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Research article

Adoption of Farm Management Systems for Cross Compliance – An empirical case in Germany

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ABSTRACT

In Germany, Farm Management Systems (FMS) have been introduced as a support to farmers' compliance with environmental and other regulations, aiming at the increase of farm level performance and sustainable farming practices. Different kinds of FMS were developed and promulgated with various approaches, determined by each federal state's agricultural advisory system. Knowledge on the FMS' uptake and effectiveness has been lacking so far. The overall aim of this paper is to provide an analysis of the implementation process and selected outcomes of the policy-driven instrumental innovation of FMS. In particular, the objectives are i) to reveal how and with what success the introduction of FMS has been realised in Germany and ii) to analyse and discuss the FMS' adoption in the federal state of Brandenburg. For the first part of the study, we elaborate a situational analysis of the policy implementation through a desk study and expert interviews. In the second part, selected results from a farmers' survey in Brandenburg are presented and a switching regression model is developed to assess the factors responsible for the uptake of FMS and to understand the role of FMS in improving the confidence in complying with Cross Compliance regulations. We found a high degree of diversity among FMS developed in the different federal states. FMS adoption rates varied, but were generally low. Institutional environment seems to have a significant influence as the same FMS had very different adoption rates among federal states. For Brandenburg, our findings show that farmers' confidence to face CC check was increased by the adoption of FMS. However, counterfactual scenario analysis proved that especially farmers who did not adopt FMS would have benefitted most if they had adopted the tool. Our study shows that there is a need for systems supporting farmers in dealing with bureaucratic requirements. Future FMS should be easy to understand, adaptable to individual farmers' needs and be available at low costs. Furthermore, there is a need to design FMS in a participatory way that integrates farmers' expectations.

1. Introduction

The concept of 'Cross Compliance' in agriculture (CC) evolved as an economic measure in the United States. The term CC refers to attachment of certain regulations (e.g., environmental requirements) to direct payments under agricultural policy (Meyer et al., 2014). The European Union introduced CC in 2003 with the aim to increase farm sustainability, defining standards regarding the environment, food safety, plant (and animal) health and animal welfare, as well as the requirement of maintaining land in good agricultural and environmental conditions (GAEC). Farmers are obliged to comply with them, if they want to be eligible for the 'single farm payments'. These regulations include two elements: (1) The Statutory Management Requirements (SMR), which refer to almost 20 legislative standards in the field of the environment, food safety, animal (and plant) health and animal welfare and (2) the GAEC obligation, which refers to a range of standards related to protecting soil, maintaining soil organic matter and structure, avoiding the deterioration of habitats, and exercising water management practices (EC, 2003). Widely, CC was perceived as an additional challenge for farmers, given the already complex European farming regulations and documentation requirements as well as increasingly demanding quality assurance standards to be fulfilled for marketing of products. Not surprisingly, scepticism regarding the capacity of farmers to comply with CC regulations surfaced shortly after introducing the scheme. Policy makers

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expected that farmers will need support to introduce the CC requirements into their daily farm managerial routines (ADE, 2009a; Celio et al., 2014).

Along with the introduction of CC in the EU, how to support farmers to comply with CC was discussed (Schramm and Spiller, 2003; Entrup et al., 2007). Farm-Audit similar to quality assurance certification schemes emerged as a first idea within the CAP Mid-term review in 2002. Later, this idea was replaced by the concept of an obligatory 'Farm Advisory System' (FAS) for Member States and combined with increased public control of agricultural land use by establishing the 'Integrated Administration and Control System' (IACS) (Schramm and Spiller, 2003). Consequently, FASs were included within the regulation regarding CC and the Single Payment Scheme (EC, 2003), making the availability of advisory services on CC standards binding for all EU member states by 2007.

1.1. Implementation of CC & FAS in Germany

The implementation of FAS in the EU member states was initiated by the rural development authorities and took place within the existing institutional settings at national or regional level. Largely, it resulted in two distinct organisational forms: (i) in a number of states, the FAS were newly established in parallel to existing agricultural advisory systems (e.g. Bulgaria or Hungary) while (ii) in other countries existing agricultural advisory systems were updated and complemented with the 'FAS' component (e.g. Germany, Netherlands, Denmark). An evaluation of the policy implementation at member state level was conducted (ADE, 2009a) shortly after their implementation at member state (MS) level. Despite limited evidence, this evaluation came to the conclusion that FAS contribute to awareness raising among farmers, of material flows and on-farm processes related to environmental, food safety or animal health aspects, and that they support the implementation of CC requirements. Furthermore, the core approach of on-farm, one-to-one advice based on checklists (in 18 MS implemented by 2008) was assessed to be particularly effective compared to off-farm or one-to all approaches (ADE, 2009b). Apart from this initial assessment, little is known so far about results and impacts of FAS on CC as there has been no second evaluation since 2009. A recent overview study on European agricultural advisory services as one key actor for farmers' access to relevant and reliable knowledge concluded that the data available to evaluate the impact of the advisory services (Knierim et al., 2017) is insufficient for meaningful assessment, a situation that is reported to prevail broadly in OECD countries (OECD, 2015).

