

Project BR0114: Study on farm assurance scheme membership and compliance with regulation under cross compliance

Report to Defra

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Executive Summary

1. Aims

The Farming Regulation Task Force recommended that membership of appropriate third-party assurance and other schemes should form part of the cross compliance inspector's risk toolkit. This was accepted by the Government who then undertook, in their response to the Task Force report, to consider how earned recognition (giving official recognition to the effective efforts made by individuals and businesses in understanding legal requirements and getting things right) can be introduced into other cross compliance measures¹ from 2013. This project sought to determine whether such schemes could provide an indicator of farm risk to be applied in the Rural Payments Agency (RPA) risk modelling for the cross compliance inspection regime in 2014 and beyond, that is, whether meeting assurance scheme standards means that those farms are less likely to be in breach of cross compliance requirements.

2. Scope and Data

The analyses focussed on RPA inspection result data for 11 Statutory Management Requirements (SMRs) and Good Agricultural and Environmental Condition (GAECs) for the years 2005 through 2012. Ultimately two of the GAECs (11 and 15) proved to have insufficient data for any meaningful analysis, so the results reflect analysis of the remaining 5 SMRs and 4 GAECs. This was linked with membership data from three farm assurance schemes: Red Tractor, LEAF Marque and Soil Association. Farm type and farm size information from the Agriculture Census was added. This data was analysed to determine whether assurance scheme members are more likely to meet the regulatory requirements of cross compliance than non-members. The analyses focussed on the SMRs and GAECs that are most commonly breached² (Table 1) and the assurance schemes that have larger memberships and cover a wide range of farming enterprise.

SMR/GAEC covered by RPA inspections
SMR 6: Pig identification & registration
SMR 7: Cattle identification and registration
SMR 8: Sheep and goats identification
SMR 9: Plant protection products
SMR 11: Food and feed law
GAEC 1: Soil Protection Review
GAEC 6: Sites of Special Scientific Interest
GAEC 8: Public rights of way
GAEC 11: Control of weeds
GAEC 14: Protection of hedgerows and watercourses
GAEC 15: Hedgerows

Table 1: SMRs/GAECs included in the analysis

The SMRs/GAECs in Table 1 (apart from GAECs 6 and 15) tend to have breaches each year. The choice of SMRs/GAECs with higher levels of breach (generally more than 10 per annum) was in order to better analyse relationships with farm assurance membership.

¹ Earned recognition within farm animal welfare inspections has been implemented: as a result, producers who are members of Accredited Welfare Assurance Schemes were not selected in 2012 for a risk-based animal welfare inspection under cross compliance

² Relevance of the assurance scheme to the SMR/GAEC was also considered. Those excluded for statistical analysis on the grounds that breaches are too infrequent: SMR 1: Wild birds; SMR 5: Habitats and species; SMR 10: Restrictions on the use of substances having hormonal or thyrostatic action and beta-agonists in farm animals; SMR 12: TSEs; GAEC 5: Environmental Impact Assessments; GAEC 7: Scheduled monuments; GAEC 9: Overgrazing and unsuitable supplementary feeding methods; GAEC 10: Heather and grass burning; GAEC 12: Agricultural land which is not in agricultural production; GAEC 13: Stone walls; GAEC 16: Felling of trees; GAEC 17: Tree Preservation Orders

3. Statistical analysis

The linked dataset of inspection outcome and membership of an assurance scheme was assessed in a number of steps:

- Initially, to get an overview of the dataset, graphs and data summaries were produced in order to highlight positive relationships between assurance scheme membership and inspection performance
- Secondly, and following the lead of prior analyses, a multilevel logistic regression model was applied which statistically assessed the link between different factors (e.g. farm size, farm type) and compliance for each SMR and GAEC
- To test the robustness of the findings, a number of variations in the modelling were carried out to gauge if the results were sensitive to changes in the data.

4. Results

Strong links were found between lower levels of non-compliance and assurance scheme membership for five of the nine SMRs and GAECs considered – SMRs 6, 7, 8, and 11, and GAEC 1. The confidence in these results is driven by the amount of data that we have available for the Red Tractor assured farms – the much larger membership of the Red Tractor schemes means that there is a more substantial number of inspection data to analyse and test for statistical significance. Although we have been able to estimate positive effects for the other assurance schemes, the amount of uncertainty in the predictions has meant we cannot claim statistical significance. The root of this uncertainty is the comparatively small data set for number of members in LEAF Marque and Soil Association schemes and thus much less inspection data to analyse. That is not to say that these smaller schemes do not have a positive effect on non-compliance rates: the amount of data does not allow us to say with any certainty that the results are statistically significant. The amount of uncertainty in many of the estimated models is also due to the low levels of non-compliance on inspected farms for the majority of SMRs and GAECs under consideration, that is, there are too few inspection breaches to find statistically meaningful results. Indeed for seven of the SMR/GAECs non-compliance rates are below 5% over the eight years (2005 to 2012) and this works against finding significant results even for the much larger Red Tractor schemes. Variations in the modelling were undertaken and showed the results to be robust.

Key messages

- There is strong evidence that assurance scheme membership reduces the chances of non-compliance for several of the SMRs and GAECs that were considered in this study.
- For some of the SMRs and GAECs, the rate of non-compliance is so low that it is not possible to draw statistically significant conclusions about the effects of assurance scheme membership.
- We have identified other factors that have a noticeable impact on non-compliance rates.

1. Introduction

The body of this report presents a non-technical summary of the project. After a short section on the background to the rationale for the project the following sections outline the data and methods used in the study and the results. More technical detail is provided in the Technical Annex.

Background

In June 2010, as part of the Coalition Government's Growth Agenda, James Paice, Minister of State for Agriculture and Food, established the Farming Regulation Task Force (2011). The Task Force was to advise the Government on a new approach to regulation in England that looks through the eyes of a farmer or food processor. As part of a new approach to the culture of regulation, the Task Force recommended that a framework be developed to enable industry to take greater responsibility. To this end, the Task Force stated:

Government inspection and enforcement must become more efficient and more effective. The competent authority must remain key, but it must adopt a tighter, risk-based approach to regulation. Critical to this is for Defra and its agencies to establish a system of 'earned recognition' that enables regulators to reward good practice with less frequent inspection.

Earned recognition involves using third-party information and other personal evidence to assess risk and therefore the need for the Government or its agents to inspect. This project assesses the degree to which earned recognition in the form of farm assurance scheme membership can be applied for more efficient inspection of compliance with regulations under cross compliance. Statutory Management Requirements (SMRs) and Good Agricultural & Environmental Conditions (GAECs) are the verifiable standards that must be included in cross compliance inspection of claimants for the Single Payment Scheme (SPS) and EU legislation requires a physical on-farm inspection. The inspections are carried out principally by the Rural Payments Agency with SMRs 7 and 8 (cattle and sheep ID respectively) carried out separately and selected under a different risk selection model operated by the British Cattle Movement Service (BCMS).

Industry self-regulatory 'farm assurance' schemes have become well established in all production sectors since the 1990s and, in England, most are now consolidated into the Red Tractor scheme. Other schemes such as LEAF Marque can build on Red Tractor with some additional criteria, and organic certification follows a similar process of farm inspection and certification against organic production standards. For example the Red Tractor Scheme has a membership of 78,000 farms and Red Tractor scheme inspectors carry out over 60,000 inspections per annum as compared to the 11,500 planned inspections carried out by the RPA in 2011/12. Box 1 provides a very brief overview of the main assurance schemes considered in this research.

The current method used by RPA for selecting farms for cross compliance inspections, as described in the *Evaluation of Cross Compliance*, incorporates a random element, a scored risk element and a targeted risk element. The scored element takes account of "A range of risk data [which] is obtained from a variety of sources" whereas the targeted risk is based upon referrals from a number of enforcement bodies and the general public.

In order for the regulator to take account of farm assurance to reduce the inspection burden on certified farms an analysis of the schemes should be able to demonstrate:

- That they have specific standards with direct read across to the relevant legal requirements, and;
- That the effect of the scheme standards and regular assessments against them has resulted in improved levels of legal compliance.

Some research to this effect has already been undertaken in the realm of animal welfare. Defra project AW0510 concluded that those farms in an assurance scheme had a lower probability of

non-compliance with animal welfare regulations than randomly selected farms. Defra (2013) and its agencies have adopted earned recognition for:

- Farm animal welfare inspections: as a result, producers who are members of Accredited Welfare Assurance Schemes were not selected in 2012 for a risk-based animal welfare inspection under cross compliance, and;
- Dairy hygiene inspections: earned recognition was introduced by the Food Standards Agency in 2011 (reducing inspections by over 8,000 per year).

Box 1: Farm Assurance Schemes

Founded in 1991, **LEAF (Linking Environment And Farming)** promotes sustainable food and farming. It is a farming charity that works at a global level with the whole food industry, to assist with the production of good food to a high environmental standards. This standard is identified in store and on pack by the LEAF Marque logo.

LEAF Marque is an independent assurance scheme chosen by food businesses worldwide to demonstrate their environmental credentials. The scheme is based on LEAF's Integrated Farm Management (IFM) principles, which combines traditional farming methods with modern technology. IFM helps farmers to maintain high standards of food production with minimum environmental impact. The LEAF Audit is the framework for implementing IFM. It is a practical whole farm business management tool, providing a health check of the farm. The LEAF Audit allows farmers to benchmark their performance and provides action plans for continuous improvement.

The **Red Tractor** is a the UK's largest food assurance scheme which covers production standards on farms and through the rest of the supply chain to ensure food safety and hygiene, animal health and welfare, environmental protection and traceability. The Red Tractor scheme is operated independently of any particular stakeholder group through a not for profit company limited by guarantee set up by the UK food industry in 2000. The logo is used by most major UK retailers, many branded manufacturers and food service operators and appears on around £12 billion worth of food products every year. Nearly 60,000 farm enterprises are members of the Red Tractor Farm Assurance Schemes with a further 20,000 certified to the standards through partner schemes.

Genesis was operating as a partner scheme in 2010 and 2011 using standards and procedures equivalent to those of Red Tractor, and by early 2013 all of these farms have been integrated into the Red Tractor scheme. Depending on the type of enterprise every farm is assessed every year or 18 months and can be subject to additional, very short notice, spot inspections at other times.

Soil Association Certification is the UK's largest organic certification body, responsible for certifying over 70% of all organic products sold in the country. Established in 1973, over 4,500 farms and businesses all over the world have been certified.

Through the not-for-profit business Soil Association Certification, the Soil Association inspect and award organic certification to farms and businesses that meet their organic standards. Any product sold as 'organic' must comply with rules set at UK, European and international levels. These rules (known as standards) assure consumers are buying genuinely organic products that can be fully traceable back to the farm. Organic standards cover all aspects of organic food certification including production and packaging, animal welfare, wildlife conservation, and ban certain food additives in organic processed foods. Soil Association standards exceed the UK government's minimum requirements especially in areas concerning the environment and animal welfare. Each of the licensed farms and businesses are inspected at least once a year with a number of random spot inspections, which can be unannounced, also undertaken. Inspections may also be in response to a complaint or concern raised.

2. Data and methodology

This section reflects the order in which the analysis was undertaken. Initially the SMRs and GAECs were selected for inspection. This was undertaken concurrently with the gathering of significant amounts of data that would be linked to the inspection data for the selected SMR/GAECs: membership information from the assurance schemes; farm type and farm size information from the Agriculture Census.

The data needed to be collated and managed securely throughout to ensure confidentiality.

Selection of SMRs/GAECs for analysis

There are 18 SMRs and 16 GAECs in total. The proposal was to include 10 in the analysis to ensure coverage of those with consistently high levels of breach, plus any with occasional spikes in breach. Ultimately 11 were selected as follows.

