afbi Agri-Food and Biosciences Institute

Agricultural and Food Economics

Willingness of Producers to Collaborate within the Supply Chain: Survey of Beef Finishers in Northern Ireland

Undertaken as part of the DAERA E&I project:

'Examination of agri-food supply chain structures and performance to enhance competitiveness'

Siyi Feng, Myles Patton and Diane Burgess

Executive Summary

Enhanced co-ordination across parties within agri-food supply chains, *i.e.* producers, processors and retailers, is regarded as desirable so as to respond to consumers' demands for product quality and safety (Duffy R. and A. Fearne, 2006). One means of attaining collaboration is through the use of contracts. Contracts provide components of the supply chain closer to the consumer, i.e. retailers and processors, a channel to enforce a greater level of control along the supply chain compared to spot markets. In return for transferring some aspects of control, farmers gain in terms of improved assurances concerning access to markets or inputs and lower risk (Hobbs and Young, 2001). However, the growth in the use of contracts varies across sectors and tends to be more prevalent in the pig and poultry sectors compared to the beef sector. The purpose of this study is to gain a better understanding of producers' attitudes towards co-ordination arrangements and identify the attributes in verbal and written contracts that may encourage greater participation.

The analysis is based on a face-to-face survey, which was carried out on respondents who were selected using stratified sampling among beef finishers in Northern Ireland. This yielded survey data of 201 beef finishers. The analysis consisted of two components:

I. An examination of producers' willingness to participate in contracts within the beef supply chain. Regression analysis was undertaken to determine the farm and socio-economic characteristics that influence producers' decisions to participate (or not) in a contract (both verbal and written) with a processor/retailer.
II. The importance of individual contract attributes in determining the preference for a particular type of contract. This was assessed using choice experiment data collected as part of the survey.

Results

(i) Factors contributing to producers' willingness to participate in contracts

The following variables all contribute positively and statistically significantly to the likelihood of participation in contracts with downstream buyers:

- Education,
- Farm size,
- Higher percentage of farm income from beef; and
- Specialisation in particular breeds.

The results indicate that that larger farms and more specialised farms are more likely to participate or willing to participate in collaboration with downstream buyers. Also, farmers with higher educational attainments are also more likely to participate in collaboration arrangements.

(ii) Importance of individual contract attributes in determining the preference for a particular type of contract

The importance of individual contract attributes in determining the decision to choose a particular type of contract is assessed using choice experiment data. Within the choice experiment, producers were presented with choice tasks based on four different contract features, with three different levels (Table ES1).

Table ES1: Attributes and their levels of contracts in the choice experiment

	Attributes		
	Level 1	Level 2	Level 3
Price and production requirement	Spot market price	Minimum price guarantee	Minimum price guarantee plus 5% price premium if feed requirements are met
Annual volume requirement and possible delivery schedule	Min. vol. requirement of 10 cattle per annum	Min. vol. requirement of 50 cattle per annum	Min. vol. requirement of 50 cattle per annum, combined with delivery schedule
Data sharing provided by downstream buyer	General advice	General advice and quarterly data feedback	General advice and weekly data feedback
Form of agreement	Verbal agreement	1 year written contract	3 year written contract

Based on regression analysis using the choice experiment data the results indicate the following:

- **Price and production requirement**

  A pricing system based on a minimum price guarantee is not viewed favourably by farmers. This contrasts with a price premium system that is accompanied with a feed requirement, which is valued positively. The attractiveness of the latter is significantly greater for larger farms.

- **Annual volume requirement and possible delivery schedule**

  Overall, farmers dislike minimum volume requirements, particularly if this is accompanied with specified delivery schedules. However, the dislike for these attributes diminishes with farm size.

- **Data sharing provided by downstream buyers**

  In general, most farmers view data sharing initiatives unfavourably. However, farmers with A-level qualifications or above value such initiatives in a positive manner.

- **Form of agreement**

  Overall, farmers view the requirement of a written contract negatively compared to a verbal agreement, particularly longer-term contracts. However, those who have experience of enrolling in agri-environmental schemes do not dislike written contracts to the same extent as those who have no such experience.

From a policy perspective, the results on the whole support the role of education in positively influencing farmers' attitudes towards collaboration, both in terms of the likelihood of participating in supply chain collaboration arrangements and their perception of important contract attributes such as data sharing. Other studies have shown the importance of this attribute not only in terms of improving the production efficiency of farms over time, but also on enhancing the level of trust within supply chain relationships, and hence, it is desirable to draw attention to the benefits of such data sharing arrangements. It is also notable that producers who have actual experience of enrolment in written contracts in their farming enterprise (through agri-environmental schemes) are more open to engaging in formal supply chain collaborations. This suggests that overtime if it can be demonstrated that supply chain collaborations can be successful and to the

mutual benefit of all partners, it should be possible to build up a greater level of trust between farmers and downstream partners and encourage more collaboration in the future.

Willingness of Producers to Collaborate within the Supply Chain: Survey of Beef Finishers in Northern Ireland

Siyi Feng, Myles Patton and Diane Burgess

1 Introduction

The agri-food sector in Northern Ireland is faced with a diverse set of challenges and opportunities, including increasingly sophisticated consumer preferences; changing attitudes of society to food safety & integrity; health & nutrition concerns; along with biotechnology and information technology developments. In addition, the sector has experienced significant changes in terms of policy reforms, which have increased the influence of the market on production and reduced global trade barriers. The ability of the supply chain to respond to these challenges has been inhibited by the fragmented nature of the industry with a large number of small producers with diverse business objectives, a commodity culture and adversarial trading relationships throughout the supply chain (Schroeder and Kovanda, 2003).

