foreign seed or a delivery of pulses with germination capacity 99% generates the quality 98%.

Germination Capcity (Pulses)	Quality (% of Base Price)	Foreign seeds (Grains)	Quality (% of Base Price)
<85%	0%	>9	0%
85%	69%	9	5%
86%	71%	8	10%
87%	73%	7	25%
88%	75%	6	35%
89%	77%	5	50%
90%	79%	4	65%
91%	81%	3	80%
92%	83%	2	95%
93%	86%	1	98%
94%	88%	0	100%
95%	90%		
96%	92%		
97%	94%		
98%	96%		
99%	98%		
100%	100%		

The measure for water content is reconstructed to a dummy variable with value one if in the premium interval and 0 otherwise to better reflect when a desired quality is achieved. For grains the premium of 30 SEK/ton is received when the analysis show a value between 12.5% and 14 % and for pulses 50 SEK/ton is received when the analysis show a value between 16% and 17.5 %. When germination capacity is used as dependent variable, no changes are done to it since this measure is comparable between grains and pulses (higher the better).

The two independent variables of main interest are P_{it} and B_{it}. The first is a dummy variable taking the value one if the delivery is a variety of pulses and zero otherwise; hence it is an indicator on what payment scheme is used. The first two columns in Table 2 show that for every percentage point drop in germination capacity, there is a deduction from base price by 2 – 3 percentage points, hence the payment scheme for pulses is linear. The third and fourth column in Table 2 exhibit a more discontinuous scheme for grains, with a large deduction from the base price when, for example, increasing the number of foreign seeds from two to three.

Based on the Moschini and Hennessy (2001) discussion, farmers being risk averse should give them incentive to put more effort when growing grains to achieve a lower count of foreign seeds. This is to avoid the fast decline in payments when more than two foreign seeds are present. Müller and Weinschenk's (2010) conclusion could also be applicable if the farmers are loss averse, where the payment scheme for grains mimics a lump sum scheme more whereas pulses have more levels with less loss for every decline in quality. Therefore, when using the common quality measure as dependent variable, β_1 is expected to be negative. When germination capacity is dependent there is more uncertainty. If farmers are not driven by pride there is no incentive to deliver high germination capacity for grains, hence the coefficient should be positive. If pride is an important factor it should instead be insignificant or close to zero. These expectations do also vary with the size of farm, as stated in the literature review. Using the water content dummy as dependent should lead to a positive β_1 because of the higher premium received.

B_{it} is a collection of seven dummy variables indicating if the delivery consists of a variety of extra value. The varieties in scheme called "F-A" receive an extra bonus if holding certain quality (again, foreign seeds for grain and germination capacity for pulses) and the coefficient is therefore expected to be positive when the common quality measure and germination capacity is used while for water content no significant effect is expected. The rest of the bonuses only applies to grain varieties and are added to the base price. Therefore, they are expected to have no significant effect on quality if the model doesn't suffer from matching issues discussed by Ackerberg and Botticini (2002).

The control variables C_i and D_i are proxies for wealth and diversification respectively. The value for C_i is computed by taking the maximum contracted quantity for farmer i in the entire sample. The reason for the usage of max instead of the actual value is due to the assumption made that wealth does not vary greatly during the time period. If low quantity is observed in one year and then higher in another, it is assumed that the change in land use and production drives this factor instead of gains in wealth. If farmers have DARA as stated by Moschini and Hennessy (2001), the coefficient is expected to be negative for C_i, particularly if smaller farmers have a greater focus on delivering high quality. This should hold for the common measure and germination capacity, while water content being affected by investment costs, it could therefore be positive. The method for computing D_i is to count the number of unique varieties delivered by farmer i in the entire sample and is intended to show the willingness to try new production. Along with Barnes *et al*. (2015) conclusion, it is assumed that diversification spreads risk and the incentive for high quality is therefore lower, hence the coefficient is expected to be negative.

To capture the individual effects on quality from farm management practices F_i is used in the model. A Hausman test show that the null hypothesis, that random effects are the appropriate model, cannot be rejected. However it is unlikely the group means of the farmers are random and it is unreasonable to assume that the unobserved factors are independent of wealth and diversity. A fixed effect model is therefore used for estimation. The external factors affecting quality are captured by R_{it}. It is an interaction variable between region of farmer i and time t. The region is extracted from the first number of the farmer's post code hence Sweden is divided into nine regions. In the raw data time is given as a specific date, which is transformed to only be years for the estimations. R_{it} hence captures time varying regional differences, mainly weather conditions and pest infestations.