Table 2 shows the number of inspections failed in 2011, where the Competent Control Authority (CCA) is the RPA. Those selected for inclusion in the project are highlighted. As can be seen, the highlighted SMRs and GAECs are those with the higher levels of non-compliance.

RPA inspection coverage	1% inspections failed	CCA Standalone inspections failed
SMR 1: Wild birds	0	0
SMR 5: Habitats and species	1	0
SMR 6: Pig identification & registration	24	0
SMR 7: Cattle identification and registration	0	1,273
SMR 8: Sheep and goats identification	0	170
SMR 9: Plant protection products	25	7
SMR 10: Restrictions on the use of substances	0	0
SMR 11: Food and feed law	28	12
SMR 12: TSEs	2	0
GAEC 1: Soil Protection Review	81	7
GAEC 5: Environmental Impact Assessments	0	0
GAEC 6: Sites of Special Scientific Interest	2	0
GAEC 7: Scheduled monuments	0	0
GAEC 8 – Public rights of way	12	8
GAEC 9: Overgrazing and unsuitable supplementary feeding methods	0	0
GAEC 10: Heather and grass burning	1	0
GAEC 11: Control of weeds	17	22
GAEC 12: Agricultural land not in agricultural production	1	0
GAEC 13: Stone walls	0	1
GAEC 14: Protection of hedgerows and watercourses	40	37
GAEC 15: Hedgerows	3	2
GAEC 16: Felling of trees	2	1
GAEC 17: Tree Preservation Orders	0	0

Table 2: SMR/GAEC breaches 2011
(Source: RPA inspection data 2011)

Table 3 shows those SMR/GAECs that have featured in the lists of common failures over several years as provided by the RPA. It clearly illustrates that there are a well-defined number of SMRs/GAECs that fail inspection on a regular basis. The SMRs/GAECs selected for inclusion in this research (highlighted green) have featured in the lists of common failures in most years. 9 of these SMRs/GAECs have had high rates of failure (as indicated by the crosses) in each of the years shown.

SMR /GAEC	2007	2009	2010	2011
SMR 1				
SMR 5				
SMR 6	X	X	X	X
SMR 7	X	X	X	X
SMR 8	X	X	X	X
SMR 9	X	X	X	X
SMR 10				
SMR 11	X	X	X	X
SMR 12				
GAEC 1	X	X	X	X
GAEC 5				
GAEC 6		X		
GAEC 7				
GAEC 8	X	X	X	X
GAEC 9				
GAEC 10				
GAEC 11	X	X	X	X
GAEC 12				
GAEC 13				
GAEC 14	X	X	X	X
GAEC 15			X	
GAEC 16				
GAEC 17				

Table 3: Common SMR/GAEC breaches over time
(Source: RPA website - 2008 not available as at 9th July 2012)

Data

The data for this project was gathered from a number of different sources. Cross compliance inspection results data was supplied by the RPA. When cleaned, the dataset covered 45,500 inspections that were carried out in England over the period 2005 to 2012. The cleaning process is described in Box 2 and the effect of the cleaning on data available for subsequent analysis is shown in Table 4. LEAF Marque, Red Tractor and Soil Association assurance schemes provided membership data to identify the farms certified in their schemes. The analysis also included Pesticide Usage Survey data collated by Fera. This data contains self declared information about membership of assurance schemes which was included in the modelling to see if multiple membership of assurance schemes had an effect on compliance rates.

To join the various datasets together, a unique farm identifier was created based upon the common identification information used across the data sources which included address of the

business and CPH number. Once the appropriate data were obtained, a project database was constructed.

Box 2: Data cleaning process:

- For the assurance scheme data, all non-England data were removed. For LEAF Marque, Red Tractor and Soil Association most had postcodes, but many fewer had holding number (CPH – County/Parish/Holding identifier)
- For the RPA data, SMRs/GAECs outside of the scope for this project were removed
- For the PUS data, all non-approved usage records were removed
- LEAF MARQUE, Red Tractor, Soil Association, RPA and PUS data were linked together via the post code and holding number fields
- A scheme matrix was created with values of 1 or 0 indicating membership against the inspection
- Farm type and farm size were added from the June Census and linked to the dataset using the holding number
- All data identifying an individual holding were removed - postcode, address, holding number

RPA data: A summary of the RPA dataset for all scheme years from 2005 is presented in Table 4.

Year	All RPA data			Cleaned data for analysis	
	Number of inspections	1% selection	Cattle inspections	Number of inspections	Number with risk selection known
2005	3,532	234	3,236	2,870	36
2006	7,361	1,251	4,844	4,993	1,924
2007	6,665	1,051	1,105	4,496	1,914
2008	13,523	1,099	3,643	9,517	2,189
2009	10,683	1,098	3,265	7,316	2,135
2010	8,162	1,071	3,024	6,220	3,887
2011	8,325	1,072	3,203	6,309	3,780
2012	5,877	1,068	1,799	3,779	1,551

Table 4: RPA data on inspection numbers
(Before and after cleaning)

The columns under “All RPA data” show the total number of inspections as supplied. The table includes separate columns for the 1% selection³ for RPA inspections and the cattle inspections⁴ as these are generally the most frequently carried out. The fourth column show the total number of inspections after data cleaning was carried out. For example it shows that of the 8,325 inspections carried out in 2011; around 2,000 were cleaned from the database. This may have been due to inspection focussing on an SMR/GAEC that was out of scope of this project, missing data, or because we were unable to link the inspection data to census data on farm type and farm size. In addition to the total number and type of inspection, the RPA also supplied information on whether the inspection was selected randomly or based on their risk criteria. The final column shows the

³ All reports of 1% of the SPS/relevant pillar II claim population selected by RPA for a Cross Compliance inspection. Started in 2005

⁴ Selected by BCMS as the regulatory cattle inspection regime (10% until May 2009, 5% in 2009/10 and 2010/11 and 3% from 2011/12 onwards, CII year crosses calendar years: June to May).

numbers of inspections (after data cleaning) that we know were subject to inspections selected on the basis of risk rather than randomly. Reading across the table shows the drop-off in usable data for the analysis.

Assurance scheme data

Red Tractor data comprised membership lists from 2010 and 2011. Two datasets were provided – one where membership was certain for the whole calendar year and another where data quality issues (or what appeared to be breaks in membership) made membership less certain. Only the former dataset was used in the analysis. Data were provided for the Red Tractor *Beef & lamb*, *Crops*, *Dairy*, *Pigs*, and *Produce* schemes separately as were Genesis *Beef & lamb*, *Crops*, and *Pigs* (subsequently analysed both separately and with the Red Tractor data). Data from LEAF Marque and the Soil Association were their latest membership lists. A summary of the data provided by the Red Tractor, Genesis, LEAF Marque, and Soil Association assurance schemes, and the subsequent membership numbers post-cleaning that went into the analysis, is shown in Table 5. The figures for Red Tractor and Genesis are for 2011 for known members only in the middle column with the number after cleaning in the final column.

Scheme	Members	Cleaned
Red Tractor	47,129	44,347
Genesis	2,389	2,067
LEAF Marque	1,467	736
Soil Association	9,352	504

Table 5: Assurance scheme membership data

The steep drop of the numbers in the cleaned data column for LEAF Marque was due principally to the number of overseas members. The Soil Association membership list included a very high number of repetitions (reflecting membership over a number of years) which were removed.

Other factors: the dataset as described thus far includes just the holdings inspected by inspection year, inspection type and whether they belong to an assurance scheme. However, since other factors may influence the rates of non-compliance, a number of these were included in the statistical modelling. For each holding in the dataset the analysis also considered the selection method for inspection (risk based or random from RPA data), the farm size, and farm type (from Agriculture Census data). In addition to the membership data from the assurance schemes, the analysis utilised information recorded in the Pesticide Usage Survey. As part of this survey, information on multiple scheme membership is gathered and includes schemes such as Jordan Conservation Grade, and supermarket schemes such as Tesco Nurture.

Statistical Analyses

An exploratory data analysis was undertaken in order to investigate quantitative differences between inspection failures and different classes of assurance schemes. This involved the production of graphs along with data summaries that highlighted positive relationships between assurance scheme membership and inspection performance and gave an impression of the various underlying factors (for example, farm size). To begin with, the measure of inspection performance was simply a binary variable encoding whether the inspected farm was compliant or non-compliant for the SMR or GAEC under consideration. Later analyses considered the severity of the inspection breach.

Following previous research (Kilbride et al, 2012) into the associations between farm assurance membership and compliance with farming legislation, this project used a multi-level logistic regression model to assess the links between different factors and compliance for each SMR/GAEC. The model includes two random effects that serve to account for repeated farm inspections and regional trends. The first random effect is the farm itself because farms could have been inspected multiple times between 2005 and 2012. If a farm has been non-compliant at one stage, then it may change its chances of being non-compliant in other inspections. It is clear that

there are a large number of farms that have been inspected multiple times over the period and it may be important to recognise this in the models.

The second random effect in the model is the geographic region of the inspected farm. We use the nine administrative regions of England as a broad surrogate for geographic location. Although this is quite a crude measure of location, it seems to capture differences in the farm types over England and there are enough data for each region to model this effect adequately. Because farm location is not changing over time, we model these effects in a multilevel way such that farm identity is nested within a region. The statistical model's random effects control for regional effects and the effects of multiple inspections at a farm simultaneously, and we can consider these effects to have been nullified prior to the upcoming results.

More detail on the statistical analysis is provided in the Technical Annex.

Summary

In this section we have outlined the scope of the analysis as well as the data brought together into a single database that linked RPA farm inspections with farm assurance membership lists. The method of statistical analysis is briefly described (with more detail provided in the Technical Annex). The next section provides the main results of this analysis.

3. Result highlights

For five of the SMRs and GAECs, we found evidence that membership of the Red Tractor scheme has a statistically significant effect on reducing the odds of non-compliance. The reduction in the odds of non-compliance due to Red Tractor membership varied from 64% for SMR 6 to 34% for SMR 8 (see Table 5 in the Technical Annex for the full results including confidence intervals). The confidence in these results is driven by the amount of data that we have available for the Red Tractor assured farms⁵. Although positive effects have been estimated for the other assurance schemes, the amount of uncertainty in the predictions has meant we cannot claim statistical significance – this is due to the very low levels of non-compliance and the relatively small membership numbers for the other assurance schemes. However, in most cases, our best estimate of the effect of the membership of these schemes was favourable. This effect can be seen for SMR 7 when considering the effects of Red Tractor and Soil Association scheme membership. The proportions of compliance and non-compliance are similar across the assurance schemes (indeed, for Soil Association membership compliance rates are slightly better) but the difference in the amount of data means that Red Tractor assurance scheme members are estimated to have a statistically significant positive impact whereas membership of the Soil Association assurance scheme is not statistically significant (see the bottom of Table D2 in the Technical Annex).

Apart from Red Tractor scheme membership, other factors played an important role in the prevalence of non-compliance for nearly all of the SMRs and GAECs. Table 6 shows the significant factors for each model of non-compliance for all of the SMRs and GAECs under consideration. The strongest results in terms of certainty in the estimated effects come from SMR 7 as it has the most data, but significant effects were identified for nearly all of the SMRs and GAECs.