Efforts have been made to enhance the level of coordination within UK agri-food supply chains (Duffy R. and A. Fearne, 2006). It is argued that improved co-ordination will facilitate information flows through the supply chain, enabling producers to make necessary changes to respond to consumer needs more effectively (Chambers and King, 2002). Moreover, greater co-ordination provides a means to offer consumers assurances on issues such as food safety, animal welfare and environmental factors. Within its strategic action plan to stimulate growth within the agri-food industry in Northern Ireland, the Agri-Food Strategy Board highlighted the need for collaboration and consolidation within the local agri-food supply chain. The Board recommended a change in mind set which ensures that: "each partner is working towards the same goal delivering a product that meets the needs of the marketplace rather than producing a product for which a market is subsequently sought" (Agri-Food Strategy Board, 2013).

In particular, contracts are increasingly being used to enhance coordination within agri-food supply chains. For example, within the US the share of the value of agricultural production covered by contracts in the US grew more markedly, rising from 11 per cent in 1969 to 35 per cent in 2013 (MacDonald, 2015). Essentially, contracts are agreements between contractors and producers, which specify conditions of producing and/or marketing of an agricultural product. Contracts provide components of the supply chain closer to the consumer, i.e. retailers and processors, a means to enforce a greater level of control compared to spot markets. In return for transferring some aspects of control,

farmers gain in terms of improved assurances concerning access to markets or inputs and lower risk (Hobbs and Young, 2001).

However, the growth in the use of contracts varies across sectors and tends to be more prevalent in the pig and poultry sectors compared to the beef sector. This partly reflects the independent mind set of beef farmers, who tend to be resistant to stricter forms of vertical coordination. Non-contractual long-term relationships have emerged to provide a middle ground between the spot market and formal contracts (Fearne, 1998). Essentially, this refers to the development of long-term relationships based on verbal agreements between two or more parties based on trust and mutual understanding, without the use of contractual obligations.

Given the need for greater co-operative behaviour between components of the beef supply chain, it is important to gain a better understanding of beef producers' attitudes towards collaboration. Using survey data of 201 beef finishers in Northern Ireland, this study examines producers' willingness to participate in contracts within the beef supply chain. Furthermore, the choice experiment method is used to design hypothetical agreements/contracts so as to examine attributes in agreements that may encourage farmers' to participate within closer vertical collaborations with downstream buyers.

The rest of the paper is organised as follow: Section 2 presents literature review; Section 3 describes design of the survey including the choice experiment, followed by results reported in Section 4. Finally, Section 5 concludes the paper.

2 Literature review

A range of studies have investigated farmers' attitudes toward closer collaboration / contracts. In most studies the focus has been on the reasons underlying farmers' participation in collaborations; especially in terms of identifying the perceived benefits or obstacles to participation (see Schlecht and Spiller, 2012 for a more detailed discussion). These studies draw on the fact that contracts and other marketing channels already co-exist and the specific forms of the contracts are readily available to researchers (for example, Boessen et al., 2010; Boger, 2001; and Schipmann and Qaim,2011). Hence, revealed preference methods (*i.e.* by data on actual marketing channel choice) or stated preference methods (*i.e.* by survey on the acceptability of the contracts) are used in this context.

Other studies have examined the particular attributes in contracts that would encourage or discourage farmers' participation in closer collaborations (for example, Schlecht and Spiller, 2012; Steiner *et al.* 2012). Both studies listed are hypothetical

studies as the question is investigated in the context where farmers are not familiar with arranging transactions with downstream buyers using contracts. Given the hypothetical nature (and also estimation reasons), the focus is limited to a rather small set of attributes. Schlecht and Spiller (2012) examines the dairy sector in Germany, while Steiner *et al*. (2012) investigates the beef sector in Canada.

Our study uses methods similar to Steiner *et al*. (2012), but focuses on a different stage of the supply chain. We study the stage at which finishers sell their cattle for slaughter, while Steiner *et al*. (2012) examines the cow-calf producers' participation in beef alliances, which is further away from the point at which the carcass quality is revealed. This adds complications to the problem of incentivising participation. In Steiner *et al*. (2012), profit sharing is used, which in turn implies that not only positive but also adverse risks will be shared. Therefore, conclusions from their study are not necessarily applicable to finishers. Moreover, the study of Steiner *et al*. (2012) is set in Canada, the beef sector of which is very different from that in Northern Ireland. Andersson and Nilsson (2009) investigate successful building blocks to the establishment of partnerships in the Irish beef sector, the context of which is very close to ours. However, this study is based on the qualitative case study method and cases chosen include partnerships of small producers (who supply on average 10 cattle per year) with a focus on premium breeds and partnerships of large producers (who supply on average 100-200 cattle per year). These producers are rather extreme cases when compared to the average of Northern Ireland.

3 Survey design

The survey questionnaire consists of four sections. The first and second sections primarily contain questions seeking information on the characteristics of the farm, including income from beef, specialisation of a particular breed, participation in benchmarking, *etc*. The third section contains a choice experiment on farmers' attitudes towards contracting in the beef sector. Finally, the fourth section focuses on characteristics of the respondent, such as their age, education level, *etc*.

The choice experiment method is used as contracting between farmers and downstream buyers is still rare in the beef sector. The choice experiment method is useful in this case as it enables the investigation of farmers' preferences over different hypothetical contracts, which in turn reveals farmers' preference for specific attributes and their levels. Given the technical nature of choice experiments (notably numerous combinations of attributes against limited number of respondents), it was necessary to focus on a restricted number of attributes, i.e. four, each with three levels. The four attributes included in the choice experiment are 1) pricing mechanism and production

requirement; 2) delivery; 3) data sharing systems; and 4) form of agreement (Table 1). The first levels of all the attributes are specified in a way that either resemble the on-going practice of the industry or involve limited restrictions on the practices of the farmers. The second and third levels either represent higher rewards or more stringent requirements or a combination of both, which would be a departure from the on-going practice of an independent producer who decides when and where to sell its cattle freely.

