Is it the model or is it the process of using it? Extension officers evaluate ADOPT as a tool to assist planning in the pastoral sector

Oscar Montes de Oca Munguia[1,2], David J. Pannell[1] & Rick Llewellyn[1,3]

[1]School of Agriculture and Environment, The University of Western Australia, Crawley WA 6009
[2]Scion Research, 49 Sala Street, Rotorua 3010, New Zealand
[3]CSIRO, Glen Osmond SA 5064
Email: oscar.montes@scionresearch.com

Abstract. Agricultural extension professionals are aware of the complexity surrounding farmers' decisions to adopt a new technology or practice. These extension officers often need to design strategies to improve adoption though planning processes, which are commonly run collaboratively by expert groups and through deliberation rather than individually. Models have been used to assist these deliberations, but it is not clear which aspects of the model or the deliberative process are more useful for extension planning. In this study, we research how ADOPT, a model that predicts adoption, may assist decision making in planning for agricultural extension. In 2018, we used ADOPT in three workshops with extension officers from the pastoral sector in New Zealand to analyse the adoption of four well-known practices in the industry. We identified important features of the model and the process used in the workshops and asked participants to rank their usefulness. The components were: a conceptual model of adoption, a comparison between the predicted diffusion curve and actual uptake, a sensitivity analysis of the results, and a structured discussion around these components. We found that using ADOPT changed participants' perceptions on the feasibility of forecasting adoption. We also found that participants believe the process of discussing and using ADOPT was just as important, or more important, than the model's results.

Keywords: Technology diffusion, agricultural extension, adoption, modelling, pastoral farming, ADOPT.

Introduction

Planning for extension in agriculture requires consideration of the complex nature of the process via which farmers adopt new practices. In this process, many elements dynamically interact with each other over time and future conditions are uncertain. Interacting elements include the population of potential adopters, the technology or practice in question and the external context in which adoption takes place (e.g. biophysical, economic and regulatory conditions). These factors make each adoption case unique.

Agricultural extension agents are aware that a farmer's decision to adopt technologies and practices in agriculture is not as simple as choosing the option offering more economic benefits (Vanclay 2011). According to Nicholson et al. (2015, p. 1), farm decision-making consists of '…choosing a path that provides a farming business with acceptable reward for acceptable effort at an acceptable amount of risk'. For example, some farmers are willing to accept lower profits in order to maintain a lifestyle and production system that suits their goals and values, while others might be willing to operate at a high level of risk in order to maximise returns while knowing they are foregoing other opportunities. Moreover, agriculture depends on biology and climate, so its performance can be affected by factors beyond operator control. Nicholson et al. (2015) point out that agriculture operates in one of the most challenging business environments due to the combination of volatile production and prices. Kaine et al. (2011) support this idea and propose that landowners normally configure resources with technologies and practices to realise family and business objectives while managing exogenous constraints. The interdependence of all those elements imposes restrictions on how farmers can respond to opportunities and constraints and therefore can influence their decisions on whether to adopt new practices.

On the other hand, one of the aims of extension is to increase and/or accelerate the adoption of beneficial technologies and practices amongst a target population of potential adopters. The design of the extension strategy used is often developed in a planning process, which commonly is done collaboratively rather than individually. Collaborative planning is thus an iterative process where decisions emerge from discussions amongst a designated group rather than from individuals working alone. Planning theorists argue that groups are better than individuals at assessing and choosing amongst options for the future (Innes & Booher 1999). They propose that the main advantage of group discussions is having the opportunity to expose the group members to the unique knowledge of each participant about aspects of a problem that they understand better than anybody else does.

However, due to the complexity of adoption decisions, it is difficult to achieve a common understanding of what drives adoption, especially when individual knowledge and beliefs differ substantially from one another (Pannell & Claassen 2020). Wilkinson (2011, p. 47) has suggested that '…the word "adoption" is so entrenched in the language that everyone who uses the word thinks they know what is meant by it, but that its interpretation varies. This lack of common understanding is well documented in the adoption literature (Wauters & Mathijs 2014; Liu et al. 2018) and it can potentially make it difficult for experts to undertake effective planning sessions.