	Activity	Size	Year	Inspection Type	Selection method	Red Tractor
SMR 6	X	X	X	X	X	✓
SMR 7	✓	✓	✓	✓	✓	✓
SMR 8	✓	✓	✓	X	✓	✓
SMR 9	X	✓	X	✓	X	X
SMR 11	X	X	X	X	X	✓
GAEC 1	✓	✓	✓	✓	✓	✓
GAEC 6	X	X	X	✓	X	X
GAEC 8	✓	✓	✓	✓	✓	X
GAEC 11	-	-	-	-	-	-
GAEC 14	✓	✓	✓	✓	✓	X
GAEC 15	-	-	-	-	-	-

Table 6: Significant factors for each of the SMRs/GAECs

✓ signify significant effects, x signify no significant effect, - signify insufficient data

The inspected farm's main activity has an effect on chances of non-compliance for five of the SMRs and GAECs. This is to be expected as the farms of different type may have different chances to breach regulations. For instance, farms with more cattle are more likely to have problems with SMR 7 (cattle identification and registration) than farms that focus on cereals or general cropping. Thus dairy farms were estimated to have a 55% greater chance of non-compliance in SMR 7 (see the farm type rows in Table D2 in the Technical Annex). Similar arguments help us to understand why farm size is an important factor for six of the SMRs and

⁵ However, the lack of non-compliance in the other SMRs/GAECs means that significant relationships cannot be found even for the larger schemes

GAECs. For instance, the bigger the enterprise, the more land it is likely to cover and there are more chances to breach GAEC 8 (public right of way).

The inspection year plays a significant role in the logistic regression models for five of the SMRs and GAECs. This suggests that the inspection requirements may have been implemented differently, or that the farmers' responses to the SMRs and GAECs might have changed over the period 2005 to 2012, potentially since cross compliance was brand new from 2005 and farmers would have inevitably grown in their understanding and awareness of the requirements over time. Any spikes in subsequent years would probably be due to changes in rules or their implementation. Inspection type records the body responsible for the inspection and the focus of the inspection. There is no surprise that particular inspection types yield more non-compliances: "*multiple inspections*" mean that a farm has had more than one cross compliance breach detected over the calendar year and thus by definition increasing the chance of being recorded as being non-compliant; "*RPAI standalone inspections*" are reports of non-compliance detected by RPA at other non-cross-compliance inspections. The method by which the farm is selected for inspection is significant for five of the SMRs and GAECs and this is mainly driven by the effects of the targeted inspections, which are inspections that are prompted by reports of possible non-compliances to the RPA from third parties. There is little evidence that risk-based inspections are returning more non-compliances than the random inspections for these SMRs and GAECs apart from SMR 7 where higher levels of non-compliance are associated with such inspections. On the other hand, the targeted inspections have a significant effect for most of the SMRs, which was perhaps expected given the nature of this selection method.

The effect of assurance membership on non-compliance was shown to be robust via:

- explicitly modelling other significant factors
- considering potentially significant interactions between factors
- including severity of non-compliance
- including Red Tractor and Genesis enterprise based membership data for 2010 and 2011 (Genesis: Beef and Lamb, Crops, Pigs Red Tractor: Beef and Lamb, Crops, Dairy, Pigs, Produce)
- including PUS multiple membership data

In order to gain further confidence in the results obtained from the analyses, a number of other fitting exercises were carried out. Analyses were carried out on:

- The full dataset including the unknown selection method inspections, but removing known "targeted" inspections.
- Random subsets of the full dataset.
- The dataset with known selection, but with 5% of inspections randomly reassigned to opposite Red Tractor membership status.
- Because the Genesis and Red Tractor are generally considered to be very similar over the study period an analysis was carried out that combined the two into one factor.

Summary

Five of the SMRs/GAECs produced positive results – farm assurance membership makes a positive contribution to lower odds of non-compliance. These results are stable over a range of variations on the analysis. Thus, the modelling is robust and we can be confident that we are drawing the correct conclusions about the effects of the various factors. More detail of the results is presented in the Technical Annex

The amount of uncertainty in much of the estimated models is due to the low levels of non-compliance for the majority of SMRs and GAECs under consideration. Indeed for two of the GAECs there were fewer than fifty recorded non-compliances over the eight years (2005 to 2012).

Technical Annex: Statistical Analyses

Introduction

The statistical analyses detailed in this annex help to determine whether assurance scheme members are more likely to meet the regulatory requirements of cross compliance. The analyses consisted of the use of exploratory data analysis (considering cross tables of data and calculating rates of non-compliance under different scenarios) and standard statistical models (multilevel logistic regression models of non-compliance).

The data

A unique farm identifier was created that depended upon the common identification information across the data sources (the address and CPH number). This was used to join the various data sources. Once the appropriate data were obtained, a project database was constructed. The data were provided for modelling as a series of spreadsheets from which the relevant data was extracted and loaded onto the database. The supplied data was checked prior to and after loading to the database in order to correct or remove data errors before running the analyses. The data supplied by individual suppliers remained confidential between the project team and the supplier, such that the individual data supplied by the farm assurance schemes was not to be passed on to Defra or RPA and likewise the farm inspection data was not to be passed on to the Farm Assurance Scheme administrators.

In Table A1, we list the number of relevant inspections for each of the chosen SMRs and GAECs alongside the non-compliance rates. In our dataset, the high non-compliance rate and number of relevant inspections for SMR 7 stands out, but seven of the SMRs and GAECs have a non-compliance rate of less than 5%.

Inspected SMR or GAEC		Overall frequency	Percentage of non-compliances
SMR 6	Pig identification & registration	1,113	10.3
SMR 7	Cattle identification and registration	26,283	43.2
SMR 8	Sheep and goats identification	8,727	14.4
SMR 9	Plant protection products	3,827	3.7
SMR 11	Food and feed law	5,719	2.4
GAEC 1	Soil Protection Review	6,193	4.6
GAEC 6	Sites of Special Scientific Interest	1,851	1.8
GAEC 8	Public rights of way	5,155	2.8
GAEC 11	Control of weeds	6,182	1.8
GAEC 14	Protection of hedgerows and watercourses	6,059	6.6
GAEC 15	Hedgerows	5,733	0.7

Table A1: frequencies of inspections covering each of the 11 chosen SMRs and GAECs and the associated non-compliance rates.

It should be noted that the recorded inspections were made for different reasons: some were selected using the RPA's risk-based procedure, some were randomly selected and the remainder were targeted after the RPA received a notification of potential non-compliance from a third party.

We know the selection method for 17,416 out of 45,500 inspections. For the targeted inspections, we do not know which SMR or GAEC the farms were targeted for: it is quite possible that they were targeted for a SMR or GAEC that we are not considering here. It is reasonable to think that we should expect higher rates of non-compliance for farms that have been selected in this way. Also, for the risk-based inspections, we do not know the risk score that the farms had: we would hope that higher the judged risk the greater the chances of non-compliance. Due to the potential importance of this factor, we decided to focus our analysis on the 17,416 inspections where the selection method was known. Table A2 shows the non-compliance rate for this restricted set of inspections. The differences between the non-compliance rates are minor, but the number of relevant inspections is quite heavily reduced.

Inspected SMR or GAEC		Overall frequency	Percentage of non-compliances
SMR 6	Pig identification & registration	429	13.3
SMR 7	Cattle identification and registration	9,011	42.0
SMR 8	Sheep and goats identification	3,002	14.4
SMR 9	Plant protection products	1,698	4.2
SMR 11	Food and feed law	2,451	2.5
GAEC 1	Soil Protection Review	2,637	5.6
GAEC 6	Sites of Special Scientific Interest	759	2.4
GAEC 8	Public rights of way	2,125	2.5
GAEC 11	Control of weeds	2,624	1.2
GAEC 14	Protection of hedgerows and watercourses	2,540	6.3
GAEC 15	Hedgerows	2,440	0.6

Table A2: Frequencies of inspections with known selection method covering each of the 11 chosen SMRs and GAECs and the associated non-compliance rates.

As already stated, the main purpose of this study was to determine whether assurance scheme members are more likely to meet the regulatory requirements of cross compliance. To investigate this, we produced a number of cross tables that compared non-compliance with assurance scheme membership. Tables A3 and A4 are reproductions of the cross tables comparing GAEC 1 compliance with Red Tractor and LEAF Marque membership respectively. When interpreting these tables, it is important to consider the data along the rows rather than down the columns because we are interested on rates of non-compliance given assurance scheme membership and not the other way around. It is also important to remember that there are other factors at work like the aforementioned selection method. Nevertheless, Table A3 shows that the rate of non-compliance for inspected farms not covered by Red Tractor is 8.7% (116 divided by 1,332) and the rate for members is 2.5%. This seems to show a possibly strong effect of Red Tractor membership in this case. Because the total number of inspections that are either covered by Red Tractor or not is similar, it is fair to compare the numbers in this way. We can calculate similar figures from Table A4: the rate of non-compliance for inspected farms not covered by LEAF Marque is 5.7% and the rate for members is 0%. This seems to be stronger evidence than that given in Table A3, but the number of inspected farms that are covered by LEAF Marque is much smaller than the number of farms not covered so it is not fair to compare in this way and the difference might not be statistically significant (especially given the presence of other factors).

		GAEC 1 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1,216	116	1,332
	Member	1,273	32	1,305
Total		2,489	148	2,637

Table A3: cross table of GAEC 1 compliance against Red Tractor membership.

		GAEC 1 inspection result		Total
		Compliant	Non-compliant	
LEAF Marque	Not member	2,449	148	2,597
	Member	40	0	40
Total		2,489	148	2,637

Table A4: cross table of GAEC 1 compliance against LEAF Marque membership.

The full set of cross tables is presented in Appendix A to this Technical Annex. These compare membership of the four schemes with each of the eleven SMRs and GAECs. It was clear from these tables that the relative infrequency of breaches for all SMRs/GAECs (apart from SMR 7) and the size of the membership of the smaller assurance schemes would make significant relationships more difficult to discover.

It is possible that there are other factors that might be causing the effects suggested in the cross tables of Appendix A. A key part of any regression analysis is to account for potential biasing from factors other than the main factor under consideration. In our study, the main factor under consideration was assurance scheme membership; however, we know that other attributes of the farm and how the farms were chosen for inspection will influence the rates of non-compliance. For instance, we would expect more cattle-related non-compliances for farms whose main activity involves cattle. To counter-act these effects, we explicitly model the impact of the factors that we can obtain from our linked data set. Throughout this report, we have referred to information that can be used to help explain variations in non-compliance as factors and individual possibilities for that factor setting as factor levels. For example, a factor we consider is farm economic size and this factor has five levels: very small, small, medium, large and very large (taken from records in the June census).

The factors considered in subsequent models are inspection year, inspection type, selection method, farm size and main farm activity. Inspection year is included as farmers responses to regulation and inspection protocols might have changed over the eight year study period or indeed inspection requirements altered. Inspection type gives information on the body that carried out the inspection and under what inspection regime. This is important because this can tell us something about what types of breaches were the foci of the inspection. For instance, cattle identity inspections (CII) are very relevant for SMR 7 (cattle identification and registration). A list of the considered factor levels for inspection type with brief explanations is given in Appendix B. The selection was discussed earlier and the final two factors (farm size and main farm activity) are taken from the June census data. For main activity, we have the enterprise description as factor levels like “cereals” and “specialist poultry”. Appendix C shows tabulations of the relevant inspections to show the frequency of inspections for each of the levels for each factor. It is worth noting that for some of the factor levels the number of relevant inspections is small and this impacted our ability to draw significant conclusions about them.

To capture any broad geographical trends the inspections were broken down into the nine administrative regions of England. London was merged with the South East region due to the low number of inspections. Table C3 in Appendix C shows the number of inspections for each region. There was sufficient data from each region to capture any effects this might be having on compliance and this was built into the statistical models. Three of the assurance schemes seem to be proportionally distributed across the regions, but there seems to be a relative concentration of Soil Association assured farms in the South West (in our data).