The three levels in the first contract attribute, *i.e.* pricing mechanism and production requirement, include 1) spot market; 2) minimum price guarantee; and 3) minimum price guarantee and 5% price premium if certain production requirements are met. The spot market resembles the *status quo*, while the minimum price guarantee may be regarded as a reward to producers to encourage participation in a collaboration agreement as it reduces the price risk they face. However, such a pricing system is only beneficial when beef price is low and therefore may be valued less when the beef price is high. The price premium, coupled with the production requirement, in the third level enables buyers to have greater control over the quality of the cattle and may be regarded as reward to producers if the price premium is sufficient to compensate the costs and the disutilities that the requirement brings. The second contract attribute specifies minimum volume requirements, with variable thresholds of at least 10 or 50 finished cattle per year. In addition, the third level of this attribute requires farmers to meet a delivery schedule. The third contract attribute is concerned with data sharing, ranging from the processor/retailer providing the farmer with general nutritional and management practice advice, to the sharing of detailed information on the performance of the individual farmers' cattle compared to the average for the processor, including weight, conformation score, fat score average value and deadweight/liveweight gain. Levels two and three of this attribute vary in terms of the frequency of feedback provided by a detailed information system. Finally, the fourth contract attribute refers to the type and length of contract, with level one consisting of an informal verbal agreement and levels two and three referring to a formal written contract. Levels 2 and three differ in terms of the duration of the written contract.

Discussions with personnel at the Livestock and Meat Commission in Northern Ireland and Quality Meat Scotland on the chosen attributes and levels were held to make sure they are reasonably realistic to the respondents.

If respondents are asked to identify their preferred choice between two alternatives, a full factorial design implies there are $3^4(3^4-1)=6480$ choice tasks. Instead, a fractional factorial design based on the D-optimal criteria is adopted (Hensher *et al*.

2015).[1] Initially, 20 sets of choice tasks consisting of two alternatives are generated in the Ngene software. Two sets of unrealistic combinations were eliminated. This results in 18 sets of choice tasks, which are then divided into 3 blocks. Hence, each respondent is given six sets of choice tasks in the survey. Also, an opt-out of "Neither 1 nor 2" is included in the choice tasks to avoid forced choice.

The use of D-optimal criteria requires prior knowledge of the parameter values and these are specified as positive or negative values very close to zero (such as $\pm$0.01) in this study. The sign is determined by expectation grounded in theory and in understanding of farmers' preference. For example, it is expected that the sign on data sharing is positive as better data availability may help herd management on farm. On the contrary, the sign or written contract is expected to be negative because farmers have strong preference for independence and would not like to be tied to a contract. Correlations among the levels of the attributes were checked and are close (but not equal) to zero.[2]

Table 1: Attributes and their levels of contracts in the choice experiment

	Attributes		
	Level 1	Level 2	Level 3
Price and production requirement	Spot market price	Minimum price guarantee	Minimum price guarantee plus 5% price premium if feed requirements are met
Annual volume requirement and possible delivery schedule	Min. vol. requirement of 10 cattle per annum	Min. vol. requirement of 50 cattle per annum	Min. vol. requirement of 50 cattle per annum, combined with delivery schedule
Data sharing provided by downstream buyer	General advice	General advice and quarterly data feedback	General advice and weekly data feedback
Form of agreement	Verbal agreement	1 year written contract	3 year written contract

[1] Fractional factorial designs are experimental designs consisting of a carefully chosen subset (fraction) of the experimental runs of a full factorial design based on statistical methods (https://en.wikipedia.org/wiki/Fractional_factorial_design). "The best fractional factorial design is the one that is the most economical while enabling satisfactory estimation of the effects of primary scientific interest."(https://methodology.psu.edu/ra/most/fefaq) In other words, the purpose of fractional factorial design is to design an experiment that enables the estimation of the effects of primary scientific interest in an efficient way. The D-Optimal criteria is a particular criteria used in the statistical process of choosing the subset of the experiment.

[2] If the orthogonal design is used, orthogonality would imply the correlations to be zero. However, orthogonality would be loss anyway if some unrealistic alternatives have to be eliminated. In our case, an unrealistic example may involve a combination of spot market price and 3 year written contract.

Sampling is based on a list of farms that have sent cattle to abattoirs in 2016. Instead of complete random sampling, stratified sampling is used. The focus is on the inclusion of more large farms as closer collaboration is less attractive from not only the perspective of cattle suppliers (*i.e.* the farms) but also that of cattle buyers (*i.e.* the abattoirs/retails). Therefore, the list is separated into two strata corresponding to large and small farms and random sampling is carried out in the two strata respectively. About 55% of the sample were from the large farm stratum and the rest from the small farm stratum. Following a discussion with personnel at Livestock and Meat Commission in Northern Ireland, the threshold between the two strata is determined to be at least one cattle per week sent to abattoirs, leading to approximately 50 per year.

4 Survey results

4.1 Question 1: How does participation and willingness to participate in collaboration (via verbal or written agreements) with downstream buyers depend on characteristics of the farm and the farmer?

A binary logistic regression is carried out to investigate the question: how does participation and willingness to participate in collaboration with downstream buyers associate with characterisitics of the farmer and the farm? By introducing a latent variable, the binary logistic regression can be understood as in Equation 1 (Greene, 2018):

$$y = \begin{cases} 1, \ y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon > 0 \\ 0, \ y^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon \leq 0 \end{cases} \quad [1]$$

where *y* is the participation and willingness to participate, with 1 denoting yes and 0 denoting no, and $X_1, X_2,\ldots,X_p$ are the explanatory variables, while β's are the coefficients. Assuming the ε's having a standard logistic distribution, Equation 1 can be rearranged as:

$$Prob(y = 1|\boldsymbol{X}) = \frac{\exp(\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_p X_p)}{1+\exp(\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_p X_p)} \quad [2].$$

Then the regression is implemented as shown in Equation 3:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon \qquad [3]$$

where *p* is the probability of *y* equal 1. The ratio of $\frac{p}{1-p} = \frac{Prob((y=1|\boldsymbol{X})}{Prob((y=0|\boldsymbol{X})}$ is known as the odds in favour of y=1. The interpretation of β's is not as straightforward as in a linear OLS regression; however, a rearrangement of Equation 2 shows that the exponential of β's give the extent that the odds changes with changes in the independent variables in a multiplicative way as in Equation [4], which is called odds ratio (Greene, 2018):

$\frac{\left(\frac{p}{1-p}\middle| x_i = x+1\right)}{\left(\frac{p}{1-p}\middle| x_i = x\right)} = e^{\beta_i}$ [4].