Together with Great Britain, Italy and Belgium, Germany is one of the few European countries where the implementation of agricultural advisory systems is mandated at a regional (state) level, which resulted in considerable institutional diversity (Hoffmann et al., 2000). In addition to this diversity and in contrast to all other EU member states, the German implementation of FAS was combined with the dissemination of farm management systems (FMS). In this context, an FMS is defined as "an instrument for systematic documentation and analysis of production processes, aimed at continuously improving overall farm performance" (BMELV, 2006:1f). Strengthening of farm-level self-control and optimisation process through FMS became a political priority as manifested in a national subsidy scheme called 'Framework plan for the joint task of improving agricultural structure and coastal protection' (GAK) (BMELV, 2009; Boland et al., 2005). FMS was assumed as a facilitating agent of farmers' compliance to CC and consecutively, public support for CC related farm advice was linked to the introduction and implementation of this instrument. The national ministry for Agriculture (BMELV) recommended the implementation of FMS to the federal states. Depending on the state-level advisory system, FMS were developed by public institutions, agricultural chambers or independent private consulting companies. Between 2007 and 2013, the national FAS policy provided financial support for advisory services combined with FMS. It ended with the start of the new CAP period (2014–2020) and app. 15 Million Euro were spent (BMEL, 2017).

Thus, we frame the introduction of FMS in Germany as a policy driven innovation process in the agricultural sector aimed at increasing farm sustainability (Herrera et al., 2016). As farmers' adoption of environment-related instruments and practices is a complex process, usually influenced by a broad range of socio-structural and situational determinants (Siebert et al., 2006; Burton, 2014), we consider the German setting a unique occasion to study a policy-driven instrumental innovation.

1.2. Objectives of the study

The overall aim of this paper is to provide an analysis of the process and outcomes of the policy-driven instrumental innovation embodied in FMSs that targeted enhancement of farm level performance and sustainability through ensuring CC. Based on review of policy documents and current literature, we elaborate the aims and characteristics of FMS as defined within the German policy framework and categorise them within the context of agriculture-related management systems. Additionally, the state of empirical evidence and discussion on factors influencing farmers' FMS adoption is summarised. The current work investigates whether farmers' modified behaviour with regard to (CC) is indeed related to the adoption of a new information management tool. We use qualitative and quantitative data from a German case study on FMS and CC-related advisory services generated from expert interviews and a farmers' survey.

The objectives are i) to reveal how and with what success the introduction of FMS has been realised in Germany and ii) to specifically analyse and discuss the impact of FMS' adoption in ensuring CC in the German federal state of Brandenburg. For the first objective, we adopt an explorative approach and elaborate a situational analysis of the policy implementation. Specific research questions addressed are: (a) with what measures and methods did the state-level, agricultural advisory services develop and implement FMS, and (b) what adoption results were reached? For the second objective, we present an in-depth analysis of factors determining the adoption of FMS in Brandenburg. The specific research questions addressed here are: (c) what determined the adoption of FMS and (d) did FMS contribute to enhancing CC?

2. Conceptual background of FMS adoption

2.1. Farm Management Systems – aims and characteristics

The term 'farm management system' as used in the German subsidy scheme (BMELV, 2009), is not defined in scientific literature so far. Table 1 gives an overview – based on literature and expert interviews - of the most important farm management related systems, their aims and characteristics, and examples. While common denominators are their ordering and control functions, they are specific with regard to whether they address the whole or only parts of the farm's management with an aim of either supporting internal management or external transparency creation, or both.

Within the German subsidy scheme, FMSs (row 1 in Table 1) are defined as systems to support self-control of farm enterprises and to improve overall farm performance. The use of FMS is supposed to increase quality of products and processes, to ascertain the traceability of products, improve animal welfare and protection, to

Table 1
Farm management related systems in Germany, own compilation.

	Farm management related system	abbreviation	aims and characteristics	Examples
1	Systems for supporting self-control in farm enterprises	FMS	aim: to support systematic documentation and self-control to prove compliance to at least legal and subsidies related requirements or also combined with certification related requirements; in Germany only; paper or software-based systems based on checklists	GQS; KKL (2005–2011); CroCos (2005–2013)
2	Quality assurance programmes	QS	aim: to meet trade and market quality requirements, higher standards than basic legal requirements for farming; (regular) certification audit included	GlobalGAP, Fairtrade, EU Eco label; in Germany: QS (meat); QM (milk)
3	Environmental Management Systems	EMS	aim: improvement of environmental performance in organisations including legal compliance, continuous improvement process following own aims, environmental statement or performance report; government supported, certification included	EMAS (Eco Management and Audit Scheme); EFP Canada,
4	Operational management tools for single farming tasks or farm branches	OT	aim: efficient data and information management on-farm (documentation, planning, optimization, control, analysis, etc.); often software-based	Field cards, herd management programmes, sheets for economic farm assessment

contribute to an environmentally friendly production, to increase the work place security and to warrant an efficient implementation of the new standards from the EU regulation (BMELV, 2006). The policy differentiated between two levels of systems: i) 'systems to improve overall farm performance' (basic level) and ii) 'comprehensive FMS' (advanced level). The main difference is certification, which is compulsory for funding for the advanced level (BMELV, 2009).