The analysis included an assessment of whether membership of multiple schemes affected results. The Pesticide Usage Survey gathers information on assurance scheme membership. In total, we were able to link 1,186 inspections to PUS records, and we found evidence of multiple assurance scheme membership. The following assurance schemes were identified in the PUS data alongside the four assurance schemes that are being considered in this study:

Dairy: Arla, Dairycrest, Milk Link, Wisemans and other unspecified dairy schemes;

Supermarket and retail: British Retail Consortium, Field to Fork and Natures Choice/Nurture;

Other schemes: FABBL, NADFAS, OF&G, UKVA and various other unspecified schemes.

However, there is reason to question the accuracy of this dataset given that it is based on farmers' recollection of scheme names and potentially a loose use of terminology. This is borne out in the above list of "other" assurance schemes: Farmers might think they are inspected by their milk purchaser but all of these will be the Red Tractor; British Retail Consortium is not a farm assurance scheme but one for food processors/packers and therefore not relevant to cross compliance; FABBL and NADFAS are the old names for the Red Tractor beef and dairy schemes respectively. Thus we cannot be sure that we are finding incidences of multiple scheme membership. As advised by the project steering group, the only real overlaps are between Red Tractor as a foundation scheme and others (LEAF/Field to Fork/Nurture) which add additional niche criteria. All LEAF and Nurture members in the UK will be Red Tractor. There are also overlaps between Red Tractor and organic schemes to provide flexibility as to how produce can be marketed.

It should be noted that this information is based on the survey responses and there were some mismatches between what was recorded in the survey and assurance scheme membership records. The effect of being a member of multiple assurance schemes is also of interest. Figure 1 shows the number of inspected farms that had multiple scheme membership at the time of inspection. The majority of inspected farms are members of more than one assurance scheme. However, when this data was linked with the inspections for which the selection method was known, the small number of inspections meant that there was little chance of identifying a significant relationship with compliance.

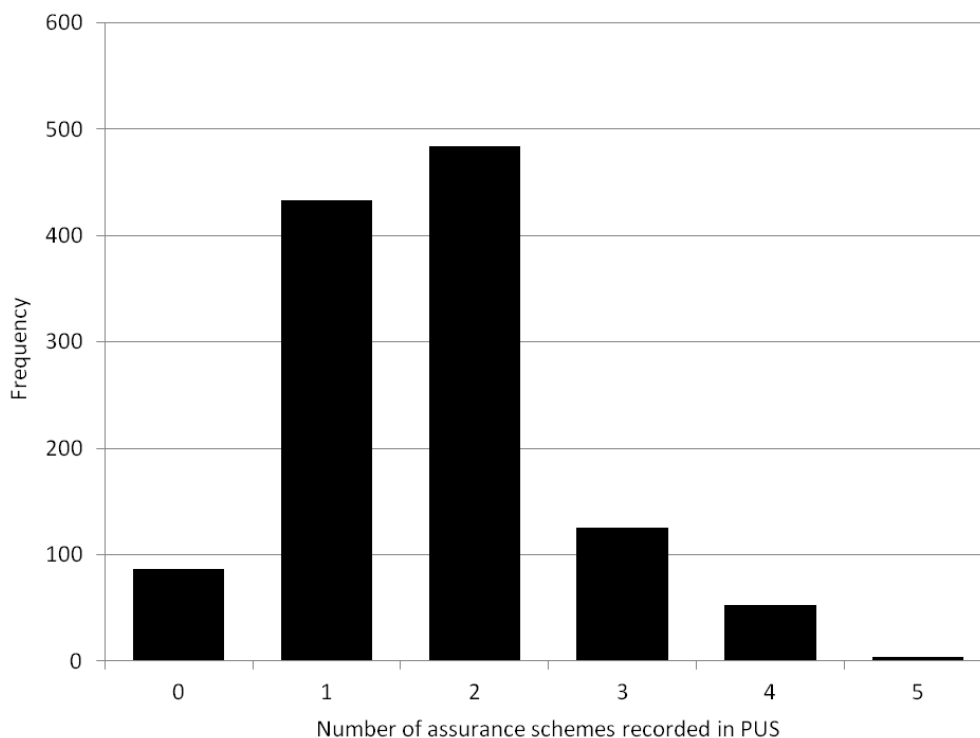


Figure 1: bar chart showing number of assurance scheme memberships per PUS-inspected holding.

The statistical model

In this section, we describe the statistical model that was used to relate the assurance schemes and non-compliance rates and the results that were produced by employing this model. Following the lead of Kilbride et al. (2012), a separate multilevel logistic regression model was used to assess the link between different factors and compliance for each SMR and GAEC. The model includes two random effects that serve to account for differences in inspection performance between farms and the administrative regions. The first random effect is the farm itself because farms are able to have been inspected multiple times over the eight year period that the RPA database covers. If a farm has been non-compliant at one stage, then it may change its chances of being non-compliant in other inspections. Figure 2 shows the frequency of all farms that been inspected against the number of times that they have been inspected over 2005 and 2012. It is clear from that figure that there are a large number of farms that have been inspected multiple times over the period and it may be important to recognise this in the models.

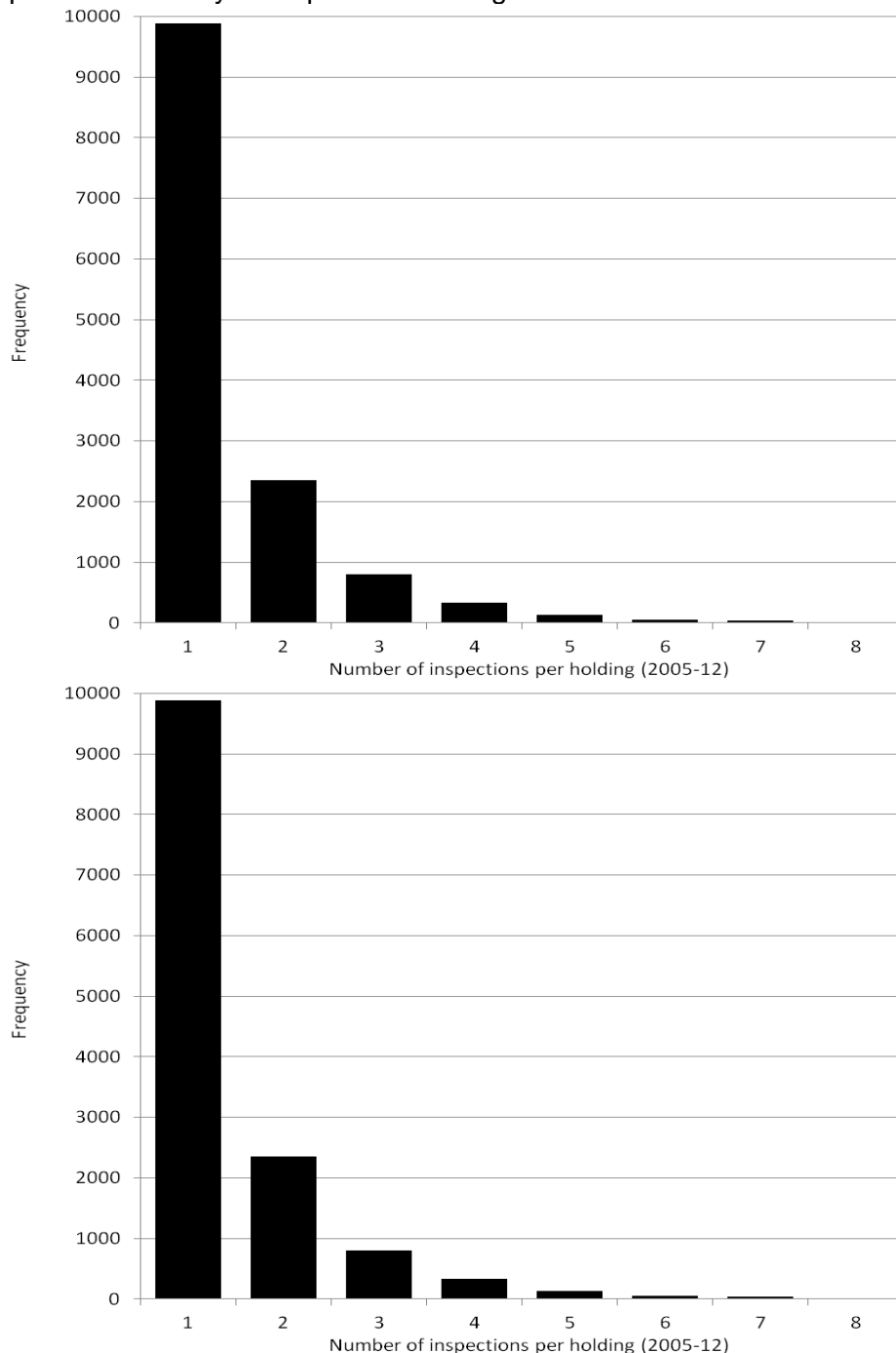


Figure 2: bar chart showing the number of inspections per holding over 2005-12 that have known selection method in our dataset.

The second random effect in the model is the geographic region of the inspected farm. Although this is quite a crude measure of location, it seems to capture differences in the farm types over England and there are enough data for each region to model this effect adequately. Because farm location is not changing over time, these effects are modelled in a multilevel way such that farm identity is nested within region. The statistical model's random effects control for regional effects and the effects of multiple inspections at a farm simultaneously, and these effects can be considered to have been nullified prior to the upcoming results.

A comprehensive description for the logistic regression procedure and methods for estimating the model's parameters are given in Ryan (1997). In practice, the individual regression models were fitted using two different statistical packages: R (R Development Core Team, 2012) and SPSS (IBM Corp., 2012). The reason for using the two different packages was that there are slight variations in estimation procedures and potential for numerical instability in the estimation procedures. However, no significant differences in the output from each package were found for all fitted models.

Due to the choice of model, it is easier to consider odds rather than probabilities of non-compliance. Specifically, these are the odds for an event happening, and the event of interest is non-compliance for each of the SMRs and GAECs. For example, if there is a 10% chance of non-compliance, then the odds of non-compliance can be expressed as:

$$\text{Odds} = 0.1/(1-0.1) = 1/9 .$$

If there is a 90% chance of non-compliance, then the odds of non-compliance can be expressed as

$$\text{Odds} = 0.9/(1-0.9) = 9/1 .$$

Odds ratios provide a natural way of interpreting the fitted coefficients from a logistic regression model. Essentially, an odds ratio gives an indication of whether the outcome of interest is more likely or not given some factor change in comparison to the reference scenario (in our models the outcome of interest is non-compliance for one of the SMRs or GAECs). The odds ratio in the model is defined by:

$$\text{Odds Ratio (OR)} = \frac{\text{Odds of non-compliance given changed factor level}}{\text{Odds of non-compliance given reference factor level}} .$$

Therefore, an odds ratio of greater than one means that non-compliance is more likely with that factor included, and, odds ratio of less than one means that non-compliance is less likely with that factor included. Of course, there is uncertainty in the estimates of the odds ratios due to sampling variation and this is captured through confidence intervals on the odds ratios. In the subsequent analyses, the 95% confidence interval is calculated and they are used to identify statistically significant (at the 5% level) departures from the odds ratio being one (that is the value for the odds ratio for which the factor is having no effect on the chances of the outcome of interest).

Before fitting the regression model to the data, the reference (or baseline) levels for each of the factors being considered in the model must be specified. Following guidance on selecting the reference levels from Ryan (1997), levels were selected where there was sufficient data to predict non-compliance rates and that, in general, matched the overall non-compliance rates for each of the SMRs and GAECs under consideration. The reference levels used in the regression modelling were:

Inspection year = 2012
 Inspection type = 1% selection
 Main activity = LFA grazing livestock
 Farm size = medium
 Selection method = random
 Assurance scheme membership = none

For simplicity and ease of computation, these reference levels were kept the same for the eleven regression models for each of the SMRs and GAECs. These levels must be kept in mind when considering the reported odds ratios in the results.