Below, the independent variable and the explanatory variables are explained in detail:

1) The independent variable is constructed based on questions on the past and current involvement of agreement and/or contract and willingness of participating in such pre-arrangements. The value "1" of the variable denotes situations in which a) farms are currently under a verbal agreement or written contract of selling finished cattle; b) farms had been under a verbal agreement or written contract before and willing to do it again; and c) farms had never been under a verbal agreement or written contract before but would be willing in principle to participate in such an agreement/contract. For all other farms, a value of 0 will be assigned to this variable. There are 124 out of 201 (61.7%) farms with value 1 and 77 (38.3%) farms with value 0.
2) Characteristics of the farmer: this set of explanatory variables include age, education and off farm job. Ages of respondents in the survey range from 22 to 91, with mean of 57.70 years old. In terms of education, answers in the survey are distinguished at detailed levels (postgraduate, degrees, further education, A-level and O-level/GCSE) and also subjects (agriculture versus non-agriculture). However, there are not many respondents in the brackets of the higher levels, especially in the subject of agriculture. Hence, education level is aggregated firstly by taking the higher qualification of agricultural versus non-agricultural and secondly to three levels: A-level or above (50 out of 201), O-level/ GCSE (44 out of 201), no formal qualification (107 out of 201). In terms of off-farm job, only 21 respondents have a full time off farm job and 10 have a part time off farm job.
3) Characteristics of the farm: this set of explanatory variables include number of finished cattle slaughtered in 2016, percentage of farm income from beef, farm profitability, specialisation in particular breeds, participation in benchmarking exercise, participation in producer groups and participation in agri-environmental schemes.

    Number of finished cattle slaughtered in 2016 serves as a proxy of farm size. Respondents were not asked to provide the specific number for the question but needed to choose the interval of which the number lie in. There are ten intervals. The smallest and the second smallest intervals range between 0 to 12 and between 13 to 24, and the third to the ninth intervals all have a range of 25, leading to the largest group (i.e. the 10^{th} group) being 200 or more. Number of farms that fall into each interval is shown in Table 2. Given the way in which the intervals increase and the

total number of intervals, the order of the intervals is approximately linear and treated as a continuous variable in the regression.

For the question on percentage of farm income from beef, respondents are asked to indicate a range. Only 4 ranges are provided as an answer (one/two/three quarters and above). Most of the respondent have a high proportion of farm income from beef; 74.6% of farms exceeding 50%, among which 74.7% exceeding 75% (Table 2). The latter category is indicative of a specialised beef production system. This variable is treated as categorical with the 0-25% chosen as the reference category.

Table 2 Frequency table of finished cattle slaughtered in 2016 and percentage farm income from beef

Finished cattle slaughtered in 2016			Percentage farm income from beef		
	Frequency	Percent		Frequency	Percent
0-12	23	11.4	0 to 24%	28	13.9
13-24	20	10.0	25 to 49%	23	11.4
25-49	19	9.5	50 to 74%	38	18.9
50-74	23	11.4	75 to 100%	112	55.7
75-99	22	10.9			
100-124	19	9.5			
125-149	11	5.5			
150-174	9	4.5			
175-199	3	1.5			
200 or more	35	17.4			
(Don't know)	17	8.5			
Total	201	100.0		201	100.0

For the farm profitability question, 128 out of 201 respondents indicate their farm made a profit in the 2015-2016 financial year, 31 indicate that it did not make a profit and 42 refused to answer. Range of profit (and loss) are further asked; however, a large proportion of respondents refused to answer. Instead of discarding the sample of the group "decline to answer" so that their answers to other questions can still be used, three categories are set up for this variable: "profit"; "loss" and "declined to answer". "Loss" is treated as the reference category. It should be noted that only the coefficient on the "profit" group has a clear interpretation.

The answers to the questions of specialisation in particular breeds, participation in benchmarking exercise, participation in producer groups and participation in agri-environmental schemes are coded with a dummy variable.

4) The missing value issue is moderate in this set of data. Seventeen respondents did not provide the number of finished cattle slaughtered in 2016 and these are excluded in the regression whenever this variable is included in a regression. Therefore, the sample size for the regression reduces to 184. For the independent variables, there are 115 farms (62.5%) with value 1 and 69 (37.5%) with value 0.

4.2 Willingness to participate in a collaboration agreement results

Results of four regressions are presented in Table 3. Model I has the least number of explanatory variables and excludes those regarding whether the farmers' participation or non-participation in benchmark, producer group and agri-environmental schemes. There are two versions of Model II, in which differ in terms of the way the variable for participation in agri-environmental schemes is included. Model IIa adds this variable directly to Model I, while Model IIb includes an interaction variable between education (A-Level or above) and participation agri-environmental schemes. Model III includes all the variables appearing in Model I and those regarding participation in benchmark, producer group and agri-environmental schemes.

Across all models, education (O-level/GCSE in particular), larger farm size (as measured by number of finished cattle slaughtered in 2016), higher percentage of farm income from beef and specialisation in particular breeds all contribute positively and statistically significantly to the likelihood of participation and willingness of participation in a verbal agreement and/or written contract with downstream buyers. The odds of participation for a farmer with O-level/GCSE is double (2.6-2.7 times) that of those with no formal qualification. The impact of specialisation in particular breeds is similar.