Models of various types have been used successfully to understand complexity and assist decision making. It has been argued that, when making decisions, the more complex the problem, the greater the potential benefits of a model (Walker 2000; Vicsek 2002; Epstein 2008; Veldkamp 2009). In order to assist with planning for agricultural extension, a model of adoption needs to logically reflect the realities of landowners making a choice about adoption (Nicholson et al. 2015) by considering the interplay between rewards, effort and risk, in terms of both the decision makers' preferences and the characteristics of the practice itself (Montes de Oca Munguia & Llewellyn 2020). The model also needs to clearly identify drivers related to potential adopters and the practice itself, distinguishing between drivers that are at the disposal of participants to design extension interventions and drivers that are outside their control. Finally, the model needs to show the effects that intervention strategies can have in the system under certain contexts.

There are many examples in the agriculture and natural resource management literature showing the use of different modelling approaches in different types of deliberative processes. Models include: economic models (e.g. Rosegrant et al. 2002), information flow models (e.g. Fountas et al. 2006), integrated models (e.g. Antle et al. 2014; Kuehne et al. 2017), and agent-based models (e.g. Laciana & Oteiza-Aguirre 2014; Schreinemachers & Berger 2011). Collaborative processes include 'robust decision-making' (Lempert et al. 2006; Haasnoot et al. 2013; Kalra et al. 2014; Maier et al. 2016), 'theory of change' approaches (Prinsen & Nijhof 2015; Allen et al. 2017; Douthwaite & Hoffecker 2017; Thornton et al. 2017) and more recent efforts to develop tools to facilitate planning for the scaling out of innovations in complex developing country scenarios (e.g. Sartas et al. 2020).

The literature is not clear in defining what a 'good deliberative process' is for extension planning and the contributing role that models may play. Using a model in group settings requires a degree of compromise between the individuals' perception of how the system works and the simplified representation of the system used in the deliberation. It is therefore inevitable that this would cause a degree of scepticism that will affect the individuals' perception of the model's results. Nevertheless, participants who are open to the use of models in their deliberations often do it pragmatically, or as the common aphorism attributed to the statistician George Box states, they may embrace the view that: 'all models are wrong, but some models are useful' (Box & Lucefio 1998).

The objective of this paper is to improve our understanding of the usefulness of models in planning for extension, and whether participants perceive the model or the process of using it to be more useful. There is already evidence in other fields that the successful use of models depends on a good deliberative process (Jakku & Thorburn 2010), and that '...A good process can survive a bad model, but a bad process isn't helped by a good model' (Lempert 2015). Furthermore, Phillips & Linstone (2016) suggest that the real objective of using models in planning, especially forecasting models, is not necessarily to be 'right', but to '… help us be better prepared to understand the range of possibilities and react with flexibility and resilience to future events', and that '…the most precise forecast is not necessarily the most useful forecast' (p. 163).

In general terms, we considered that the usefulness of a model and a deliberative process were based on their ability to generate focused technical discussions, as proposed by Forester (1999). Usefulness thus depends on facilitating detailed, focused technical arguments amongst participants about the range of options at their disposal to design extension interventions, to assess the potential performance of these interventions under a specific context, and to methodically analyse the uncertainty surrounding drivers and their effects on adoption. Thus, we consider an adoption model to be useful for extension if it can improve participants' understanding of the complex environment in which they operate by: a) illustrating how the system works and identifying key driving forces, b) quantitatively predicting the outcomes from the system in a particular context, and c) methodically analysing the uncertainty surrounding drivers and their effects on outcomes.

It is also not clear in the literature if there are specific aspects of a model that can be identified as being more useful than others. For this research, we identified three model components that were evaluated independently and are aligned to one of the three points above: a) the model's specifications of drivers and their causal relationships (e.g. functional form), b) the model's output (e.g. diffusion curve), and c) the outputs' sensitivity analysis (e.g. scenario evaluation) (Kalra et al. 2014).

ADOPT

For this research, we use the ADOPT model (Adoption and Diffusion Outcome Prediction Tool), developed by Kuehne et al. (2017), in a case study with professional extension specialists working in the pastoral sector in New Zealand.

ADOPT was selected because we consider it offers four features that can be evaluated separately in terms of their contribution to effective deliberation: ADOPT includes a conceptual framework that can be used to illustrate how the system works identifying key driving forces; ADOPT produces a predicted diffusion curve; ADOPT includes a sensitivity analysis to methodically analyse the uncertainty surrounding drivers and their effects; and it includes a structured process that can be used by groups for deliberative design.