In Appendix D, the odds ratios for all factors in the dataset (and associated confidence intervals) are given for each model of non-compliance. For two of the GAECs, no models could be fitted to the non-compliances because there were too few reported to estimate the effects of all the relevant factors. Specifically, there were only 31 non-compliances in the dataset for GAEC 11 and 14 non-compliances for GAEC 15. Given the limited number of non-compliances for these two, there was little hope of adequately fitting a logistic regression model without further information.

The reported results in Appendix D show that, for five of the SMRs and GAECs, there is evidence that membership of the Red Tractor scheme has a significant effect (at the 5% level) on the chances of non-compliance. The small amount of data for the other assurance schemes meant that no significant relationships were found. However, in most cases, the best estimate of the effect of the membership of these schemes was favourable. This effect can be seen for SMR 7 when considering the effects of Red Tractor and Soil Association scheme membership: the proportions of compliance and non-compliance are similar across the assurance schemes (indeed, for Soil Association membership it is slightly better) the difference in the amount of data means that Red Tractor is estimated to have a significant positive impact whereas that for Soil Association is not significant (see the fitting results of Appendix D and compare with the cross tables of Appendix A).

To highlight the positive impact of Red Tractor membership, Table 5 gives the odds ratios from the fitted models comparing the effects of membership on the odds of non-compliance for the nine SMRs and GAECs where models could be produced (significant results in bold).

SMR or GAEC	Odds ratio for Red Tractor membership against no assurance scheme membership		
	Estimate	95% confidence interval	
		Lower	Upper
SMR 6	0.36	0.17	0.75
SMR 7	0.64	0.58	0.71
SMR 8	0.66	0.52	0.84
SMR 9	1.31	0.74	2.35
SMR 11	0.46	0.22	0.95
GAEC 1	0.49	0.31	0.77
GAEC 6	0.48	0.14	1.70
GAEC 8	0.83	0.45	1.54
GAEC 14	1.15	0.76	1.76

Table 5: the estimated odds ratios and associated confidence intervals highlighting the impact of Red Tractor membership on odds of non-compliance.

Apart from Red Tractor scheme membership, other factors played an important role in the prevalence of non-compliance for nearly all of the SMRs and GAECs. Table 6 shows the significant factors for each model of non-compliance for all of the SMRs and GAECs under consideration (the factors and their levels are shown in Appendices C and D). The strongest results in terms of certainty in the estimated effects come from SMR 7 as it has the most data, but significant effects were identified for nearly all of the SMRs and GAECs.

	Activity	Size	Year	Inspection Type	Selection method	Red Tractor
SMR 6	X	X	X	X	X	✓
SMR 7	✓	✓	✓	✓	✓	✓
SMR 8	✓	✓	✓	X	✓	✓
SMR 9	X	✓	X	✓	X	X
SMR 11	X	X	X	X	X	✓
GAEC 1	✓	✓	✓	✓	✓	✓
GAEC 6	X	X	X	✓	X	X
GAEC 8	✓	✓	✓	✓	✓	X
GAEC 11	-	-	-	-	-	-
GAEC 14	✓	✓	✓	✓	✓	X
GAEC 15	-	-	-	-	-	-

Table 6: significant factors for each of the models.

The inspected farm's main activity has an effect on chances of non-compliance for five of the SMRs and GAECs. This is to be expected as the farms of different type may have different chances to breach non-compliances. For instance, farms with more cattle are more likely to have problems with SMR 7 (cattle identification and registration) than farms that focus on cereals or general cropping. Similar arguments help us to understand why farm size is an important factor for six of the SMRs and GAECs. For instance, the bigger the enterprise, the more land it is likely to cover and there are more chance to breach GAEC 8 (public right of way).

The inspection year plays a significant role in the logistic regression models for five of the SMRs and GAECs. This suggests that the farmers' responses to the SMRs and GAECs might have changed over the period 2005 to 2012. Figure 3 is a diagram comparing the confidence intervals (on a log scale) for the odds ratios comparing the year effect with the baseline year (2012). It shows that 2009, 2010 and 2011 are not significantly different from each other or 2012. Further 2006, 2007 and 2008 are not significantly different from each other. The first year, 2005, is significantly different to every other year and the uncertainty about that year's effect is much greater due to the small number of available inspections from 2005. This was as a result of 2005 being the first year cross compliance was in operation and, given the time it took to establish the necessary processes, inspections could only begin in October, and there was insufficient time to conduct more than a low number.

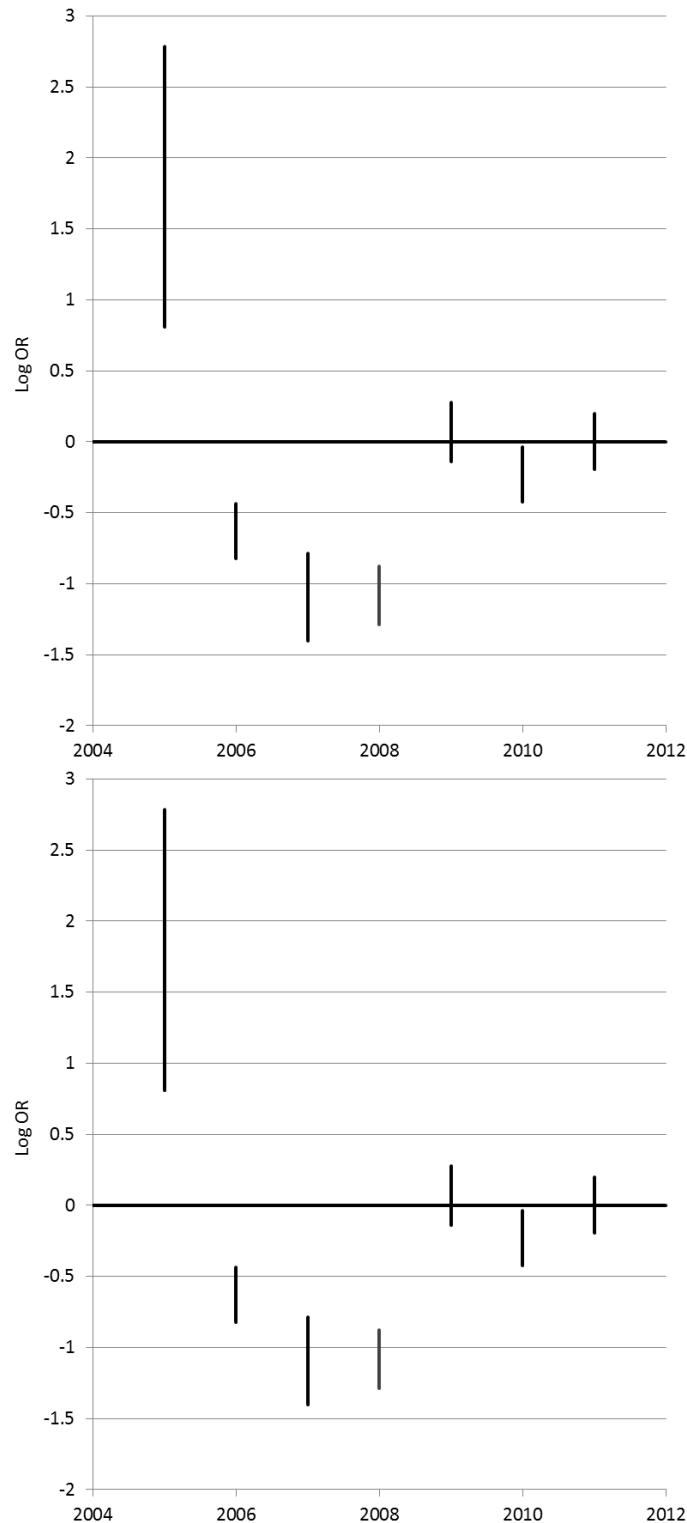


Figure 3: diagrammatic representation of the odds ratio confidence intervals from the non-compliance model for SMR 7.

There are two factor levels that consistently result in increased chances of non-compliance being recorded: “multiple inspections” and “RPAI standalone inspections”. These factor levels fall under the broad factor of “inspection type” that records the body responsible for the inspection and the focus of the inspection (see Appendix B). There are no surprises that these inspection results categories yield more non-compliances because “multiple inspections” mean that a farm has had more than one cross compliance breach detected over the calendar year and thus by definition increasing the chance of being recorded as being non-compliant. “RPAI standalone inspections” are reports of non-compliance detected by RPA at other non-cross-compliance inspections.

The method by which the farm is selected for inspection is significant for five of the SMRs and GAECs and this is mainly driven by the effects of the targeted inspections, which are inspections that are prompted by reports of possible non-compliances to the RPA from third parties. There is little evidence that risk-based inspections are returning more non-compliances than the random inspections for these SMRs and GAECs. The exception comes for SMR 7 where the estimated odds ratio is 1.3 with confidence interval (1.1, 1.5). On the other hand, the targeted inspections have a significant effect for most of the SMRs, which was perhaps expected given the nature of this selection method.

Since these significant factors have been explicitly modelled there is greater confidence that the correct factors are modelled. Also, it is shown that, where Red Tractor has been found to have a significant effect, this effect is still present even after the strong effect of the other factors has been accounted for. However, the models do not explicitly consider the interactions between the different factors. It is theoretically possible to include interaction terms in our model, but it would not be possible to look at all possible cross-products between all factors. It is possible to investigate relationships in the factors in an attempt to model potentially significant interactions to assess whether some factor combinations are more likely than others and if this is impacting the analyses. The following features were identified in the data (all the statements should be proceeded by the words “relatively speaking”):

- There are few small and very small dairy farms and specialist poultry farms.
- All farms whose activity is given as “other” are very small.
- There are fewer than expected large or very large LFA or lowland grazing farms.
- Far more RPAI and SAG standalone inspections occurred in 2012.
- Nearly all “CII” inspections occurred in 2005, and these tend to be risk-based or targeted.
- Red Tractor membership seems to coincide more with larger farms.
- There is a higher proportion of dairy that are Red Tractor assured.

Adding interaction terms into the models that correspond with the preceding statements had little effect and, in some cases, where factors have been found to coincide, there has still been enough evidence to show them to have significant effects in opposite directions. For example in the model SMR 7 non-compliance, Red Tractor membership coincides with a reduction in odds of non-compliance whereas larger farms coincide with an increased rate of non-compliance.

In the RPA inspection data, there is information about the severity of the non-compliances for each recorded non-compliance. This is a judgement that is made by the inspector based on criteria that have changed slightly over the period being investigated in this study. In the data, there were seven categories given for severity of non-compliances. The seven recorded categories of non-compliance severity were mapped to three for modelling purposes to try to standardise the meanings of the severity ratings across the years (see Table 7).

Modelled category	Severity rating recorded in RPA inspection
“Low”	“Minor”, “Minimum”, “Very low”, “Low”
“Medium”	“Medium”
“High”	“High”, “Very high”

Table 7: translation of recorded severity categories to what was modelled.

A similar model to the one used for the binary response was used (a proportional odds model) that focussed on non-compliances and specifically the odds of a non-compliance being in the “medium” or “high” category rather than the “low”. The reference category is as before, but looking at departures from the “Low” rating. Due to data constraints, it was only possible to fit an adequate model to the reported severities for SMR 7. In Appendix E, odds ratios are given for each of the factors: Table E1 gives the odds ratios that compare the odds of going from the “Low” category to the “Medium” category, and Table E2 gives the odds ratios that compare the odds of going from the “Low” category to the “High” category. In both cases, there is significant evidence that Red

Tractor membership has a positive effect on the chances of the non-compliances being rated as “Medium” or “High”. In plain terms, this means that, if a farm breaches SMR 7, then we would expect that it is less likely to be rated as having “Medium” or “High” severity if it is assured by Red Tractor. Again, the evidence for the other assurance schemes seems to be positive (especially for the chances of going from “Low” to “High”), but the uncertainty is too great due to the small number of farms under those schemes to have statistical significance.