The impact of the number of cattle slaughtered in 2016 appears to be moderate, as e^{β} is around 1.15. However, it should be noted that this variable is treated as continuous, with the value ranging from 1 to 10. The estimation suggests the odds increases by 15% for a farm with around 25 finished cattle slaughtered more than another one in the next smaller group. The odds doubles if, for example, a farm in Group 8 (150-174 cattle slaughtered in 2016) is compared to a farm in Group 3 (25-49 cattle slaughtered in 2016).

Farmers with a higher proportion of farm income from beef are more likely to participate or be willing to participate in verbal agreement or written contracts with downstream buyers than those with lower proportions. The difference is statistically significant for those with a proportion higher than 50%.

When participation of agri-environmental scheme is not included in the regression (Model I), the coefficient on education A-level or above is statistically significant and has the expected positive sign, suggesting farmers with formal qualifications, similar to those

with O-level/GCSE, are more likely or more willing to participate in pre-arrangements with downstream buyers. However, when the variable participation in agri-environmental schemes is included within the model (Model IIa), the coefficient on education A-level or above remains positive but becomes more moderate and insignificant. The sign of participation in agri-environmental scheme itself is positive, indicating that the participation of agri-environmental scheme also increases the likelihood or willingness of participation in supply chain pre-arrangements. The odds double if a farm has been or is enrolled in agri-environmental schemes. The interaction term between education and participation in agri-enviromental schemes within Model IIb suggests that there may be two subgroups of farmers with A-level qualifications or above. One of these subgroups are much more likely than the other to participate in both supply chain collaboration and agri-environmental schemes, and exhibit an odds ratio of exp(0.522+0.719)=3.46, compared to exp(0.522)=1.69 for the other subgroup. However, the coefficients are insignificant because the participation in agri-environmental schemes variable effectively divides the already small high education group into even smaller subgroups. There is no such issue for those with O-level / GCSE level only, but for those with A-level qualifications or above it is difficult to assess the impacts of education and participation in agri-environmental scheme simultaneously as the two variables are highly correlated.[3]

The Chi-square tests suggest all the models are significant. Based on the Akaike Information Criterion and Bayesian Information Criterion, Model (IIa) and Model (II) are preferred. Nevertheless, the differences in the information criteria and the percentages of correct predictions among the alternative models are small. Therefore, the confusion matrix is presented for Model (I) only (Table 4).

[3] It is generally evident from the literature that well educated farmers are more likely to participate in agri-environmental schemes (Wilson and Hart, 2000; Lastro-Braso *et al.*, 2015). This is supported in this study, with the data indicating that there is a statistically significant positive correlation between education and participation in agri-environmental schemes.

Table 3: Regression results of farmers' participation/ willingness to participate in supply chain collaboration

	(I)			(IIa)			(IIb)			(III)		
	B	Sig	Exp(B)	B	Sig	Exp(B)	B	Sig	Exp(B)	B	Sig	Exp(B)
Age	-.015	.363	.985	-.019	.263	.981	-.018	.289	.982	-.019	.270	.981
Education_A level or above	**.869**	**.080**	**2.383**	.611	.243	1.842	.522	.391	1.686	.522	.324	1.686
Education_O level / GCSE	**1.001**	**.047**	**2.720**	**.956**	**.061**	**2.601**	**.980**	**.052**	**2.663**	**.963**	**.064**	**2.620**
Profitability (Yes)	-.196	.699	.822	-.323	.531	.724	-.252	.621	.777	-.258	.618	.773
Profitability (Declined to answer)	-.059	.923	.943	-.235	.704	.791	-.104	.865	.901	-.194	.754	.824
Off farm job	.416	.432	1.516	.356	.506	1.427	.400	.451	1.492	.380	.483	1.462
Number of finished cattle slaughtered in 2016	**.150**	**.017**	**1.162**	**.144**	**.024**	**1.155**	**.148**	**.020**	**1.160**	**.129**	**.046**	**1.137**
Percentage farm income from beef (1)	.864	.222	2.373	.883	.213	2.419	.890	.212	2.434	1.063	.150	2.895
Percentage farm income from beef (2)	**1.853**	**.006**	**6.381**	**1.999**	**.003**	**7.381**	**1.942**	**.004**	**6.975**	**2.307**	**.002**	**10.044**
Percentage farm income from beef (3)	**1.600**	**.005**	**4.953**	**1.675**	**.003**	**5.337**	**1.680**	**.004**	**5.367**	**1.947**	**.002**	**7.005**
Specialisation in a breed	**1.042**	**.006**	**2.834**	**.917**	**.017**	**2.501**	**1.008**	**.008**	**2.740**	**.757**	**.059**	**2.133**
Participation in Benchmark										.207	.764	1.230
Participation in Producer group										.788	.230	2.198
Participation in agri-environmental scheme				.731	.109	2.076				**.806**	**.082**	**2.239**
Edu_A level or above*Participation in agri-environmental scheme							.719	.350	2.053			
Constant	-1.398	.258	.247	-1.145	.361	.318	-1.222	.328	.295	-1.417	.267	.242
AIC		223.9			223.2			225.0			225.4	
BIC		262.5			265.0			266.8			273.6	
Chi squared [*df*]		43.559 [11]			46.230 [12]			44.448 [12]			48.071 [14]	
Percentage of correct predictions (Baseline 62.5%)		70.7			69.6			70.1			69.6	

(Note: variables highlighted in bold are statistically significant at the 10% level.)