The process of using ADOPT consists of three steps. These steps include: first, presenting and discussing the conceptual model; second, methodically answering a sequence of questions to define the model's inputs – this step requires the group to discuss each question, understand its relevance and reach consensus for each answer; and third, discussing the effects of different variables on the model's output using sensitivity analysis.

Most importantly, ADOPT is one of the few tools available that explicitly provides ex-ante adoption analysis in agriculture. We consider these features can generate the level of technical enquiry suggested by Forester (1999) for planners to 'assess practically, comparatively and prescriptively a range of viable options at their disposal'. Given its features, ADOPT may be able to facilitate discussions about the potential effects of drivers on the adoption of a technology or practice, where experts in different fields are encouraged to make contributions throughout the process, as suggested by Innes & Booher (1999).

Methods

Workshops

Three separate workshops were conducted in 2018 with 34 professionals representing a range of organisations involved in research and extension in the pastoral sector in New Zealand after human research ethics approval was granted by the University of Western Australia. These participants have extensive knowledge of the population of pastoral farmers in New Zealand, and some were also experts on the specific technologies used in this research. Pastoral farming dominates the rural agribusiness sector in New Zealand, more specifically 'sheep and beef' farming (producing meat and fibre) and dairy cattle farming. Technology has always played an important role in the sector. Organisations represented in the workshops were: Dairy NZ (an industry organisation), the Red Meat Profit Partnership (a research programme), AgResearch (an agricultural research company), the Ministry for Primary Industries, the Alliance Group (a meat processing company), Beef & Lamb New Zealand (an industry organisation), and Lincoln University.

The number of participants for each workshop were 18, 10 and 6, with no repetition. The first two workshops were attended by dairy industry specialists and the third workshop was attended by sheep and beef farming specialists.

Extension officers were asked to complete a questionnaire before their workshop and one at the end, to detect shifts in their perceptions about using models before and after their participation (Montes de Oca Munguia 2020). Reponses were summarised as a group and used to define statistical models. The pre-workshop questionnaire was sent alongside the invitation to participate two weeks prior to the workshop. This questionnaire included questions regarding the participant's area or work, their perception of the usefulness and the feasibility of predicting adoption, and their opinion on the importance of several drivers of adoption to be considered while thinking about adoption.

The post-workshop questionnaire included questions about their perceptions on the usefulness of the group discussion generated in the workshop and different components of ADOPT. Participants were also asked whether their participation in the workshop had changed their opinion about the ability of a model to forecast adoption and whether their opinion on the importance of different adoption factors had changed from their original perceptions. Finally, they were asked what actions they were likely to take in relation to predicting adoption after the workshop. A total of 31 participants completed the pre-workshop questionnaire. Of those, 24 completed the post-workshop questionnaire.

Participants were made aware that the objective of the workshop was to use their expert opinion to evaluate the use of ADOPT for extension planning using an example of a well-known technology available to pastoral farmers in New Zealand. We selected familiar practices as a reference point rather than a new practice so that participants would be more confident in assessing the model's output. We clarified that the intention of the workshop was not to validate the model results against measured adoption. Current adoption of these practices was estimated using the results of a survey of pastoral farmers in New Zealand (Montes de Oca Munguia 2020). Each group was asked to select an example from four available options:

- *Use of body condition scoring.* The assessment of Body Condition Scoring (BCS) is used to estimate body fat reserves in both cows (visual) and ewes (feeling backbone with fingers and thumb). BCS is used as a management tool to determine feed requirements and improve reproductive performance.
- *Use of pasture management software.* Use of computers, tablets and smartphone apps or programmes to calculate feed demand, feed availability and feed quality for sheep and cattle at any time of the year and for different levels of production. Information can be used for both tactical and strategic decisions.
- *Use of Plantain and/or Lucerne for summer grazing.* Plantain and Lucerne are used to increase the amount and quality of summer feed in grazing systems. Plantain is more often used as a pasture mix, but it can also be used as a special purpose crop, lasting 2-3 years. Lucerne is used on soils with low soil moisture holding capacity to increase production.
- *Use of a formal, audited nutrient management plan.* Used to actively manage nutrients (N and P) on the farm in a formal, audited way. They can be developed in conjunction with a fertiliser consultant or as part of an environmental plan developed by industry or local government. Nutrient management may include managing the type, placement and timing of fertiliser applications; crop rotations; precision application; and stock exclusion from waterways.