For the 2010 and 2011 assurance scheme data, we had more information on the type of scheme being assured under for both the Genesis and Red Tractor schemes. Specifically, we had additional information on the following schemes:

- Genesis: Beef and Lamb, Crops, Pigs.
- Red Tractor: Beef and Lamb, Crops, Dairy, Pigs, Produce.

It was hoped that this might help make links between specific enterprise-based assurance schemes and relevant SMRs and GAECs. Again the low number of relevant inspections and non-compliances limited the ability to fit models for all SMRs and GAECs. It was possible to fit a logistic regression model for SMR 7 non-compliances (further details of the fit and the results are given in Appendix F). Out of the eight enterprise-based schemes listed above, there was only enough data to estimate the effects of five of the schemes and the modelling found that only one had a significant effect on SMR 7 non-compliance. The estimated odds ratio for Red Tractor Beef and Lamb membership was 0.7 with a confidence interval of (0.6, 0.8). In most cases, similar (albeit weaker) factors effects to the modelled factor effects were seen across all years.

Finally, a model was run that linked with the multiple assurance scheme data from the PUS. The hypothesis was that farms with a higher number of assurance scheme memberships could be expected to have less chance of non-compliance. However, due to probable shortcomings in the PUS assurance scheme membership data as discussed earlier, the small number of inspections linking the RPA inspections and PUS data, and the high number of important factors that were being considered, it was not possible to fit adequate models.

In order to gain further confidence in the results obtained from the analyses, a number of other fitting exercises were undertaken. Analyses were carried out on:

- The full dataset including the unknown selection method inspections, but removing known “targeted” inspections.
- Random subsets of the full dataset.
- The dataset with known selection, but with 5% of inspections randomly reassigned to opposite RT membership status.
- Because the Genesis and Red Tractor are generally considered to be very similar over the study period an analysis was carried out that combined the two into one factor.

In all cases, results were very similar to the results in which all the data where selection methods is known were used. This suggests that the modelling undertaken is robust and that the correct conclusions about the effects of the various factors are drawn.

Conclusions

The link between avoiding non-compliance and assurance scheme membership is strong for five of the nine SMRs and GAECs modelled. The strength of these results is driven by the amount of data that was available for the Red Tractor assured farms. Although it has been possible to estimate positive effects for the other assurance schemes, the amount of uncertainty in the predictions has meant statistical significance cannot be claimed. The amount of uncertainty in much of the estimated models is due to the low levels of non-compliance for the majority of SMRs and GAECs under consideration. Indeed for two of the GAECs there were fewer than fifty recorded non-compliances over the eight years (2005 to 2012).

As discussed in the previous section and highlighted in the fitting results of Appendix F, there is a lot of information in the analyses about important factors that could be of use to the RPA. In

particular, these results could be used to help inform updates to their risk-based selection process. In practice, this could be done by coupling the information from the odds ratio tables with information about the prevalence of non-compliance and the judged importance of compliance for each SMR and GAEC. For SMR 7, the “risk-based” selection method had the effect of increasing the chances of non-compliance, but, for GAEC 1, the inspections that were selected under the “risk-based” criteria coincided with fewer than expected non-compliances.

Of course, all statistical models are in some way approximate, but effects discussed here and the breadth of the analyses undertaken suggests that the findings are robust.

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Appendix A

Below are the cross tabulated data that compares assurance scheme membership with inspection compliance for each of the eleven SMRs and GAECs under consideration. Note that these tables focus on the inspections for which the selection method is known. Also, when interpreting these tables, it is important to consider the data by row and not by column and to remember that there are other factors at work.

		SMR6 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	323	54	377
	Member	49	3	52
Total		372	57	429

		GAEC1 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	2347	144	2491
	Member	142	4	146
Total		2489	148	2637

		SMR7 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	4999	3616	8615
	Member	224	172	396
Total		5223	3788	9011

		GAEC6 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	714	18	732
	Member	27	0	27
Total		741	18	759

		SMR8 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	2442	415	2857
	Member	128	17	145
Total		2570	432	3002

		GAEC8 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	1960	53	2013
	Member	111	1	112
Total		2071	54	2125

		SMR9 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	1524	68	1592
	Member	102	4	106
Total		1626	72	1698

		GAEC11 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	2450	31	2481
	Member	143	0	143
Total		2593	31	2624

		SMR11 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	2248	61	2309
	Member	141	1	142
Total		2389	62	2451

		GAEC14 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	2244	146	2390
	Member	137	13	150
Total		2381	159	2540

		GAEC15 inspection result		Total
		Compliant	Non-compliant	
Genesis	Not member	2283	13	2296
	Member	143	1	144
Total		2426	14	2440

Tables A1: cross tabulated data on inspection results against Genesis membership

		SMR6 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	369	56	425
	Member	3	1	4
Total		372	57	429

		GAEC1 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2449	148	2597
	Member	40	0	40
Total		2489	148	2637

		SMR7 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	5197	3768	8965
	Member	26	20	46
Total		5223	3788	9011

		GAEC6 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	724	18	742
	Member	17	0	17
Total		741	18	759

		SMR8 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2548	429	2977
	Member	22	3	25
Total		2570	432	3002

		GAEC8 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2039	50	2089
	Member	32	4	36
Total		2071	54	2125

		SMR9 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	1586	72	1658
	Member	40	0	40
Total		1626	72	1698

		GAEC11 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2554	31	2585
	Member	39	0	39
Total		2593	31	2624

		SMR11 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2351	60	2411
	Member	38	2	40
Total		2389	62	2451

		GAEC14 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2344	156	2500
	Member	37	3	40
Total		2381	159	2540

		GAEC15 inspection result		Total
		Compliant	Non-compliant	
Leaf Marque	Not member	2387	14	2401
	Member	39	0	39
Total		2426	14	2440

Tables A2: cross tabulated data on inspection results against LEAF Marque membership

		SMR6 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	184	39	223
	Member	188	18	206
Total		372	57	429

		GAEC1 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1216	116	1332
	Member	1273	32	1305
Total		2489	148	2637

		SMR7 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	2427	1907	4334
	Member	2796	1881	4677
Total		5223	3788	9011

		GAEC6 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	359	9	368
	Member	382	9	391
Total		741	18	759

		SMR8 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1032	227	1259
	Member	1538	205	1743
Total		2570	432	3002

		GAEC8 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	975	21	996
	Member	1096	33	1129
Total		2071	54	2125

		SMR9 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	710	30	740
	Member	916	42	958
Total		1626	72	1698

		GAEC11 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1305	19	1324
	Member	1288	12	1300
Total		2593	31	2624

		SMR11 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1125	43	1168
	Member	1264	19	1283
Total		2389	62	2451

		GAEC14 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1181	56	1237
	Member	1200	103	1303
Total		2381	159	2540

		GAEC15 inspection result		Total
		Compliant	Non-compliant	
Red Tractor	Not member	1204	5	1209
	Member	1222	9	1231
Total		2426	14	2440

Tables A3: cross tabulated data on inspection results against Red Tractor membership

		SMR6 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	371	57	428
	Member	1	0	1
Total		372	57	429

		GAEC1 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	739	18	757
	Member	2	0	2
Total		741	18	759

		SMR7 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	5194	3772	8966
	Member	29	16	45
Total		5223	3788	9011

		GAEC6 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2065	53	2118
	Member	6	1	7
Total		2071	54	2125

		SMR8 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	1623	72	1695
	Member	3	0	3
Total		1626	72	1698

		GAEC8 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2586	31	2617
	Member	7	0	7
Total		2593	31	2624

		SMR9 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2382	62	2444
	Member	7	0	7
Total		2389	62	2451

		GAEC11 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2374	159	2533
	Member	7	0	7
Total		2381	159	2540

		SMR11 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2482	148	2630
	Member	7	0	7
Total		2489	148	2637

		GAEC14 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2419	14	2433
	Member	7	0	7
Total		2426	14	2440

		GAEC15 inspection result		Total
		Compliant	Non-compliant	
Soil Associa.	Not member	2387	14	2401
	Member	39	0	39
Total		2426	14	2440

Tables A4: cross tabulated data on inspection results against Soil Association membership

Appendix B

Below are definitions for some of the abbreviated factor level names that are discussed in our analyses. In the RPA inspection data, the type of inspection result is recorded. In Table B1 are brief explanations provided by the RPA for each of the inspection type results.

Inspection type	Brief description
1% selection	All reports of 1% of the SPS/relevant pillar II claim population selected by RPA for a Cross Compliance inspection. Started in 2005.
CII	Selected by BCMS as the regulatory cattle inspection regime (10% until May 2009, 5% in 2009/10 and 2010/11 and 3% from 2011/12 onwards, CII year crosses calendar years: June to May).
SAG standalone	All reports of 3% regulatory Sheep and Goat inspection regime, which started in 2007, selected by BCMS. These inspections include both SPS and non SPS claimants. Started in 2007.
AH standalone	Reports of Cross Compliance non compliance only from AHVLA found during their other (animal health) inspections i.e. those in addition to the 1% Cross Compliance selection they do on behalf of RPA. Started in 2007.
EA standalone	Reports of Cross Compliance non compliance only from EA found during any other routine inspections they conduct. Started in 2005.
RPAI standalone	Any report of a Cross Compliance non-compliance found by RPAI through non Cross Compliance related inspections, e.g. through a Land Eligibility, or an agri-environment (ELS, HLS), inspection. Started in 2005.
Multiple inspection	This is a record created to show the final position for any given SBI if it has been subject to either more than 1 Cross Compliance related inspection in a calendar year (i.e. 1% selection or animal ID) or more than 1 separate report of a non compliance in a calendar year obtained from another inspection regime additional to RPA cross compliance (i.e. EA or AH).

Table B1: brief descriptions of the inspection types considered in our analyses (provided by the RPA).

Appendix C

The following tables show frequencies of all factor levels for the data that have been used in the analyses. In total, there were 45,500 inspections that could be linked to additional data about farm size, activity and location. Of those inspections, we could only identify the method of selection for inspection for 17,416. Table C1 gives the frequencies for each

Selection method	Frequency
Random	2,223
Risk-based	14,043
Targeted (referred to RPA)	1,150
Unknown	28,084

Table C1: frequencies of inspections that were selected under three different regimes.

Tables C2 to C6 show the frequencies of each factor level for each factor that was considered in our analysis (for the whole dataset and the inspections where the selection method is known). It should be noted that, although there seems to be fair numbers of inspections for most factor levels, not all of the inspections in the RPA dataset were relevant to our eleven SMRs and GAECs under consideration and this is reflected in the number of relevant inspections shown in Table 2.

Inspection year	Overall frequency	Frequency with known selection method
2005	2,870	36
2006	4,993	1,924
2007	4,496	1,914
2008	9,517	2,189
2009	7,316	2,135
2010	6,220	3,887
2011	6,309	3,780
2012	3,779	1,551

Table C2: frequencies of inspections in each calendar year.

Region	Overall frequency	Frequency with known selection method
East Midlands	4,969	2,015
East of England	3,238	1,412
North East	1,882	752
North West	6,977	2,453
South East	4,843	1,811
South West	11,732	4,277
West Midlands	6,553	2,491
Yorkshire and the Humber	5,306	2,205

Table C3: frequencies of inspections for each of the nine administrative regions.