FMS consist, in general, of (i) a checklist for self-control, (ii) a filing system for documentation and (iii) a set of additional information material on the background of requirements. Some FMS only refer to the CC requirements while others include requirements of additional quality management or certification systems such as QS, EurepGap, EMAS or ecological farming (row 2 in Table 1). FMS are available on paper and/or additionally a CD or as electronic version only (Zapf, 2009). Checklists in certification based quality assurance systems can include the same criteria as checklists for CC in FMS. Thus, it has become one aim of some German FMS to include all criteria available to develop a generic database. Depending on certification programmes or environmental management schemes each farm participates (Zapf, 2009), the database can be used to develop a customized farm-specific checklist that including all relevant criteria. This corresponds with research developments which seek to create documentation systems for automated (internal) compliance control in agriculture (Sørensen et al., 2010; Nash et al., 2011; Nikkilä et al., 2012).

Environmental Management Systems (EMS) are closely related to FMS as defined above, and frequently go beyond the legal requirements in their management goals. Additionally, they have the aim to provide information and tools to inform the public about the environmental performance of a farm. Investigated examples are the EMS supporting programmes in Australia (Cary and Roberts, 2011) or the Environmental Farm Plans (EFP) in single provinces in Canada (Atari et al., 2009; Knierim, 2007), and in New Zealand (Manderson et al., 2007). The latter ones in particular, are rather planning tools than documentation tools like FMS. Operational management tools differ from FMS, when they address only particular farming tasks or farm branches like herd management or field cards for plant production. They are not considered systems to address the whole farm.

2.2. Factors influencing farmers' FMS adoption behaviour

Farmers' adoption of innovations has been an object of scholars' interest for more than fifty years and a vast number of empirical studies exist. One impressive proof are the publications of E.M. Rogers and his colleagues, as compiled in the classical reader 'diffusion of innovations' (published in its 5th edition in 2003). However, although these authors propose both innovation characteristics and procedural steps of the process as cross-cutting success features, there are also critics who emphasise the situational contingency of innovation adoption (Hoffmann, 2007; Albrecht, 1973). Hence, it is necessary to extend the analysis to subjectively perceived fostering and hindering factors (Hoffmann et al., 2009) and to broaden the range of considered influencing factors towards the embedding social system, e.g. the role of family members, colleagues, neighbours and communities of practice (Siebert et al., 2006).

Frequently, studies on farmers' adoption behaviour concentrate on farm and farmer characteristics to be influential including e.g. age and gender of farmer, farming experience, formal education, farm income, size and type of business etc. – a convention that is criticised for its frequent lack of unequivocal demonstration of cause-effect relations (Siebert et al., 2006; Burton, 2014). Farmers' beliefs and subjectively perceived norms and constraints have equally been reported as averagely to strongly influencing factors on (intended) behavioural change (e.g. Werner et al., 2017). Recent studies on farmers' search for information and knowledge exchange in the context of innovation processes provided evidence on the importance of both, peers and colleagues as well as advisors as influencing innovation related decision making (Klerkx and Proctor, 2013; Oreszczyn et al., 2010).

Looking closer at studies addressing farmers' adoption of farm management related systems, we identified only a small number of empirical research mostly stemming from Canada and Germany. Atari et al. (2009) investigated participation in the environmental farm plan (EFP) in Novo Scotia, Canada and found a positive relation given with farm income, years of farming experience, and type of agribusiness while a negative relation was observed with age and formal education. Higher participation rates could be observed among livestock producers, similar to EFP implementation in Ontario, Canada and the Countryside Stewardship Scheme in England (Atari et al., 2009). Adoption of Farm Management Information systems as computer-based technologies/software are related to most importantly age, formal education and skills related aspects such as learning style or information management. The farm-advisor relationship may also contribute, but is not considered as important as formal education and farmers' opinions and experiences (Alvarez and Nuthall, 2006). Therefore, "Farmers with small farms, being 50 years or older, with less formal education, and with learning styles that emphasize either concrete experience or active experimentation, in contrast to reflective observation or abstract conceptualisation, are less likely to use software than colleagues exhibiting different characteristics" (Alvarez and Nuthall, 2006:

p.58).

Knierim (2007) argues that the Environmental Farm Plan (EFP) programme in Ontario, Canada can be considered a success with regard to FMS adoption, with approximately 27.000 farmers participating in the initial trainings and more than 50% of Ontario's farmers being at least partially enrolled in the programme. Fostering factors included an active role of farmers' organisations in developing and implementing EFP as well as intensive cooperation of several other corporate actors from the public and private agricultural sector (Knierim, 2007:353). Financial incentives, which are often assumed as key drivers for adoption, played a less important role (Atari et al., 2009; Knierim, 2007), instead facilitated learning processes through motivating group training events, where informal information exchange as well as phases of individual reflection, assessments and activity planning are assumed to be important. Nevertheless, cost free access in the initial phase, as it was the case in Ontario, is assumed to be very helpful.