All practices have been available in the industry for at least 20 years, but they all showed different levels of current adoption by the time the workshops took place. The survey found body condition scoring was the most widespread practice amongst surveyed farmers, reaching 74% adoption. This was followed by using Plantain and Lucerne for summer grazing (56%), the use of pastoral management software (45%) and the use of nutrient management plans (38%).

Participants at each workshop were asked to select the practice they were more familiar with or more interested in. The use of formal, audited nutrient management plans amongst dairy farmers was used as the example for the first workshop. The use of pasture management software amongst dairy farmers was used as the example for the second workshop, and the use of a formal, audited nutrient management plans amongst sheep and beef farmers was used as the example for the third workshop.

The workshops consisted of three facilitated steps:

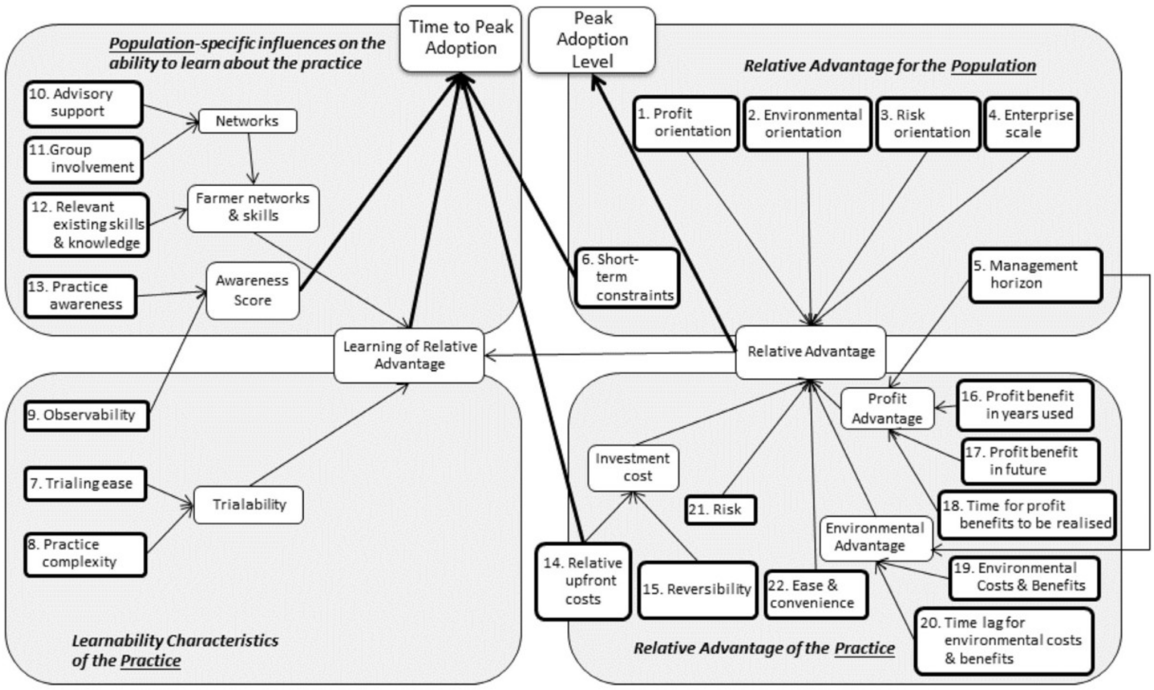
- A presentation and discussion about ADOPT's conceptual model, covering the model's specifications of drivers and their causal relationships.
- Running ADOPT on-line to produce a diffusion curve and compare it with the survey's measured adoption for the selected practice.
- An exercise to use ADOPT's sensitivity analysis to adjust the initial forecast to be closer to the survey's measured adoption curve, discussing the assumptions behind observed discrepancies.

Conceptual model discussion

The ADOPT conceptual model shown in Figure 1 was presented by the facilitator and discussed by the group. The presentation also covered the mechanics of using ADOPT in the workshop: participants were required to discuss and agree on the answers to 22 questions about the numbered variables in the four quadrants represented in Figure 1. In ADOPT, responses are used in mathematical functions to predict time to peak adoption and peak adoption level using cause-effect relationships for each relationship shown in the conceptual model.