Inspection type	Overall frequency	Frequency with known selection method
1% Selection	5,851	2,622

AH Standalone	451	177
CII	23,117	7,966
EA Selection	4,740	2,846
EA Standalone	457	79
Multiple Inspection	2,815	959
NE Standalone	16	1
RPAI Standalone	371	111
SAG Standalone	7,682	2,655

Table C4: frequencies of inspections for each inspection as defined by the RPA (see Appendix B).

Main farm activity	Overall frequency	Frequency with known selection method
Cereals	3,844	1,739
Dairy	6,042	2,367
General Cropping	3,601	1,628
Horticulture	522	236
LFA Grazing Livestock	7,569	2,625
Lowland Grazing Livestock	17,134	6,274
Mixed	5,551	2,075
Other Types	128	70
Specialist Pigs	658	223
Specialist Poultry	451	179

Table C5: frequencies of inspections for each main farm activity as given in the June Census.

Farm size	Overall frequency	Frequency with known selection method
Very Small	17,335	6,801
Small	7,841	3,026
Medium	10,175	3,756
Large	5,718	2,077
Very Large	4,431	1,756

Table C6: frequencies of inspections for the listed farm size as given in the June Census.

Table C7 shows the percentages of inspections that are recorded in the RPA dataset on farms that are covered by the four assurance schemes under consideration. To get this data, the RPA inspection data was cross-referenced with membership information provided by the assurance schemes.

Assurance scheme	Overall percentage	Percentage with known selection method
Genesis	5.0	5.3
LEAF Marque	0.8	1.0
Red Tractor	55.1	53.4
Soil Association	0.4	0.4

Table C7: percentages of inspections that were carried out on farms that are covered by each of the assurance schemes.

Appendix D

In Tables D1 to D9, there are details of the odds ratios stemming from each model fit. For each reported factor level, the tables give odds ratios comparing the odds of non-compliance if that factor level is used instead of the reference level with the odds of non-compliance for the reference levels. In this version of the model the reference category is specified as:

Inspection year = 2012, Inspection type = 1% selection, Main activity = LFA grazing livestock, Farm size = medium, Selection method = random, Assurance scheme membership = none.

If the odds ratio is greater than one, then non-compliance is more likely at the specified factor level than at the reference category. Similarly, if we find an odds ratio less than one, non-compliance is more likely at the reference level. The 95% confidence intervals are reported for each of the factor levels. If the confidence interval does not include 1, then there is some evidence that there is a change in odds caused by changing to that factor level from the reference level. Tables D1 to D9 highlights those confidence intervals and associated odds ratio estimates for which the interval does not include 1. It can be said that the difference from parity is statistical significant at the 5% level in these cases (where the null hypothesis is that the factor does not alter the odds and the alternative is that the odds ratio is not equal to one).

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	N/A**		
	2007	0.501	0.137	1.887
	2008	0.539	0.136	2.131
	2009	0.512	0.139	1.887
	2010	0.655	0.197	2.171
	2011	0.535	0.167	1.720
	2012	Ref*		
Main activity	Cereals	N/A**		
	Dairy	0.370	0.084	1.627
	General cropping	0.091	0.008	1.036
	Horticulture	N/A**		
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	1.013	0.390	2.633
	Mixed	1.276	0.441	3.692
	Other types	N/A**		
	Specialist pigs	1.209	0.307	4.769
	Specialist poultry	N/A**		
Farm size	Very small	0.680	0.273	1.698
	Small	1.621	0.620	4.235
	Medium	Ref*		
	Large	0.661	0.118	3.717
	Very large	1.988	0.563	4.235
Selection method	Random	Ref*		
	Risk-based	0.996	0.357	2.779
	Targeted due to referral	3.181	0.822	12.309
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	2.158	0.885	5.263
	NE standalone	N/A**		
	RPAI standalone	N/A**		
	SAG standalone	N/A**		
Genesis	Member	0.388	0.084	1.793
	Non-member	Ref*		
LEAF Marque	Member	N/A**		
	Non-member	Ref*		
Red Tractor	Member	0.360	0.172	0.751
	Non-member	Ref*		
Soil Association	Member	N/A**		
	Non-member	Ref*		
Model intercept		0.428	0.070	2.628

Table D1: estimated odds ratios for all factors considering the relative odds of non-compliance for SMR 6.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were two few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	6.021	2.242	16.164
	2006	0.533	0.439	0.648
	2007	0.335	0.246	0.457
	2008	0.339	0.276	0.417
	2009	1.073	0.872	1.320
	2010	0.792	0.653	0.961
	2011	1.002	0.824	1.218
	2012	Ref*		
Main activity	Cereals	0.483	0.385	0.606
	Dairy	1.553	1.280	1.885
	General cropping	0.595	0.477	0.743
	Horticulture	0.724	0.449	1.165
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	1.307	1.140	1.499
	Mixed	0.930	0.780	1.109
	Other types	2.171	0.946	4.983
	Specialist pigs	1.004	0.614	1.642
	Specialist poultry	0.527	0.329	0.845
Farm size	Very small	0.512	0.445	0.589
	Small	0.866	0.746	1.006
	Medium	Ref*		
	Large	1.110	0.932	1.322
	Very large	1.545	1.276	1.871
Selection method	Random	Ref*		
	Risk-based	1.258	1.076	1.472
	Targeted due to referral	2.210	1.770	2.758
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	1.631	1.147	2.320
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	3.163	2.257	4.433
	NE standalone	N/A**		
	RPAI standalone	N/A**		
SAG standalone	N/A**			
Genesis	Member	0.935	0.751	1.165
	Non-member	Ref*		
LEAF Marque	Member	1.133	0.599	2.143
	Non-member	Ref*		
Red Tractor	Member	0.644	0.582	0.713
	Non-member	Ref*		
Soil Association	Member	0.762	0.390	1.487
	Non-member	Ref*		
Model intercept		0.737	0.471	1.153

Table D2: estimated odds ratios for all factors considering the relative odds of non-compliance for SMR 7.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	0.181	0.022	1.514
	2007	0.444	0.260	0.758
	2008	0.430	0.272	0.680
	2009	0.284	0.18	0.449
	2010	0.263	0.175	0.394
	2011	0.403	0.273	0.596
	2012	Ref*		
Main activity	Cereals	0.762	0.410	1.418
	Dairy	1.674	0.940	2.982
	General cropping	0.622	0.321	1.205
	Horticulture	1.452	0.401	5.260
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	1.550	1.151	2.086
	Mixed	1.439	0.956	2.164
	Other types	N/A**		
	Specialist pigs	2.071	0.920	4.664
	Specialist poultry	2.009	0.714	5.655
Farm size	Very small	1.432	1.055	1.944
	Small	1.874	1.341	2.621
	Medium	Ref*		
	Large	0.763	0.476	1.222
	Very large	1.006	0.615	1.646
Selection method	Random	Ref*		
	Risk-based	1.062	0.741	1.522
	Targeted due to referral	2.227	1.298	3.821
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	1.555	0.917	2.638
	NE standalone	N/A**		
	RPAI standalone	N/A**		
	SAG standalone	1.105	0.645	1.893
Genesis	Member	0.788	0.451	1.376
	Non-member	Ref*		
LEAF Marque	Member	1.986	0.550	7.168
	Non-member	Ref*		
Red Tractor	Member	0.662	0.523	0.838
	Non-member	Ref*		
Soil Association	Member	0.409	0.051	3.296
	Non-member	Ref*		
Model intercept		0.220	0.089	0.542

Table D3: estimated odds ratios for all factors considering the relative odds of non-compliance for SMR 8.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	v		
	2006	N/A**		
	2007	0.871	0.326	2.328
	2008	0.895	0.263	3.042
	2009	0.458	0.127	1.651
	2010	0.669	0.247	1.811
	2011	0.686	0.254	1.851
	2012	Ref*		
Main activity	Cereals	0.592	0.221	1.585
	Dairy	0.489	0.157	1.523
	General cropping	1.075	0.425	2.716
	Horticulture	2.119	0.543	8.264
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	0.906	0.398	2.064
	Mixed	0.908	0.328	2.515
	Other types	3.440	0.322	36.708
	Specialist pigs	N/A**		
	Specialist poultry	3.385	0.553	20.713
Farm size	Very small	1.541	0.672	3.533
	Small	2.082	0.911	4.756
	Medium	Ref*		
	Large	2.410	1.029	5.645
	Very large	0.660	0.227	1.919
Selection method	Random	Ref*		
	Risk-based	1.596	0.770	3.309
	Targeted due to referral	2.090	0.830	5.263
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	2.475	1.128	5.429
	NE standalone	N/A**		
	RPAI standalone	15.308	4.572	51.254
SAG standalone	N/A**			
Genesis	Member	1.290	0.419	3.970
	Non-member	Ref*		
LEAF Marque	Member	N/A**		
	Non-member	Ref*		
Red Tractor	Member	1.314	0.735	2.351
	Non-member	Ref*		
Soil Association	Member	N/A**		
	Non-member	Ref*		
Model intercept		0.022	0.005	0.091

Table D4: estimated odds ratios for all factors considering the relative odds of non-compliance for SMR 9.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	2.401	0.157	36.790
	2007	1.207	0.335	4.353
	2008	1.655	0.382	7.174
	2009	0.991	0.224	4.386
	2010	1.022	0.275	3.794
	2011	1.120	0.314	3.995
	2012	Ref*		
Main activity	Cereals	0.816	0.224	2.979
	Dairy	0.386	0.056	2.636
	General cropping	1.526	0.522	4.459
	Horticulture	0.913	0.074	11.205
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	1.189	0.513	2.754
	Mixed	1.118	0.338	3.700
	Other types	3.632	0.265	49.765
	Specialist pigs	3.878	0.551	27.277
	Specialist poultry	N/A**		
Farm size	Very small	1.123	0.443	2.843
	Small	1.109	0.402	3.060
	Medium	Ref*		
	Large	0.594	0.120	2.948
	Very large	0.415	0.072	2.831
Selection method	Random	Ref*		
	Risk-based	1.542	0.653	3.639
	Targeted due to referral	1.349	0.371	4.914
Inspection type	1% selection	Ref*		
	AH standalone	9.754	0.592	160.709
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	0.886	0.249	3.159
	NE standalone	N/A**		
	RPAI standalone	N/A**		
SAG standalone	N/A**			
Genesis	Member	0.281	0.024	3.264
	Non-member	Ref*		
LEAF Marque	Member	4.142	0.470	36.543
	Non-member	Ref*		
Red Tractor	Member	0.458	0.220	0.953
	Non-member	Ref*		
Soil Association	Member	N/A**		
	Non-member	Ref*		
Model intercept		0.022	0.004	0.114

Table D5: estimated odds ratios for all factors considering the relative odds of non-compliance for SMR 11.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	N/A**		
	2007	0.210	0.108	0.410
	2008	0.533	0.244	1.163
	2009	0.476	0.237	0.959
	2010	0.533	0.304	0.936
	2011	0.665	0.385	1.151
	2012	Ref*		
Main activity	Cereals	0.195	0.066	0.582
	Dairy	0.366	0.100	1.334
	General cropping	1.016	0.560	1.842
	Horticulture	0.905	0.232	3.527
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	0.988	0.612	1.596
	Mixed	1.396	0.713	2.735
	Other types	2.376	0.691	8.175
	Specialist pigs	3.634	1.094	12.07
	Specialist poultry	4.314	1.240	15.013
Farm size	Very small	2.480	1.319	4.664
	Small	1.388	0.673	2.863
	Medium	Ref*		
	Large	0.625	0.210	1.858
	Very large	0.443	0.118	1.664
Selection method	Random	Ref*		
	Risk-based	0.654	0.438	0.974
	Targeted due to referral	0.917	0.439	1.917
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	1.678	0.849	3.316
	NE standalone	N/A**		
	RPAI standalone	10.513	3.338	33.111
SAG standalone	N/A**			
Genesis	Member	0.611	0.209	1.785
	Non-member	Ref*		
LEAF Marque	Member	N/A**		
	Non-member	Ref*		
Red Tractor	Member	0.490	0.313	0.770
	Non-member	Ref*		
Soil Association	Member	N/A**		
	Non-member	Ref*		
Model intercept		0.125	0.051	0.305