Table 3: Confusion matrix based on Model (I)

Observed		Predicted Y .00	1.00	Total	Percentage	Percentage Correct
Y	.00	33	36	69	37.5%	47.8%
	1.00	18	97	115	62.5%	84.3%
Overall Percentage				184		70.7%

4.3 Choice experiment on farmers attitude towards contracting

The econometric modelling of choice experiment is based on the random utility model (McFadden, 1974). The key components in the regression model are shown in Equation 5 and 6:

$U_i = X\beta + Z_i\gamma_i + \varepsilon_i$ [5]

$P_i = \frac{e^{V_i}}{e^{V_1}+e^{V_2}+\cdots+e^{V_N}}$, with $V_i = X\beta + Z_i\gamma_i$ [6]

where U_i is the utilility of a respondent choosing alternative i consisting of a deterministic part V_i and a stochastic part ε_i and P_i is the probability of the alternative i being chosen. It should be noted that only the relativity of U (i.e. whether U_i is greater than U_j) can be identified, not their absolute levels. Also the expression of P_i builds on the assumption that the ε_i's are independent and identically distributed with Gumbel (type 1 extreme value) distribution. This is called the multinomial logistic model in literature (Greene, 2018).

The explanatory variables *X*'s and *Z*'s in Equation 5 are those contributing to the utility, including the attributes of the alternatives and also characteristics of the individuals making the choices. However, for the coefficients to be identifiable, the values of *X*'s and *Z*'s need to vary in the choice experiment. That is, they need to have different values in different alternatives. Therefore, coefficients of the characteristics of the respondents are not identifiable if these variables are directly included in the regression.

To investigate the impacts of, for example socio-economic, characteristics of the respondents on the choices they make, interactions between these variables and the attributes of the alternatives need to be created and then incorporated in the regression model. This is the only meaningful way of examining impacts of non design covariates in an unlabelled choice experiment (Hensher *et al.*, 2015). Under the basic model, the impact of a particular (level of a) attributes can be briefly assessed through $V = \beta_i x_i$, which assumes that it is valued in the same way by all farmers regardless of their farm size, education level *etc*.[4] The interaction model, in which the impact becomes $V = \beta_{i1}x_i + \beta_{i2}x_i c_i$ where c_i is the socio-economic characteristic, provides a means to allow the valuation of a specific attribute of the alternative to vary with the characteristics of the farm or the farmer $\frac{\partial V}{\partial x_i} = \beta_{i1} + \beta_{i2}c_i$.

In addition, the part of $Z_i\gamma_i$ in Equation 3 could be useful in a choice experiment in which some attributes are present in some but not all alternatives or in which the alternatives are labelled. For example, travel time in a train or in a car can have either

[4] Unlike the linear regression, β_i no longer represent the marginal impact of x_i on the probability of making a choice, which becomes $\frac{\partial P}{\partial x_i \beta_i} * \beta_i$. But the sign of β_i is still meaningful.

the same impact on utility (hence appearing as part of β) or different impacts (as part of $Z_i\gamma_i$). Since our choice experiment is unlabelled, the part of $Z_i\gamma_i$ is not used in our regression with the exception of the intercept. In the regression of this study, there are two dummy variables for each attributes. Level 1 (Table X) is chosen as the reference and the dummy variables represent Level 2 and Level 3 (compared to Level 1).

4.4 Choice experiment results

Results of three regressions are presented in Table 5, including two basic models and one model with interaction effects. The basic models only include attributes of the alternatives in the choice tasks as explanatory variables (*i.e.* contract attributes). The model with interaction effects include interactions between some of the contract attributes and farm/farmer characteristics, namely farm size (again measured by number of cattle slaughtered in 2016), farmers' education level and farmers' enrolment in agri-environmental schemes.[5] As mentioned in the binary regression section, the no responses to the question on the number of cattle slaughtered resulted in a missing value issue and therefore the regression can only be run with a reduced sample when this variable is included. In order to enable comparisons between the basic and interaction models, the former is estimated using both the full sample and the reduced sample.

The basic models in which only the contract attributes are included show similar results for the full sample and the reduced sample cases. An alternative specific intercept is included for alternatives 1 and 2. This takes into account the "systematic" difference in the preference for the alternatives not explained by the explanatory variables. Similar to the use of dummy variables, there needs to be one reference level. We have chosen the opt-out option as the reference and therefore the intercepts represent the lower likelihood that respondents actually make a choice between the two alternatives as revealed by the sign of the estimation. Furthermore, the value for the intercept of alternative 1 is less negative than that of alternative 2. This may suggest alternative 2 is less attractive than alternative 1 in general. However, it may reflect the left to right bias in answering choice tasks.[6] When the reduced sample is used, despite still being negative, the intercept for alternative 2 is closer to zero and becomes insignificant. This supports the conjecture that the larger negativity of the intercept for alternative 2 is caused by the behavioural bias since the excluded data are those who answered they do not know how

[5] Other characteristics of the farm/farmer, such as participation in benchmark schemes, age, etc. have been tested but are not significant.
[6] In the literature, the left to right response bias means that alternatives appearing first (usually the left or the top) are more likely to be chosen (Hensher *et al.*, 2015).

many cattle were sent for slaughter in 2016 and hence more likely to make little effort in the completion of the survey.

Within the basic model regressions all but the data sharing attributes have the expected signs. Moreover, as Level 3 for each of the contract attributes entails higher reward or more stringent requirements, coefficients on the dummy variables for this level have greater values (in absolute term) than those on the dummy variables for Level 2. With regards to the "price and production requirement" attribute, the results suggest that the premium component, which is accompanied with a feed requirement, is attractive to farmers, while the minimum price guarantee component is not. Contrary to expectations, the sign on the data sharing variables are negative (although insignificant), suggesting that greater availability of data is not viewed favourably by farmers.

As discussed earlier, the interaction model provides a means to allow the valuation of specific contract features to vary with the characteristics of the farm or the farmer. The inclusion of interaction terms greatly improves the goodness-of-fit of the model. Results in Table 5 suggest that the attractiveness of a premium payment system on cattle price combined with feed requirement is significantly greater for larger farms. Similarly, the dislike for the minimum volume requirement diminishes with farm size. This is unsurprising as it is more straightforward for large farms to meet this requirement.