Factors impacting on satisfaction with different quality management systems in Germany were investigated by Enneking et al. (2007). They concluded that socio-demographic factors have no influence and that instead the gains in image, in sales and in production efficiency are important factors. A system's costs were found to be less influencing than (expected) effects from its implementation. Application trainings were described as highly appreciated by farmers and follow-up events for participating farmers to clarify questions, inform on news and refresh motivation were recommended.

3. Material and methodology

3.1. Research approach and data collection

We combined an explorative, Germany-wide overview on FMS adoption with an in-depth study on influencing factors in the German state of Brandenburg. We made use of a mixed method approach and complemented qualitative expert interviews with a quantitative survey (Punch, 2005). The data source of the study is part of an exploratory study on CC related advisory services conducted for the Ministry of Agriculture in Brandenburg in 2009 (Knierim et al., 2011). It included a desk study, 13 semi-structured interviews with experts on agricultural advisory services and FMS from national and state level authorities and a questionnaire-based telephone survey with 71 farm managers in Brandenburg.

The desk study analysed websites on German FMS, reports and grey documents from public authorities and statistics received through interviews. Expert interviews were recorded, summarised, crosschecked following a protocol and authorised by the interviewee. The telephone survey was conducted with a sample stratified according to farm size, representative for the heterogeneous farm structure in Brandenburg (Knuth and Knierim, 2013). The questionnaire contained mainly closed questions regarding CC related advisory services including the use of FMS. In this paper, we present an analysis of selected responses pertaining to farmers' information needs and experience with FMS. The questionnaire was discussed with two experts on FMS and pretested with four farmers and thereupon modified.

3.2. Data analysis

We performed a manual content analysis of the interviews' transcripts and the desk study material to distinguish FMS characteristics (content wise, costs, ways of using them), adoption and farmers' assessments of the systems (Punch, 2005). The farmers' survey response rate was satisfying, as from 140 contacted farm managers 71 completely filled questionnaires were collected. Data was checked for plausibility, digitalized and a descriptive analysis was conducted with IBM SPSS.

Secondly, the impact of FMS adoption on meeting the cross compliance obligations was quantitatively analysed. In order to answer questions regarding the adoption of FMS and its impact on confidence to face administrative checks on CC, it is necessary to understand the counterfactuals i.e. would there be any change in confidence level if farmers who did not adopt the FMS were to adopt the system or if the adopters were to dis-adopt the system. The confidence level of farmers regarding CC regulations was measured by the following question: “Imagine, you are being informed that your farm is going to be checked on CC in the following days by the administrative bodies. Do you feel safe in all fields of CC?“ Interviewees were asked to assign a score between 0 and 100. The problem in hand fits well for an endogenous switching regression model (Ghimire and Kotani, 2015),where

$$A^i = 1 \; if \; \beta Z^i + u^i > 0 \tag{1}$$

$$A^i = 0 \; if \; \beta Z^i + u^i \leq 0 \tag{2}$$

where A^i is the adoption of FMS system and Z^i are determinants of its adoption.

In case of confidence in meeting CC requirements, this leads to two regime equations

$$\text{Regime 1} : C^i = \gamma_1 X_1^i + \varepsilon_1^i, \; if \; A^i = 1 \tag{3}$$

$$\text{Regime 2} : C^i = \gamma_2 X_2^i + \varepsilon_2^i, \; if \; A^i = 0 \tag{4}$$

Equation (3) indicates the confidence level when FMS is adopted, while equation (4) represents the confidence level when there is no adoption of FMS. The model is estimated using the “Movestay” package of STATA software. The set of explanatory variables related to adoption of FMS viz. education level of farmers, size and type of farms, previous experience on checks for CC, organizational linkages of farmers etc. are selected on the basis of previous literature described in section 2.2. The variables included in the model are explained further in Table 4 in the result section.

4. Results

The results of the exploratory study at federal states' level and of the Brandenburg case study on the effect of FMS on CC of farms are provided in the sections below.

4.1. FMS implementation and adoption in Germany

The study among experts clearly reveals the diversity of the German FMSs and that adoption of FMS in Germany is low to very low in most states. FMS were developed by various actors across the states (Table 2, column 2). While some public agencies engaged in their development (e.g. Baden-Wuerttemberg), in other cases, adaptations of the FMS developed by the national farmers' association (KKL), which is a comprehensive checklist (all possible requirements a farm has to comply with) that can be customized according to farm level specifics, were disseminated (Bavaria, Lower Saxony).

Regarding the FMS characteristics, a basic and a comprehensive version can be distinguished: basic FMS only refer to CC requirements in their checklist (e.g. CroCos in Brandenburg, Saxony-Anhalt or Mecklenburg-West-Pomerania), while comprehensive FMS go beyond CC and include requirements of quality management or other certification systems (e.g. GQS in Baden-

Table 2
Overview of FMS in selected German states (2010).