Table D6: estimated odds ratios for all factors considering the relative odds of non-compliance for GAEC 1.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	N/A**		
	2007	0.147	0.015	1.448
	2008	0.983	0.096	10.039
	2009	0.924	0.146	5.853
	2010	0.234	0.026	2.112
	2011	0.139	0.010	1.991
	2012	Ref*		
Main activity	Cereals	0.265	0.020	3.513
	Dairy	0.565	0.093	3.442
	General cropping	0.176	0.014	2.152
	Horticulture	N/A**		
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	0.131	0.013	1.303
	Mixed	0.301	0.024	3.760
	Other types	N/A**		
	Specialist pigs	N/A**		
	Specialist poultry	N/A**		
Farm size	Very small	0.580	0.104	3.228
	Small	0.671	0.107	4.191
	Medium	Ref*		
	Large	2.540	0.449	14.364
	Very large	3.077	0.430	22.028
Selection method	Random	Ref*		
	Risk-based	0.383	0.086	1.700
	Targeted due to referral	0.332	0.023	4.760
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	3.422	0.858	13.659
	NE standalone	N/A**		
	RPAI standalone	26.509	1.657	424.120
SAG standalone	N/A**			
Genesis	Member	N/A**		
	Non-member	Ref*		
LEAF Marque	Member	N/A**		
	Non-member	Ref*		
Red Tractor	Member	0.479	0.135	1.702
	Non-member	Ref*		
Soil Association	Member	N/A**		
	Non-member	Ref*		
Model intercept		0.294	0.027	3.172

Table D7: estimated odds ratios for all factors considering the relative odds of non-compliance for GAEC 6.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	0.428	0.082	2.238
	2007	0.124	0.050	0.309
	2008	0.133	0.038	0.468
	2009	0.177	0.061	0.507
	2010	0.209	0.092	0.473
	2011	0.141	0.058	0.342
	2012	Ref*		
Main activity	Cereals	4.371	1.101	17.36
	Dairy	2.219	0.530	9.298
	General cropping	6.702	1.719	26.127
	Horticulture	N/A**		
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	2.579	0.640	10.382
	Mixed	1.856	0.351	9.815
	Other types	N/A**		
	Specialist pigs	N/A**		
	Specialist poultry	N/A**		
Farm size	Very small	0.413	0.165	1.033
	Small	0.284	0.086	0.943
	Medium	Ref*		
	Large	1.816	0.786	4.201
	Very large	2.469	1.057	5.768
Selection method	Random	Ref*		
	Risk-based	1.198	0.561	2.556
	Targeted due to referral	2.433	1.026	5.768
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	1.239	0.420	3.655
	NE standalone	N/A**		
	RPAI standalone	N/A**		
	SAG standalone	N/A**		
Genesis	Member	0.418	0.073	2.398
	Non-member	Ref*		
LEAF Marque	Member	1.328	0.426	4.139
	Non-member	Ref*		
Red Tractor	Member	0.829	0.447	1.538
	Non-member	Ref*		
Soil Association	Member	2.238	0.057	87.391
	Non-member	Ref*		
Model intercept		0.03	0.006	0.144

Table D8: estimated odds ratios for all factors considering the relative odds of non-compliance for GAEC 8.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	N/A**		
	2006	2.273	0.640	8.071
	2007	0.320	0.153	0.670
	2008	0.474	0.193	1.163
	2009	0.751	0.347	1.624
	2010	0.521	0.263	1.035
	2011	0.751	0.391	1.442
	2012	Ref*		
Main activity	Cereals	23.990	5.481	104.996
	Dairy	8.537	1.913	38.098
	General cropping	19.028	4.270	84.792
	Horticulture	10.580	1.614	69.367
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	11.869	2.763	50.984
	Mixed	14.577	3.179	66.845
	Other types	N/A**		
	Specialist pigs	10.519	1.544	71.65
	Specialist poultry	N/A**		
Farm size	Very small	0.366	0.198	0.676
	Small	0.691	0.376	1.217
	Medium	Ref*		
	Large	1.326	0.740	2.375
	Very large	1.811	1.023	3.205
Selection method	Random	Ref*		
	Risk-based	0.841	0.522	1.357
	Targeted due to referral	1.876	1.065	3.306
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	N/A**		
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	1.876	1.009	3.489
	NE standalone	N/A**		
	RPAL standalone	30.357	15.651	58.882
SAG standalone	N/A**			
Genesis	Member	0.808	0.393	1.662
	Non-member	Ref*		
LEAF Marque	Member	0.486	0.118	2.000
	Non-member	Ref*		
Red Tractor	Member	1.152	0.756	1.755
	Non-member	Ref*		
Soil Association	Member	N/A**		
	Non-member	Ref*		
Model intercept		0.008	0.001	0.039

Table D9: estimated odds ratios for all factors considering the relative odds of non-compliance for GAEC 14.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Appendix E

In the RPA inspection dataset, there is information about the severity of non-compliance. A multinomial regression model is fitted to the data to estimate the increase in odds from having low severity of non-compliance to having medium severity and high severity. There was only enough information in the data for SMR7 inspections to get useful estimates of the factor effects on severity of non-compliance due to the small number of non-compliances for the other SMRs and GAECs under consideration. Table E1 gives the odds ratios going from a low severity rating to medium, and Table E2 gives the odds ratios going from a low severity rating to a high severity rating. The reference category in this fit is the same as for the full model fit, but starting from the situation where the inspected farm has been judged to be non-compliant with low severity.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	0.405	0.173	0.944
	2006	0.264	0.192	0.362
	2007	0.276	0.156	0.487
	2008	0.255	0.177	0.369
	2009	0.898	0.661	1.221
	2010	5.942	4.017	8.791
	2011	0.779	0.581	1.043
	2012	Ref*		
Main activity	Cereals	0.968	0.600	1.563
	Dairy	1.218	0.881	1.684
	General cropping	0.695	0.437	1.103
	Horticulture	0.553	0.224	1.367
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	0.916	0.714	1.176
	Mixed	0.993	0.718	1.373
	Other types	0.925	0.178	4.790
	Specialist pigs	1.433	0.541	3.792
	Specialist poultry	0.310	0.104	0.921
Farm size	Very small	0.994	0.773	1.279
	Small	1.108	0.848	1.447
	Medium	Ref*		
	Large	0.940	0.697	1.268
	Very large	0.907	0.663	1.241
Selection method	Random	Ref*		
	Risk-based	1.106	0.824	1.485
	Targeted due to referral	1.797	1.206	2.678
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	1.421	0.637	3.171
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	1.587	0.732	3.443
	NE standalone	N/A**		
	RPAI standalone	N/A**		
SAG standalone	N/A**			
Genesis	Member	0.755	0.514	1.109
	Non-member	Ref*		
LEAF Marque	Member	1.407	0.498	3.972
	Non-member	Ref*		
Red Tractor	Member	0.834	0.697	0.999
	Non-member	Ref*		
Soil Association	Member	0.631	0.196	2.030
	Non-member	Ref*		
Model intercept		0.983	0.397	2.438

Table E1: estimated odds ratios for all factors considering the relative odds of medium severity for SMR 7.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2005	0.609	0.202	1.840
	2006	0.900	0.607	1.335
	2007	0.666	0.356	1.246
	2008	0.885	0.578	1.357
	2009	0.668	0.431	1.035
	2010	3.456	2.090	5.717
	2011	0.868	0.583	1.293
	2012	Ref*		
Main activity	Cereals	2.273	1.361	3.796
	Dairy	0.847	0.548	1.312
	General cropping	1.487	0.917	2.411
	Horticulture	0.478	0.132	1.729
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	1.156	0.859	1.554
	Mixed	1.202	0.812	1.779
	Other types	3.177	0.654	15.442
	Specialist pigs	2.475	0.879	6.967
	Specialist poultry	1.294	0.491	3.406
Farm size	Very small	1.222	0.907	1.646
	Small	1.126	0.813	1.559
	Medium	Ref*		
	Large	0.786	0.520	1.186
	Very large	0.761	0.491	1.181
Selection method	Random	Ref*		
	Risk-based	1.104	0.777	1.569
	Targeted due to referral	2.535	1.621	3.964
Inspection type	1% selection	Ref*		
	AH standalone	N/A**		
	CII	0.920	0.417	2.030
	EA selection	N/A**		
	EA standalone	N/A**		
	Multiple inspection	1.633	0.773	3.450
	NE standalone	N/A**		
	RPAI standalone	N/A**		
SAG standalone	N/A**			
Genesis	Member	0.702	0.401	1.228
	Non-member	Ref*		
LEAF Marque	Member	0.459	0.087	2.417
	Non-member	Ref*		
Red Tractor	Member	0.455	0.364	0.570
	Non-member	Ref*		
Soil Association	Member	0.423	0.050	3.564
	Non-member	Ref*		
Model intercept		0.498	0.192	1.288

Table E2: estimated odds ratios for all factors considering the relative odds of high severity for SMR 7.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were two few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

Appendix F

For the Genesis and Red Tractor assurance schemes, further information on the enterprise related assurance scheme membership for the years 2010 and 2011 was included in the analysis. Due to the significant reduction in the number of relevant inspections, a logistic model could only be reliably fitted to the SMR7 inspection results. The odds ratios from the fit are given in Table F1.

Factor	Level	Odds ratio		
		Estimate	95% confidence interval	
			Lower	Upper
Inspection year	2010	0.786	0.673	0.919
	2011	Ref*		
Main activity	Cereals	0.392	0.266	0.578
	Dairy	1.219	0.811	1.831
	General cropping	0.460	0.307	0.690
	Horticulture	0.204	0.076	0.553
	LFA grazing livestock	Ref*		
	Lowland grazing livestock	1.329	1.056	1.674
	Mixed	0.828	0.613	1.120
	Other types	4.901	0.873	27.519
	Specialist pigs	1.104	0.437	2.788
	Specialist poultry	0.298	0.134	0.658
Farm size	Very small	0.344	0.268	0.442
	Small	0.656	0.506	0.851
	Medium	Ref*		
	Large	1.259	0.914	1.733
	Very large	2.397	1.633	3.517
Selection method	Random	Ref*		
	Risk-based	1.234	0.849	1.795
	Targeted due to referral	4.552	2.589	8.001
Inspection type	1% selection	N/A**		
	CII	Ref*		
	Multiple inspection	1.900	1.357	2.661
Genesis beef and lamb	Member	0.674	0.321	1.937
	Non-member	Ref*		
Genesis crops	Member	0.786	0.319	1.937
	Non-member	Ref*		
Genesis pigs	Member	1.89	0.379	9.422
	Non-member	Ref*		
Red Tractor beef and lamb	Member	0.701	0.580	0.846
	Non-member	Ref*		
Red Tractor crops	Member	0.816	0.573	1.161
	Non-member	Ref*		
Model intercept		1.429	0.896	2.277

Table F1: estimated odds ratios for all factors considering the relative odds of non-compliance for SMR 7.

* "Ref" denotes the reference or baseline category for the logistic regression

** For this category, there were too few observations to reliably estimate the odds ratios given problems caused by quasi-complete separation.

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