Of particular interest are the interactions between data sharing & education and that between type of contract & participation of agri-environmental schemes, the estimation of which is re-arranged and presented in Table 6. Similar to the basic model, the sign on the data sharing variables (both Level 2 and Level 3) are negative, suggesting that greater availability of data is not viewed favourably by farmers. However, this is not true for farmers with A-level qualifications or above, who value data sharing systems positively. In the test runs of the regression, farmers with O-level/GCSE are distinguished from those without formal education; however, both groups value data sharing in a similar and negative way. With regards to written contracts, those who have experience of enrolling in agri-environmental schemes do not dislike these contracts to the same extent as those who have no experience of enrolling in agri-environmental schemes. Indeed, the combined coefficient of written contract with shorter term (1 year) and enrolment in agri-environmental schemes is positive.

Table 4: Regression results of the multinomial logistic model

				Basic Model (all)		Basic Model (excluding missing data)		Interaction Model	
Sample size				201		184		184	
				Estimate	Pr(>|t|)	Estimate	Pr(>|t|)	Estimate	Pr(>|t|)
1:(intercept)				-0.154	0.343	-0.100	0.558	-0.074	0.670
2:(intercept)				**-0.338**	**0.051**	-0.239	0.187	-0.227	0.219
Price_prod_2				0.090	0.583	0.042	0.805	0.078	0.768
Price_prod_3				**0.611**	**0.000**	**0.634**	**0.000**	0.137	0.544
Volume_deli_2				**-0.274**	**0.013**	**-0.272**	**0.019**	**-1.048**	**0.000**
Volume_deli_3				**-0.403**	**0.000**	**-0.365**	**0.002**	**-1.429**	**0.000**
Data_sharing_2				-0.062	0.589	-0.068	0.567	-0.176	0.190
Data_sharing_3				-0.132	0.288	-0.164	0.207	**-0.249**	**0.086**
Contract_2				**-0.276**	**0.014**	**-0.293**	**0.012**	**-0.482**	**0.000**
Contract_3				**-0.622**	**0.000**	**-0.694**	**0.000**	**-0.824**	**0.000**
Price_prod_2	*	A5_1	Cattle slaughtered					0.007	0.853
Price_prod_3	*	A5_1	Cattle slaughtered					**0.101**	**0.000**
Volume_deli_2	*	A5_1	Cattle slaughtered					**0.143**	**0.000**
Volume_deli_3	*	A5_1	Cattle Slaughtered					**0.189**	**0.000**
Data_sharing_2	*	edu_a	Edu - A Level or above					**0.348**	**0.089**
Data_sharing_3	*	edu_a	Edu - A Level or above					0.269	0.156
Contract_2	*	A17_1	Ag-environment scheme					**0.554**	**0.005**
Contract_3	*	A17_1	Ag-environment scheme					**0.349**	**0.097**
AIC				2513		2298		2200	
BIC				2546		2330		2258	
Log-Likelihood				-1246.3		-1139		-1082.2	
McFadden R^2				0.035		0.042		0.089	

(Note: 1. Numbers following contract attributes denote the level. 2. Variables highlighted in bold are statistically significant at the 10% level.)

Table 5 Impacts of education and experience with agri-environmental schemes on valuation of contract attributes

Attributes	Qualifications		Experience of enrolling in agri-environmental schemes	
	Below A-level	A-Level or above	No	Yes
Data Sharing -detailed quarterly information	-0.176	-0.176+**0.348**		
Data Sharing -detailed weekly information	**-0.249**	**-0.249**+0.269		
Written contract 1 year			**-0.482**	**-0.482+0.554**
Written contract 3 years			**-0.824**	**-0.824+0.349**

5 Conclusion and discussion

A survey, including a choice experiment, was undertaken to investigate beef farmers' attitudes towards collaboration in the supply chain in Northern Ireland. Specifically, the survey examines the factors that influence beef farmers' decision to participate or willingness to participate in the pre-arrangement of cattle sales with down-stream buyers and also the attributes of the pre-arrangements that encourage or discourage participation. The forms of the pre-arrangement vary widely. A verbal agreement may be regarded as loose as it can only impose a limited number of basic conditions on the cattle (particularly their quality), but still facilitates some coordination between the buyer and seller compared to trade on the spot market. In contrast, a written contract may potentially specify many requirements on the sellers, accompanied with appropriate levels of reward.

Our results suggest that larger farms and more specialised farms are more likely to participate or willing to participate in collaboration with downstream buyers. These results are in line with expectations as these characteristics are indicative of farms that are more commercial oriented. Farmers with higher education attainment are also more likely to participate in collaboration arrangements.

The choice experiment results suggest that in terms of pricing mechanism, a minimum price guarantee is not attractive to farmers. This is consistent with Anderson and Nilsson (2016) who showed that an attempt to introduce a minimum price system within a beef partnership in Ireland had to be abandoned due to negative perceptions by producers. Nevertheless, minimum pricing may be viewed more favourably in the future if domestic prices are more exposed to volatile global prices depending on future trade arrangements post-Brexit. In contrast, the results indicate that farmers generally willing

to fulfil some feeding requirements in order to earn a premium. However, this result needs to be treated with a certain amount of caution as the feed requirement is by necessity rather abstract in the survey. In reality, farmers will need to weigh the benefits of the premium against the stringency of the feeding requirement. In addition, processors will only be able to offer a premium if the specified requirements lead to an improvement in the final product quality that is rewarded sufficiently in the marketplace.