Federal state	Main advisory system	Widely spread FMS[a]	FMS characteristics		FMS advice subsidized?	Uptake by farmers in the state in %[c]
			CC or CC+	Costs[b] in €		
Lower Saxony	Chambers	BMS/KKL	CC+	670 for FMS + advice	yes	20
Bavaria	Mixed	Mein Bauernh of check (KKL)	CC+	65 for training	no	15
Saxony	Mixed	GQS SN	CC+	35	no	11
Saxony-Anhalt	Private	CroCosST	CC	95	no	2,5
		CroCosST-KKL		400	no	
Thuringia	Private	USL-CC; CCM-IAK	CC	–	yes	7
			CC	600		
Mecklenburg-West Pomerania	Private	CroCos-KKL	CC+	500 for FMS + advice	No	5
Baden-Wuerttemberg	Mixed	GQS $_{BW}$	CC+	55	yes	5
Brandenburg	Private	CroCosLAB	CC	250	no	–
		CroCosKKL	CC+	350	no	–

[a] The FMS in this column are commonly known by the acronym presented.
[b] If nothing else mentioned, costs for a handbook including a checklist as paper version for first year of purchase; yearly update costs are not included.
[c] Source: expert interviews 2009; CC = checklist refers only to CC legal requirements, CC+ = checklist can be adjusted to farm specific and includes additional to CC legal requirements, other requirements like QS, organic farming, etc. The FMS adoption figures relied on sales and/or were estimated by experts.

Württemberg or KKL in Lower-Saxony) (cf. FMS characteristic 'CC' and 'CC+' in Table 2). FMS were made known to farmers by public authorities at state level, so that in all states at least one FMS was available. Similar to the FMS development, also a huge diversity of the institutional setup for the provision of CC-related advice became evident: In some cases, it was carried out by official agencies only (e.g. Baden-Württemberg, Hessen, Saxony), in others by official agencies in collaboration with farmers' organisations (Bavaria), or by the agricultural chambers (Lower Saxony, Rhineland-Palatinum, Schleswig-Holstein) or by private advisory enterprises (Brandenburg, Saxony-Anhalt, Thuringia).

Costs of FMS ranged between 0 and 1000 Euro per unit, in states with private advisory systems often higher than in public or mixed systems. Subsidies for advice related to the introduction of FMS were available only in 5 out of 16 states. The main advisory approach was one-to-one advice. Only in Bavaria, a group approach was implemented by the state-level farmers' union, training farmers to use the KKL checklist independent of advisors. Additionally, some states provided a cost-free official CC checklist (e.g. Mecklenburg-Pomerania) or offered cost-free advice on single aspects of CC without FMS (e.g. Bavaria). Although widely propagated, the system KKL was not longer updated at national level after 2011 because of overall low uptake numbers, and only two single versions on federal state level (KKL$_{BY,}$ BMS/KKL) were continued.

The overall FMS adoption figures in Germany were lower than expected by experts and the views on the future of FMS for CC were predominantly negative. This was especially evident in private advisory systems. Apparently, in the first years of implementation of CC and related FMS support (2005–2007) adoption figures were high in some states, though declined in subsequent years. Several experts related the low uptake of FMS with farmers' first experiences in CC checks which they described as less alarming than expected. Highest overall uptake could be observed in Lower Saxony with 20% of all farmers, a state with semi-public advisory services (agricultural chamber) and subsidized FMS development and implementation. One expert at national level evaluated the group approach in Bavaria - off-farm trainings on how to use KKL$_{BY}$ to be more effective than the one-to-one approach in all other KKL-implementing states. Also surprising is the fact that the FMS GQS in Baden-Wuerttemberg, developed by a public authority and promoted in adjusted versions by several further German states, had a relatively low uptake with only 5% of all farmers adopting it.

4.2. Cross compliance and FMS adoption in Brandenburg

In Brandenburg, the existing agricultural advisory system is exceptional within Germany as well as within Europe, as it is completely privatized (Knuth und Knierim, 2013). Therefore, farm advice related to Cross Compliance had to be paid by farmers only, and FMS that support CC were developed by private consultancy firms and promoted without subsidies. Two such FMS viz. CroCosLAB, CCM-AHB, received official recommendation from the Ministry of Agriculture. CroCosLAB is basically a management handbook including a checklist restricted to CC requirements. It is not possible to generate a farm specific checklist.

Before investigating the use of FMS, we present farmers' response on what topics they needed information or advice and how often (cf. Table 3). The selected topics were items chosen to cover the regulations of Statutory Management Requirements (SMR) and GAEC obligation (EC, 2003) aiming to check farmers' information demand for all farm management aspects of CC. For some cases, this selection, resulted in thematic overlap (e.g., general biodiversity and farm bird biodiversity), which is already inherent to the categorization of Cross Compliance regulation. Our results show that farmers mainly need assistance with fertilizers and pesticide related regulations, KULAP and Natura 2000 policy instruments as well as animal health and diseases issues. They seldom seek advice on topics such as application of sewage sludge, grassland protection and animal friendly stable construction. Table 3 also shows only few items on which some farmers often take advice, specifically pesticides usage and animal health. A weighted score is created to rank the CC topics with regard to information demand. Noticeable, is the high number of farmers that claim not to need information (22% or more mentioned 'never'). This may relate to the disproportionately high education level within the sample, as 70% (50 out 71) have a university degree (Knierim et al., 2011).