The model is estimated using Ordinary Least Squares and a Breausch-Pagan test for heteroscedasticity rejects the null that the data have constant variance and therefore robust standard errors is used along with fixed effects. Nine regressions are performed in total, three on the entire sample with the common quality measure, germination capacity and water content as the dependent variable respectively. For robustness check, three regressions are performed when excluding farms with a maximum contracted quantity above average and three when only farmers who have grown both grains and pulses during the time range is included. The first three robustness checks examines if the model fit all farmers no matter wealth or if there are differences in how smaller farms as a group handle risk. The three remaining robustness checks serves to see if a sample with only farmers that have been subject to both payment schemes during the time period changes the result compared to when fully specialized farmers are included in the main estimations.

The model could suffer from endogeneity in various ways. The variation in quality captured by P_{it} could be explained by the characteristics of the crop itself and as mentioned afore, B_{it} could suffer from the matching issues considered by Ackerberg and Botticini (2002). Pride and DARA are expected to be working in the same direction, and problems may therefore occur to extinguish these when the common quality measure is used as dependent variable. The proxy for diversity may instead act as a proxy for specialization in seed production, giving the opposite sign of the coefficient. Dividing Sweden into nine regions may be a too broad specification to capture local weather conditions and pest infestations.

7. Results

The results from the regressions described in model and method section are shown in Table 3.

Table 3: Estimation of coefficients using Common quality, germination capacity and water content as dependent variable on three different samples.

	Full Sample			Quantity < Mean			Farmers growing both Grains and Pulses		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Common Quality	Germination Capacity	Water Content	Common Quality	Germination Capacity	Water Content	Common Quality	Germination Capacity	Water Content
Payment Scheme	-15.310***	-5.001***	-0.203***	-15.139***	-4.694***	-0.196***	-15.216***	-5.026***	-0.208***
	(1.137)	(0.247)	(0.021)	(1.208)	(0.255)	(0.022)	(1.141)	(0.249)	(0.022)
Max Contracted Quantity	0.000	-0.000	0.000	-0.000***	-0.000***	0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Diversity	-9.534***	-2.227***	0.116	-1.576***	-0.180	0.081	-2.513	0.505	-0.034
	(2.017)	(0.554)	(0.189)	(0.544)	(0.230)	(0.068)	(2.065)	(0.604)	(0.059)
Bonus Schemes:									
F-A	6.375	1.525***	0.041	5.983	1.361***	0.019	9.070	3.208***	-0.058
	(3.955)	(0.487)	(0.068)	(4.060)	(0.486)	(0.066)	(7.937)	(0.898)	(0.105)
Wheat 15 %	3.708*	1.376***	0.116***	3.660*	1.868***	0.108***	5.793**	1.460***	0.081**
	(1.913)	(0.211)	(0.027)	(1.945)	(0.213)	(0.028)	(2.465)	(0.282)	(0.034)
Oats 15 %	5.927**	-0.780***	-0.128***	6.121**	-0.648**	-0.114***	3.640	0.188	-0.270***
	(2.702)	(0.280)	(0.041)	(2.716)	(0.272)	(0.042)	(4.996)	(0.534)	(0.071)
Barley 10 %	-8.719***	1.903***	-0.003	-8.583***	1.949***	0.001	-10.509***	1.415***	-0.044
	(2.486)	(0.200)	(0.028)	(2.501)	(0.203)	(0.029)	(3.374)	(0.281)	(0.043)
Barley 20 %	-9.464***	0.969***	-0.053*	-9.079***	0.926***	-0.013	-10.585***	0.696	-0.016
	(2.121)	(0.319)	(0.029)	(2.294)	(0.349)	(0.030)	(3.456)	(0.488)	(0.043)
Barley 30 %	3.501**	2.730***	0.043	3.087	2.585***	0.019	6.204***	5.294***	-0.125***
	(1.663)	(0.459)	(0.103)	(1.896)	(0.477)	(0.106)	(1.829)	(0.400)	(0.030)
Rye 30 %	5.218	-0.208	-0.224	1.043	-0.725	-0.305*	omitted	omitted	omitted
	(3.383)	(0.757)	(0.161)	(3.495)	(0.753)	(0.163)			
Constant	138.077***	109.428***	0.318	113.613***	103.033***	0.506	117.380***	101.054***	0.568
	(9.329)	(2.770)	(1.039)	(3.967)	(1.434)	(0.550)	(18.694)	(9.303)	(0.872)
Observations	14,645	17,822	17,608	11,335	13,385	13,051	7,195	8,490	8,125
R-squared	0.277	0.380	0.274	0.301	0.385	0.298	0.237	0.370	0.264