The first high-level driver of adoption in the ADOPT model is relative advantage. Theories related to relative advantage for modelling are well supported in literature and include subjective expected utility theory (Tversky & Kahneman 1981), prospect theory (Laibson & Zeckhauser 1998), and multi-attribute utility theory (Huang et al. 2011). The application of these theories in models of decision-making have been reviewed extensively (e.g. Behzadian et al. 2010). The use of different population orientations (i.e. preferences) to weight characteristics of the practice when calculating overall relative advantage in the conceptual model illustrates the interplay between rewards, effort and risk in decision making in agriculture, as proposed by Nicholson et al. (2015).

Figure 1. The ADOPT conceptual model



Source: Kuehne et al. (2017)

The second high-level driver of adoption in the ADOPT model is learning, which is a key focus for extension professionals. The ADOPT conceptual model identifies cause-effect relationships affecting the likelihood of adoption and the time lag from the availability of the innovation to the decision to adopt it in three stages as suggested by Lindner et al. (1982). They are: first, the discovery stage – the time it takes for the producer to be aware of the existence of the innovation; second, the evaluation stage – the time from awareness to first use, on a trial basis; and third, the trial stage – the time from the initiation of trial use to the acceptance of the innovation. Thus it covers the stages of awareness, trialling and adoption as outlined by Pannell et al. (2006).

ADOPT results

The process of using ADOPT in all workshops consisted of running the on-line version of ADOPT and having a 1 to 3-minute group discussion about each of the 22 questions until agreement was reached on an answer. ADOPT results were then presented, compared with the survey results, and discussed.

Figure 2 shows an example of the ADOPT questions participants were asked to answer. The question and its explanation are displayed on the top-right. After group discussion, participants agreed on an answer (bottom-right) and moved on to the next question. The list of variables and their correspondence of each variable to a quadrant in the conceptual model is displayed in the list on the left-hand side of the screen. A printout of the conceptual model (Figure 1) remained visible to participants throughout the process, so the facilitator could point out the links between each numbered question and their relationships with other variables.

Table 1 shows, for each workshop, the estimated current uptake level and average time to adopt from the survey and the ADOPT outputs resulting from the group's discussion. The table shows differences between each group's predictions and the survey estimates of current adoption levels. Participants were reminded that the intention of the comparison was not for validation purposes, but rather to reflect on the characteristics of the practice and the population that might be behind the differences.

Workshop 1 participants produced a peak level prediction relatively close to the estimated current uptake level, but an unusually long time to peak. In contrast, workshop 2 participants produced a prediction of the time to reach peak adoption close to estimates of current adoption times but predicted peak adoption levels were much higher than current uptake levels. Predictions generated by workshop 3 participants were much higher than current adoption levels and involved a much longer time to reach the predicted peak than the average time to adoption experienced by adopters so far.