The interviewed farmers' understanding of FMS was broad and included all systems listed in Table 1. Therefore, 44 out of 71 farmers stated to use an FMS while only five out of them used an FMS, which was explicitly developed to support CC (CroCos LAB) and recommended by the Ministry of Agriculture. A quarter of sampled farmers (18 out of 71) depended on regional Quality assurance systems (QS or QM) and 11 mentioned "self-developed systems" (Fig. 1). The State Ministry's recommendation for two FMS

Table 3
Farmers' stated demand for information & advice on CC-topics (N = 71) in Brandenburg, Germany.

CC topics	R1 (often)[a]	R2 (sometimes) [a]	R3 (seldom) [a]	R4 (Never)	Weighted Score[b]	Rank
Application and storage of fertilizers and its documentation	6	34	9	22	44,6	1
KULAP/Natura 2000 area	9	26	9	24	43,1	2
Application and storage of pesticides and its documentation	11	25	7	28	42,3	3
Animal health/diseases	12	19	13	26	41,4	4
Safe handling and storage of food and feed	6	23	18	23	39,0	5
Crop rotation and organic soil matter balance	6	18	19	28	34,3	6
Safe storage of hazard substances, e.g.: diesel, machine oil	2	22	21	25	33,8	7
Protection of landscape features	4	19	17	31	31,5	8
Protection of biodiversity	1	21	21	27	31,4	9
Mitigation/prevention of erosion	2	20	19	30	30,5	10
Herd register and animal identification	7	16	12	36	30,5	10
Bird protection	3	17	15	36	27,2	12
Maintenance of fallow land	1	16	16	38	23,9	13
Animal friendly stable construction	3	10	19	38	22,9	14
Grassland protection/possibilities for ploughing up grassland	1	13	19	38	22,5	15
Application of sewage sludge	0	3	4	63	4,8	16

[a] Frequency: **often**: more than once per year, **sometimes**: once per year, **seldom**: less than once per year.
[b] Weighted Score: (3*R1 + 2*R2 + R3)*100/(number_of_responses*3).

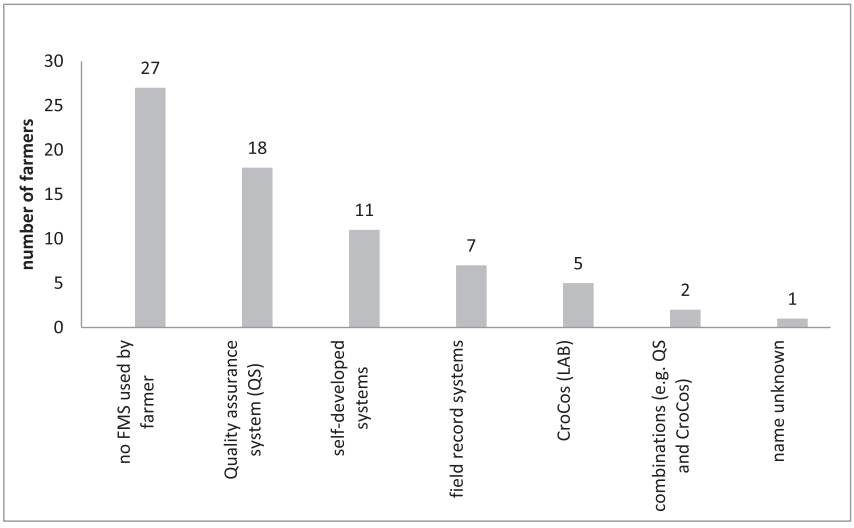

Fig. 1. Adoption of FMS and related systems in Brandenburg.

was only known by 8% (6 out of 71). Farmers, who stated that they used an FMS, were asked how helpful they find it for compliance with CC requirements. Roughly half of them (24 out of 44) evaluated their system as overall helpful (grade 1 or 2). Those farmers that evaluated their system as partly (or not at all) helpful, most often used quality assurance systems (9 out 12). Regarding CC checks, 53 out of 71 interviewed farmers mentioned some degree of confidence in case they would be checked. Among the 17 farmers, who explicitly mentioned to be least confident were 11 farmers who used a quality assurance system, operational tools or systems they had developed themselves while six did not use an FMS or related system.

Due to data limitations, farm managers (regimes) are grouped as non-adopters and adopters. Adopters include users of either quality assurance systems, operational systems/tools or other market-offered/commercial systems. Farmers who mentioned 'self-developed system' are considered non-adopters.

4.3. Factors influencing FMS adoption and confidence in Brandenburg

The estimated switching regression results are provided in Table 4. The estimated adoption equation shows that education of the farmers, size of the farm and costs of farm advisory services are the major factors in adoption of FMS and related systems in the state of Brandenburg. Farmers that spent high on advisory services tended to adopt FMS or related systems. It is also clear that frequency of administrative checks on CC compliance drives the adoption of FMS in Brandenburg. In case of confidence, regime equations show that size of the farm and the adoption status of FMS are the major factors that affected the confidence level in meeting CC. Education level did not affect the confidence level but affected the adoption of FMS. The influence of FMS on the confidence level is explained by the counterfactuals described in next section.