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dummy variable for payment scheme is significant at one percent level across all models. When inspecting the coefficient in column (1) where the common quality measure is used as dependent variable, it indicates that pulses on average have 15.31 percentage points lower quality than grains in terms of deduction from base price. The sign is therefore as anticipated and supports Moschini and Hennessy (2001), that farmers are risk averse. It could also be a sign of loss aversion among farmers if the payment schemes are comparable to those discussed by Müller and Weinschenk (2001). Sticking to the coefficient for payment scheme while observing column (2) where germination capacity is dependent the sign is still as before while the magnitude has changed. On average, pulses have five percentage points lower germination capacity than grains even though the incentive schemes is only based on this measure for pulses. This is the contrary to the expectations and could be explained by natural differences in the crop and/or pride amongst farmers. When water content is dependent in column (3), the probability of receiving the premium is 20 % lower for pulses than for grains, Ceteris Paribus. This is contradicting the expectation which were based on the differences in payments for grains and pulses. When the sample is modified there are no major changes in the magnitude of the coefficient for payment scheme. For the common quality measure the magnitude decreases slightly in absolute terms while the largest variation can be seen for germination capacity when the farmers with a contracted quantity less than the mean is used.

The estimated coefficients for the bonus schemes given to certain varieties vary in significance between used sample and dependent variable. Beginning with F-A which is based on quality delivered, it is not significant when neither common quality nor water content is dependent. The latter is as expected while the former is puzzling, especially since it is positive and significant when germination capacity is dependent. This could be a sign of weakness in the construction of the common measure. The magnitude of the coefficient also varies across samples when germination capacity is used. It nearly doubles in value when only farmers that have grown both grains and pulses are included in the sample. In this specification a variety of F-A has on average 3.2 percentage points higher germination capacity.

The remaining bonus schemes are added as a percentage to the base price and were therefore anticipated to not be significant, but as can be seen in Table 3, this is not the case for many of them. For the extra valuable wheat varieties the coefficient is significant for all models and samples but at different confidence intervals. The magnitude also varies between the samples but the pattern is different from F-A's. The unpredictable pattern is also found in the not yet discussed bonus schemes where the most notable changes are found in Oats 15 percent and Barley 10 – 20 percent. Here the coefficient changes sign depending on which dependent variable is used and specified sample. A general explanation to the great variation in the significance, sign and magnitude amongst the bonus scheme could be the small number of observations of these. Considering for example Rye at 30 percent, it gets omitted due to collinearity in the specification for columns (7)-(9). Some signs of endogeneity issues can be found when focusing solely on germination capacity as the dependent variable. With the exception for Oats, all other coefficients are significant and positive across the samples even though no extra payment is made to the farmer as a result of this. This could support issues with matching discussed by Ackerberg and Botticini (2002), hence high performing farmers enters contracts with valuable crops.

The proxy for wealth, Max Contracted Quantity is only significant when the smaller farms are included and then only when the common measure and germination capacity is the dependent variable as shown in column (4) and (5). However the magnitude is the same across all specifications with small variations around zero. The sign of the coefficient was expected to be negative when the common measure and germination capacity are used as dependent variable while there is little to support this in the results. Even though it is negative in column (4) and (5) it’s ambiguous to draw any conclusions on whether farmers have DARA or pride in their production. If they do however the results show it is of small magnitude.

In column (1), (2) and (4), diversity is significant and negative as expected. When using the full sample, growing one more seed crop leads to an average decrease in common quality by 9.5 percentage points while there is a great leap when only examining the smaller farms. Here the quality drop is only 1.6 percentage units, indicating that diversity and in extension spreading risks matters less in a small farm perspective. The decrease in magnitude between (1) and (2) follows the same patterns as for payment scheme.

Some comments can be made on the explanatory power of the models. Throughout the specifications, germination capacity as the dependent variable have the highest R-squared ranging from 0.370 – 0.385. Only including smaller farms in the sample gives the overall highest R-squared while only including farms with both grains and pulses gives the lowest. The relatively low R-squared could also explain the intercept higher than 100 for models using common measure and germination capacity. These indicators only range from 0 – 100 making the value of the intercept unintuitive. Table 3 also show that the foreign seeds measure suffer from missing values, explaining the gap in observations between the common quality measure and the other dependent variables which is present no matter what sample is used.