Data sharing initiatives provide a means to improve the flow of information from buyers to sellers on, for example carcass quality. Within the literature, it is argued that such systems are mutually beneficial in the sense that they enable farmers to make improvements to on-farm management decisions, which should enhance the performance of their beef enterprises, and at the same time have a positive impact on the number of cattle meeting processor/retailer specification requirements (Leat *et al.*, 2008). Despite the apparent benefits of data sharing, the results generally indicate that farmers do not appreciate the potential value of such initiatives. This may be attributable to a variety of factors, e.g. farmers' general distrust of processors leading to unwillingness to frequent engagement or difficulty in handling large quantities of information. Although the results show the overall negative perception of data sharing, it is evident from the choice experiment that a subset of farmers view this attribute favourably. In particular, farmers with A-level qualifications or above value this attribute positively. More generally, education is shown to have positive impacts on both participation of collaboration and the valuation of contract attributes. However, the level of education attainment required for the realisation of positive impacts differs. Notably, farmers with O-level / GCSE are more likely to participate / be willing to participate in supply chain collaborations than those without formal qualifications, but the two groups do not differ in terms of valuing data sharing.

Nevertheless, from a policy perspective, the results on the whole support the role of education in increasing the level of co-ordination in the supply chain. Leat *et al*. (2008) showed within Scotland how data sharing using information technology between a retailer, a beef processor and beef producers has not only helped improve the production efficiency of farms over time, but also had a positive impact on the level of trust within collaborative relationships by increasing the level of transparency and encouraging interaction across the supply chain.

Another variable of interest is participation in agri-environmental schemes. The results indicate that higher education qualifications (especially A-Level or above) are positively linked to enrolment in agri-environmental schemes, in which is consistent with the literature. Given this interaction and the limited number of observations, it is difficult

to assess the impact of enrolement in agri-environmental schemes on the participation / willingness to participate in supply chain collaborations. Nevertheless, farmers who have enrolled in agri-environmental schemes view the requirement of a written contract (compared to verbal agreement) more favourably than those who have not. This suggests that producers who have actual experience of enrolment in written contracts in their farming enterprise (through agri-environmental schemes) are more open to engaging in formal supply chain collaborations.

In this paper, we investigate attributes that would encourage or discourage beef farmers' participation in supply chain collaboration. The choice experiment method is used since this practice is not common practice in the beef sector. Overtime, if it can be demonstrated that supply chain collaborations can be successful to the mutual benefit of all partners, it should be possible to build up a greater level of trust between farmers and downstream partners and encourage more collaboration in the future.

References

Agri-Food Strategy Board (2013).Going for Growth: A Strategic Action Plan in Support of the Northern Ireland Agri-Food Industry. Belfast, the UK.

Andersson, M. and Nilsson, J. (2009): Partnerships in the Irish Beef Industry: Contract Theoretical Analyses, *Journal of International Food & Agribusiness Marketing* **21 (4)**, 312-38.

Boessen, C., Parcell, J., Franken, J., Lawrence, J., Plain, R. and Grimes, G. (2010): Producer perceptions and attitudes toward hog marketing contracts, *Agribusiness* **26 (3)**, 405-24.

Boger, S. (2001): Quality and contractual choice: a transaction cost approach to the Polish hog market, *European Review of Agricultural Economics* **28 (3)**, 241-62.

Chambers, W. and King, R.P. (2002): Changing agricultural markets: Industrialization and vertical coordination in the dry edible bean industry, *Review of Agricultural Economics* **24 (2)**, 495-511.

Duffy, R. and Fearne, A. (2006): Effective partnerships for agri-food chains: the impact of supply-chain partnerships on supplier performance in the UK fresh-produce industry, *Quantifying the agri-food supply chain*, 225-39.

Fearne, A. (1998): The evolution of partnerships in the meat supply chain: insights from the British beef industry, *Supply Chain Management: An International Journal* **3 (4)**, 214-31.

Greene, W.H. *Econometric Analysis (8th)*. New York, NY, USA: Pearson, 2018.

Hensher, D., J.M. Rose, and W. Greene *Applied choice analysis (2nd)*. Cambridge, UK: Cambridge University Press, 2015.

Leat, Philip MK, Cesar Revoredo-Giha, and Beata Kupiec-Teahan (2008): Improving market orientation in the Scottish beef supply chain through performance-related communications: The case of the McIntosh Donald Beef Producer Club and Qboxanalysis. No. 112886. Scottish Agricultural College, Land Economy Research Group.

MacDonald, J.M. (2015): Trends in agricultural contracts, *Choices* **30 (3)**, 1-6.

McFadden, D. 1974.Conditional logit analysis of qualitative choice behavior, P. Zarembka, ed., *Frontiers in Econometrics*. New York, NY, USA: Academic Press.

Schipmann, C. and Qaim, M. (2011): Supply chain differentiation, contract agriculture, and farmers' marketing preferences: The case of sweet pepper in Thailand, *Food Policy* **36 (5)**, 667-77.

Schlecht, S. and Spiller, A. (2012): A latent class cluster analysis of farmers' attitudes towards contract design in the dairy industry, *Agribusiness* **28 (2)**, 121-34.

Schroeder, T.C. and Kovanda, J. (2003): Beef alliances: motivations, extent, and future prospects, *The Veterinary clinics of North America. Food animal practice*. **19 (2)**, 397,417, vii.

Steiner, B., Lan, K., Unterschultz, J. R., Boxall, P., Laate, E., Yang, D. and Bank, C. W. (2012): Producer preferences towards vertical coordination: The case of Canadian beef alliances. 123rd EAAE Seminar, February 23-24, 2012, Dublin, Ireland.

Wilson, G.A. and Hart, K. (2000): Financial imperative or conservation concern? EU farmers' motivations for participation in voluntary agri-environmental schemes, *Environment and Planning A* **32 (12)**, 2161-85.

Young, L.M. and Hobbs, J.E. (2002): Vertical linkages in agri-food supply chains: changing roles for producers, commodity groups, and government policy, *Review of Agricultural Economics* **24 (2)**, 428-41.