Figure 2. Example of on-line ADOPT used in Workshop 2

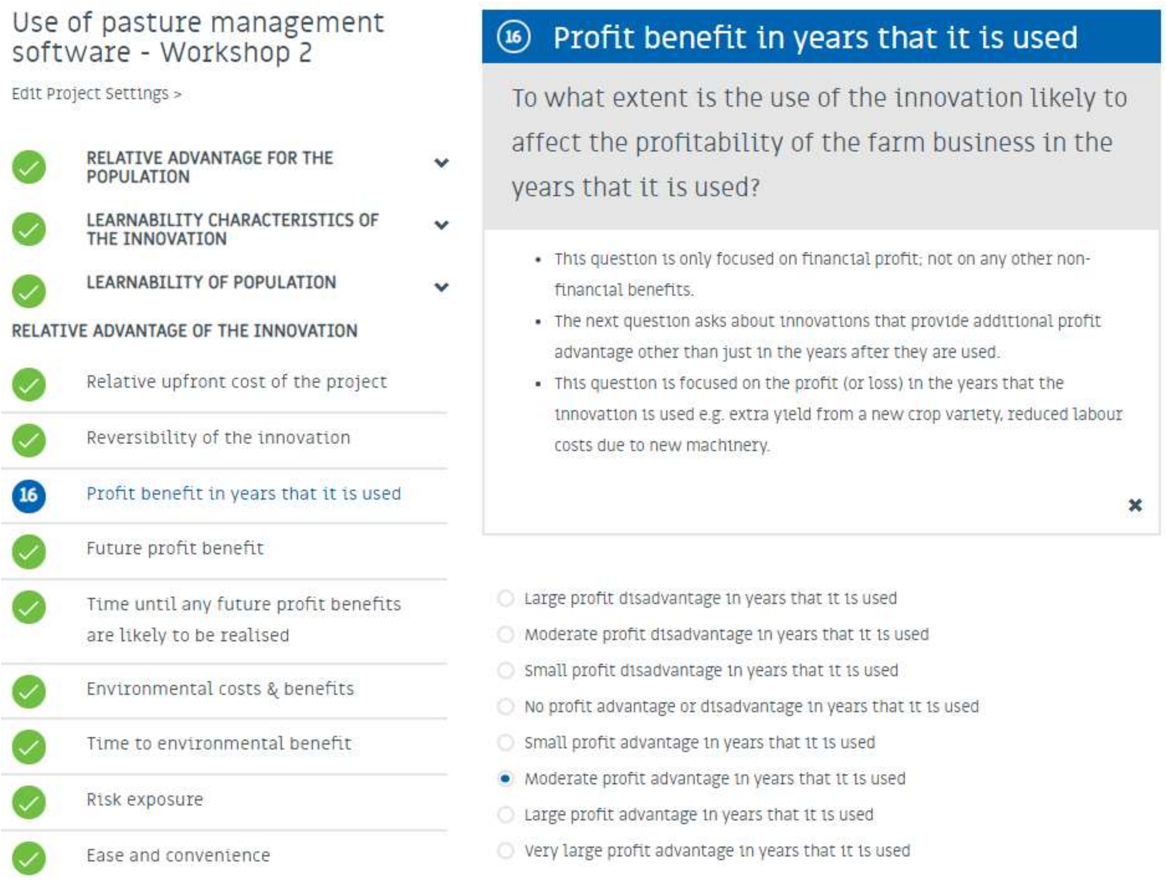


Table 1. Simulated results in relation to current levels of uptake from a recent survey

Workshop	Practice	Measured current adoption level from survey	Average time to adoption estimated from survey	Predicted peak adoption level from participants' ADOPT run	Predicted time to near-peak adoption from participants' ADOPT run
1	Audited nutrient management plans	38%	6 years	59%	21 years
2	Pasture management software	45%	12 years	94%	13 years
3	Audited nutrient management plans	38%	6 years	93%	13 years

Sensitivity analysis

The last step in the workshop was an exercise to allow adjustment of participants' inputs, informed by ADOPT's sensitivity analysis and the predictions generated by the initial inputs. The purpose of this exercise was to allow participants to identify the variables that, if adjusted, would have the most impact on the outputs. Participants were encouraged to explore different combinations of variables that would adjust their initial prediction and discuss the assumptions behind their answers. In this case, the sensitivity analysis identifies the variables that have the most effect on the model's predictions of peak level of adoption and time to peak adoption. Figure 3 shows ADOPT's sensitivity analysis for Workshop 2.

The horizontal axis shows the question numbers, which correspond to each numbered variable in the conceptual model. In each graph, the vertical axis shows the step changes that occur in each output by changing the answer to the question one level up or down. The change in peak adoption level occurs in terms of adoption percentage and the time to peak adoption is measured in number of years.

Figure 3. ADOPT's sensitivity analysis diagram used to analyse the use of pasture management software in Workshop 2

Sensitivity analysis allowed participants to make separate adjustments to both their prediction of peak adoption levels and time to reach peak adoption by exploring different sets of variables (as illustrated in the conceptual model – Figure 1). For example, participants in workshop 2 aimed at reducing their predicted peak adoption level while retaining their predicted time to reach peak adoption. Figure 3 shows that the most sensitive variable for changing the predicted peak adoption level on the use of pasture management software was the level of profit benefits in years that the practice is used (question 16), followed by profit benefits in the future (question 17) and environmental costs and benefits (question 19). Figure 3 shows that, for example, adjusting the answer to question 16 one level down would reduce the prediction by 21%. In their example, this would adjust their initial peak adoption prediction from 94% to 73%. Participants agreed to reduce this variable by one level. After making this adjustment, the process was repeated to decide whether to make more adjustments to the same variable or adjust other variables, making constant references to the conceptual model. Table 2 shows, for each workshop, the variables that were adjusted from the initial run and the resulting adjusted predictions.