7. Discussion

The estimations show that there is a clear difference in quality depending on whether grains or pulses are grown. The lower qualities among pulse deliveries may come from the payment scheme used whereas the linear schemes do not give incentives enough deliver a high quality product. This could be driven by risk aversion and loss aversion in accordance with the findings proposed by Moschini and Hennessy (2001) and Müller and Weinschenk (2001). If contracts were long term, expanding over several years, this pattern could however shift as discussed by Holmstrom and Milgrom (1987). It is important to note that the magnitude of the quality difference is uncertain and if it leads to implications for the current contract structure. If it is indeed driven by risk and loss aversion in conjunction with assuming that the optimal quality is not delivered, it would require Lantmännen to revise the structure of payments for pulses and put more weight on higher quality levels. If the explanation lies within the difference of natural characteristics in the crop such a change could instead lead to the price risk being shifted towards the grower. This is an important factor for the farmer according to Ackerberg and Botticini (2002) and problems could therefore lead to difficulties for the contractor to find growers willing to produce on these terms. Some brief comments can be made on the premium for water content. The simple expectation of a high premium leading to the right water content did not find support in the estimations. Either the premium is too low to weigh up the costs or other factors such as knowledge are of greater importance for improvement.

It can be suspected that the magnitude of natural crop differences lies in the estimated coefficients when germination capacity is the dependent variable. This may be the first-difference of pulses but since it is also perfectly correlated with the payment scheme evaluated, this model has issues in determining the causal effect. This problem spills over on the common quality measure constructed for this research and it is therefore not unreasonable to assume that the effect of the payment scheme is overestimated. However the strength of the common measure is that is constructed from the base price deductions. Assuming that the base price is exogenous and includes factors such as natural differences affecting production costs and riskiness this measure could indeed be used to make performance evaluations between the two payment schemes. To improve the estimations and avoiding the collinearity between payment scheme and natural traits of pulses, further analysis should be made on a data sample that have different incentive programs between grains and pulses but also in-between these crops as well. A suggestion would be to merge data from more seed buyers than just Lantmännen.

When overviewing the estimations on how bonus schemes effect quality, the most notable result is that of F-A. It only being significant for germination capacity is unclear. If it would have an impact on foreign seeds it should show when the common measure is the dependent variable but instead it only improves germination capacity. This is contradicting in two ways; first, grains do not receive the bonus based on germination capacity. Second, grains are highly overrepresented in the sample so few observations on F-A grains with unchanged germination capacity while many observations on F-A pulses with improved germination capacity leading to this result alone is unlikely. Endogeneity issues from matching may explain the increased germination capacity but oddly these high performing farmers do not reduce foreign seeds at the same time. It could be that the bonus payments do not give enough incentives to improve quality but this needs further analysis to say if it is appropriate to draw up new terms in the contracts for growing F-A crops. The estimated coefficient for the other bonus schemes also delivered ambiguous result but did show signs of endogeneity due to matching. Too few observations on these bonuses are suspected to be the main factor for the inconclusive results and would therefore also benefit from further analysis when including lab results from more seed buyers.

The estimations on how wealth affects quality do not support the study by Moschini and Hennessy (2001) where farmers have DARA. Neither does it indicate evidence of pride varying with wealth although it should be noted that these were expected to affect quality in the same way. If the number of different seed crops a farmer have grown during 2014-2018 is a good proxy for diversification, the estimation do show that diversifying leads to a decreased quality. Explanations for this is the improved viability shown by Barnes et al. (2015) driven by risk spreading making the farmer less reliable on payments from high quality. Not surprising, the models did not give rise to a high explanatory power. Proxies for wealth and diversification along with the farm- and time/region fixed effects are insufficient to explain variations in seed quality. Appropriate measures of local conditions could replace the time/region fixed effects and more extensive data on individual farm traits may improve the measure on key factors affecting quality in a more refined model and in return yield a higher explanatory power. This should however be done with caution, having Just and Pope's (2001) discussion in mind.

8. Conclusion

How quality varies as a result of payments schemes have been examined in this paper. The purpose of this research was to answer the questions "how seed quality differs between a linear payment scheme and a discontinuous payment scheme and if a bonus scheme for varieties of higher value to the buyer gives the farmer an incentive to deliver higher quality?" along with "if a higher premium for reaching desired water content increases the probability of doing so?". Seed quality is on average 15 percentage points lower for the linear scheme when a common quality measure based on payment of base price is the dependent variable. When germination capacity is the quality indicator, quality is only five percentage units lower for the linear scheme which. The probability of reaching the appropriate water content is 20 % lower for pulses even though the payment is higher than for grains. The effect of the bonus schemes is ambiguous but show signs of matching issues with high performing farmers growing more valuable crops. The only bonus scheme that was based on quality showed no sign or little sign of improving delivered quality.

Some problems with the estimations have been discussed and this also opens up opportunities for further research. The problem of distinguishing the causal effect of the linear payment scheme and the natural differences between grains and pulses have been raised and if data were to be obtained from several different seed buyers applying different payment scheme between and within grains and pulses a model with better precision could be estimated. The research would preferably also include data on local weather conditions and pest infestations along with farm characteristics data. This would most likely also help to solve the problem of ambiguous results on the effect of bonus schemes.

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