4.4. Counterfactual scenario

In order to understand the impact of adoption of FMS on the confidence level of farmers on readiness for an administrative check on CC on their farms, two counterfactual scenarios are estimated using the regime equations. Firstly, observed confidence level of farmers who adopted an FMS and predicted confidence using regime equation (1) is compared to a scenario of "without FMS" predicted by regime 2 equation. Fig. 2 shows that the

Table 4
Estimated regime equations and adoption equations using endogenous switching regression model.

Regime	Variables	Explanation	Coefficients
Confidence level of adopters in meeting CC requirements			
	Edu-dummy1	Attained at least University Education = 1 or else 0	−19.59
	Size_200_500	Farm size between 200 and 500 ha	−89.55**
	Size_500_1000	Farm size between 500 and 1000 ha	−65.22**
	Size_1000_cons	Farm size more than 1000 ha	−52.46**
		Constant	228.98**
Confidence level of non-adopters in meeting CC requirements			
	Edu-dummy1	Attained at least University Education = 1 or else 0	−10.92
	Size_200_500	Farm size between 200 and 500 ha	−28.62
	Size_500_1000	Farm size between 500 and 1000 ha	−91.41**
	Size_1000_cons	Farm size more than 1000 ha	−9.15
		Constant	69.0**
FMS adoption			
	Size_200_500	Farm size between 200 and 500 ha	2.61**
	Size_1000	Farm size more than 1000 ha	1.98**
	Edu-dummy1	Attained University Education = 1	1.89**
	Size_500_1000	Farm size between 500 and 1000 ha	2.39**
	Checkd2	Already checked for CC	0.23**
	Edu-dummy2	Attained Apprentice level Education = 1	1.50**
	Membership	Member of farmer organisations	0.25
	Costsf1	Cost of advisory services	0.16*
	Pigpoultry	Pig and Poultry farm	0.10
	Mixfarm	Mixed farm	−0.14
	_Cons	Constant	−5.44**

** Significant 0.05 level and * 0.1 level.

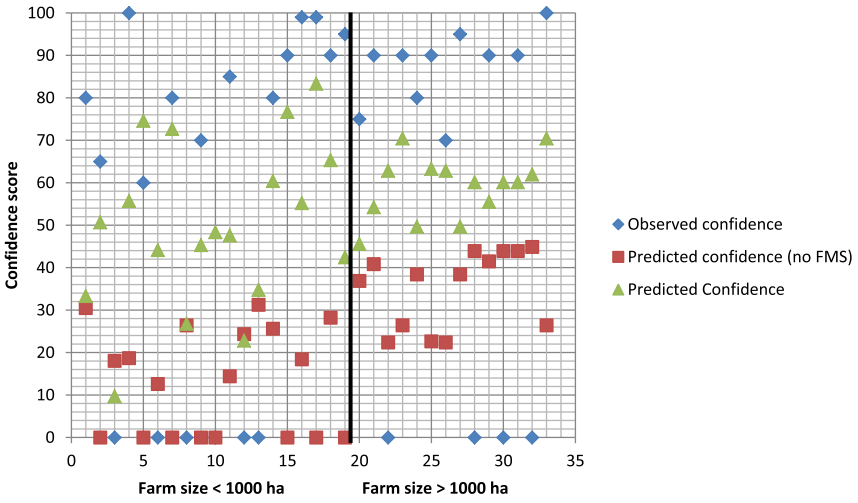

Fig. 2. Farmers' confidence scores in counterfactual scenario of dis-adoption of FMS by adopters.

predicted level of confidence of farmers who adopted the FMS decreases from an average score of 53 to a score of 22 in case of 'no FMS scenario' (dis-adoption). It is to be noted that mean observed confidence (against CC check) of farmers who adopted FMS is 59.5 out of 100. The average gain of confidence by farmers who adopted the FMS is 31 points. Fig. 2 also shows that large farmers with more than 1000 ha are much more confident in complying CC without FMS adoption.

Fig. 3 shows a scenario where the farmers who did not adopt FMS adopt the FMS. The estimated relation shows that most of the farmers would become fully confident if they adopted the FMS. It is to be noted that mean predicted and observed confidence of farmers who did not adopt the FMS is 63 out of 100. Comparing Figs. 2 and 3, it can be noticed that non-adopters predicted to be more than 50% confident to face a CC check without an FMS while the adopters are less than 50% confident to face a CC check without the FMS system. Because of the already high confidence level, the non-adopters could become 100% confident with adoption of an FMS system irrespective of the size of their farm.

5. Discussion

5.1. Adoption of FMS in Germany

The diversity of FMS developed in Germany is striking and fits to the diverse landscape of advisory systems in the country. This is due to the delegation of responsibilities for FAS implementation to each federal state. The results in Table 2 show overall low but diverging adoption figures for FMS in each state. They suggest that FMS characteristics, e.g. certification included or not, and the institutional environment including subsidies and different advisory approaches are influencing factors. Further research is needed to investigate the influence of the institutional environment of FMS support, in particular subsidies to use advisory services to