The wrap-up discussion after the sensitivity analysis centred on the feasibility of predicting adoption, the general use of prediction models in extension and the 'strengths and weaknesses' of using ADOPT for extension planning. There was discussion about factors that affect the diffusion of innovations that are not only outside the individual farmer's control but also outside the scope of any model. For example, participants highlighted the role of impending legislation in the future uptake of audited environmental farm management plans. Experts observed that the 'pressure to comply' amongst the farming community has increased recently, and therefore peak adoption level in a voluntary basis has not been reached for this practice yet. Participants did not feel this pressure could be captured explicitly in the relative advantage equation.

Table 2. Comparison between initial and adjusted ADOPT predictions for each workshop

	Workshop 1		Workshop 2		Workshop 3	
Predictions	Initial	Adjusted	Initial	Adjusted	Initial	Adjusted
Peak adoption	59%	48%	94%	66%	93%	35%
Time to near peak adoption	21 years	10 years	13 years	13 years	13 years	12 years
ADOPT answers						
1. Profit orientation	a minority		almost all		a minority	
2. Environmental orientation	about half		a minority		a majority	
3. Risk orientation	a majority		a minority		a majority	
4. Enterprise scale	almost all		almost all		almost all	
5. Management horizon	a majority		almost none		a majority	
6. Short-term constraints	almost all		almost all		almost none	
7. Trialing ease	moderately easy	easily	easily		moderately difficult	difficult
8. Innovation complexity	very difficult	slightly difficult	difficult		difficult	moderately difficult
9. Observability	moderately	easily	difficult		difficult	moderately difficult
10. Advisory support	a minority	about half	about half		a majority	
11. Group involvement	a minority		a minority		a minority	
12. Relevant existing skills & knowledge	almost all	a majority	about half		a majority	
13. Innovation awareness	a minority	about half	almost all		a majority	
14. Relative upfront cost of innovation	moderate		minor		large	
15. Reversibility of innovation	very easily		very easily		easily	
16. Profit benefit in years that it is used	small profit advantage		moderate	small	moderate	small
17. Profit benefit in future	moderate profit ad		moderate	small	small	
18. Time for future profit benefits to be realized	3 to 5 years	6 to 10 years	1 -2 years		3 to 5 years	6 to 10 years
19. Environmental impact	small		no net		large	small
20. Time for environmental impacts to be realized	3 to 5 years		not applicable		1 to 2	
21. Risk	small reduction		small		moderate	
22. Ease and convenience	no change		small increase		small decrease	

Some participants suggested that ADOPT could be complemented with other models analysing 'macro' variables, such as bioeconomic models, but many participants felt that extension planning should not be 'run by models'. However, there was also discussion about the strengths of ADOPT. Participants expressed that the model included the factors than need to be in place to assess the 'adoptability' of an innovation. After this discussion participants were asked to fill in the post-workshop questionnaire and the workshop concluded.

Statistical analysis of workshop questionnaires

The frequency of responses from both pre and post-workshop questionnaires were summarised. Due to the ordinal nature of the data and the small sample size, we grouped and reported responses for each question (collected on a scale from 1 to 10) into three intervals: low scores (e.g. rarely, disagree, not useful), medium scores (e.g. sometimes, moderately agree, moderately useful) and high scores (e.g. often, agree, useful).

We also conducted non-parametric testing to explore the statistical relationships between responses. Recognising the limitations arising from our small sample size, we consider these tests could be used more confidently in subsequent studies with larger samples. Firstly, we conducted a paired-samples Wilcoxon test (i.e. Wilcoxon signed-rank test) to detect a shift in the perception of participants using the responses to four questions that were asked both before and after the workshop. Those questions were:

- In your view, is it possible to predict adoption adequately?
- In your view, how important are the following factors in driving adoption:
    - Characteristics of the farmer.
    - Characteristics of the technology or practice.
    - External factors, out of farmers' control.

Secondly, we defined five variables based on the responses of a selection of post-workshop questions (Table 3). The variables were used to build an ordered logit regression model to identify the level of contribution of each ADOPT feature in the participant's perception of usefulness of the discussion.

Table 3. Variables used to test the usefulness of the workshop components

	Question
Dependent variable	How useful did you find the workshop to focus technical discussion of adoption?
Independent variables	How do you rate the contribution of the following model features explored today to the discussion: Diffusion s-curve Sensitivity analysis Conceptual model Process of group discussion

Results

Pre-workshop responses summary

Participants were asked to identify tasks in their work that required them to think about future adoption. Many participants were involved in the evaluation of research projects involving farmers (35%) or in decisions to invest in new technologies or practices (38%). In addition, most participants were directly involved in designing (88%) and implementing (74%) extension strategies to increase adoption of beneficial practices.