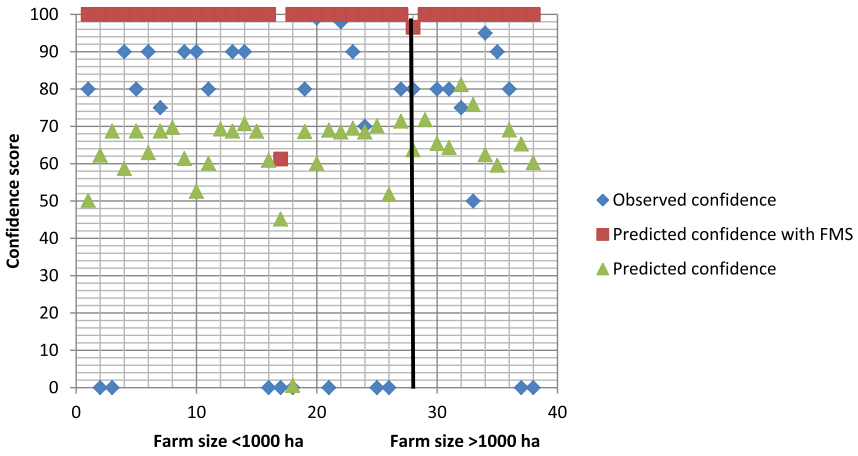

Fig. 3. Farmers' confidence scores in counterfactual scenario of adoption of FMS by non-adopters.

implement an FMS and other innovation support measures. Gunningham (2007) pleads for an optimal policy mix of regulation, economic instruments, education and information as well as self-regulation.

In addition, the role of market support measures in FMS adoption and related policy arrangements merits more research efforts. Advantages for farmers from using FMS beside improved preparation for and reducing risks during inspections, lie in opportunities to market their products at higher prices (Kempa and von Haaren, 2012). Certificate or product labels are considered important for widespread adoption of environmental management systems (Cary and Roberts, 2011; Gunningham, 2007). Hence, it will be important to integrate marketing opportunities to FMS in order to drive adoption with the ideal option of an FMS that can augment existing quality management systems (QS) and ensure good farm management practices as well as explore commercial options while helping to maintain the farm stewardship (Enneking et al., 2007).

An aspect closely related to software-based farm information management systems is that "the system must be configurable to suit a range of farm(er) characteristics" (Alvarez and Nuthall, 2006: 48). The FMS named KKL was such a system aiming to include all possible requirements to be applied by a farm in Germany and to be adjustable to provide a farm specific checklist. The fact that it did not provide additional marketing opportunities could be a reason for it to fail as a federally promoted system. Nevertheless, in Bavaria this system adjusted to regional condition combined with a group advice/training approach and cost-free access to generate a farm-specific checklist promoted by the Bavarian Farmers Union was quite successful. Here, we might see a confirmation of the importance accorded to group training approaches for successful dissemination (Atari et al., 2009; Knierim, 2007), which was equally considered by experts as more successful than one-to-one advisory approaches in other KKL implementing states.

5.2. Adoption in Brandenburg

The survey results show a low adoption rate of officially recommended FMS in Brandenburg. The calculated scores of topics requiring information or advice (Table 3) indicate overall low information demand which we attribute to the high level of education among the interviewed farm managers. We tend to confirm that formal education is an important influencing factor for information management skills, as it enhances the ability to cope with administrative procedures (Alvarez and Nuthall, 2006; Siebert et al., 2006). The differential of coefficients on university and apprentice level education on adoption of FMS supports such an argument. It may need further investigation on how to design FMS that can be easily used by farmers of any educational level.

The counterfactual in Fig. 3 shows that farmers who did not adopt the FMS are those that would have benefitted most from their adoption. The farmers who are adopters have gained additional confidence as depicted in Fig. 2. Nevertheless, it is to be noted that farmers who actually adopted the FMS were those with comparatively lower confidence than the other group. It also shows that the farmers with less than 1000 ha are likely to adopt an FMS to increase the confidence to meet CC requirements. The evidence provided by the analysis points to the fact that FMS can be potentially an instrument to improve CC, especially if the compliance checks are more stringent.

5.3. Concluding remarks

The current research work sheds light on the previously unexplored field of how FMS systems influence the CC among European farmers. Though limited in geographical coverage, the findings show that the FMS is useful in enhancing the compliance of environmental requirements. The striking evidence is that non-adopters could have benefitted most if they had adopted the tool. This suggests an inadequate design of FMS in Brandenburg. The officially recommended version is rather used by farmers with lower confidence on CC, lower farm sizes and enough education to understand the complex tool as well as those who were checked by the officials on meeting CC requirements. There is the possibility of implementing FMS in Brandenburg that can offer multiple services by integrating with QS systems or certification systems and which can offer support to market the products. There is also a need to explore additional requirements for their enhanced use. The comparison of the results at federal state level shows that additional research is needed to check the influence of institutional environment on FMS adoption (e.g. group approach, subsidies for FMS related advisory services) to come up with an optimal policy mix within the respective context. Our study shows that there is a need for systems supporting farmers in dealing with bureaucratic requirements. Future FMS should be easy to understand, adaptable to individual farmers' needs and be available at low costs. Furthermore, there is a need to design FMS in a participatory way that integrates farmers' expectations. A detailed analysis on information needs, interface design requirements, expectations on support provided to market/label the products and cost considerations is necessary.

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