Participants were asked how often they considered the likely adoption of a technology or practice in their work. Results showed that 15% of participants seldomly considered adoption, while about a quarter considered adoption occasionally (24%). Almost two-thirds of participants indicated they needed to consider adoption regularly (62%).

Prior to the workshop, most participants considered that predicting the adoption of a new technology or practice was useful. Results showed that 41% of participants considered it very useful, 44% considered it moderately useful and 15% only slightly useful.

However, while most respondents to the pre-workshop survey considered predictions useful, 38% did not believe it was possible to predict adoption adequately (Table 4).

When asked about the importance of the characteristics of the farmer in driving adoption, over two-thirds of participants considered it important (71%), 24% or participants considered it neutral, and 5% considered it not important. Participants rated the importance of the characteristics of the technology in driving adoption as important (81%), or neutral (19%). Finally, opinions before the workshop were more divided amongst participants about the importance of external factors (factors out of farmers' control) in driving adoption. Half the group considered them important (52%), 33% considered them neutral and 14% considered them not important.

Post-workshop responses summary

After the workshop, participants were asked whether their participation in the workshop changed the way they understood adoption. More than half of respondents agreed with this statement (55%), 27% were neutral and 18% of participants disagreed. Table 4 shows the responses to questions included in both the pre and post-workshop questionnaires. The largest changes to participants' perceptions following the workshop were an increase in the perception that it is possible to predict adoption adequately, and an increase in the importance ascribed to external factors out of farmers' control as influences on adoption.

Table 4. Participants' changes in opinion before and after the workshop

In your view, is it possible to predict adoption adequately?		**Disagree**	**Neutral**	**Agree**
	Pre-workshop	38%	29%	33%
	Post-workshop	14%	24%	62%
In your view, how important are the following factors in driving adoption		**Not important**	**Neutral**	**Important**
Characteristics of the farmer	Pre-workshop	5%	24%	71%
	Post-workshop	5%	21%	74%
Characteristics of the technology or practice	Pre-workshop	0%	19%	81%
	Post-workshop	0%	5%	95%
External factors, out of farmer's control	Pre-workshop	14%	33%	52%
	Post-workshop	5%	16%	79%

We also asked participants to rate the usefulness of the workshop and the different features of ADOPT to generate focused technical discussion of adoption. All participants considered that the workshop was useful. Table 5 shows how participants rated the usefulness of different components we evaluated.

Table 5. Participants' rating of the usefulness of workshop components

How do you rate the usefulness of the following information and model features explored today	**Not useful**	**Neutral**	**Useful**
Conceptual model	0%	4%	96%
Process of group discussion	0%	0%	100%
Diffusion S-curve	8%	25%	67%
Sensitivity analysis	4%	13%	83%

All components of the workshop, including the ADOPT conceptual model, ADOPT results and the process of using it were considered useful by most of the participants. The presentation of the ADOPT conceptual model was considered useful by most participants and the process of group discussion was considered useful by all participants. Regarding ADOPT outputs, most participants considered them useful, with some participants being neutral about them and one or two participants considered them not useful.

Finally, we asked participants what actions they were likely to take in relation to predicting adoption after the workshop. A minority (4%) said they would take no action, 25% said they would reassess their practice, 33% said they would change their approach or advice, and the majority (58%) said they would seek extra information or training.

Statistical analyses

We had limited success regarding the two analyses used to explore the statistical relationships between responses, possibly due to the low number of observations (n=24). However, the paired samples Wilcoxon test detected a significant shift in two of the perceptions of participants listed in Table 4. The test indicated a significant difference in the perceived ability of models to predict adoption after the workshop (p = 0.046), and the importance of external factors (p = 0.044).

According to the test, participants' opinion did not change significantly regarding the importance of characteristics of farmers and the practice after the workshop. On the other hand, the regression analysis aimed at identifying which factors from Table 5 had the most influence on the rating of the overall usefulness of the workshop did not identify any statistically significant factors (p<0.05).

Discussion

Was it the model or the process of using it? Our results show that all participants rated the process of group discussion to be useful, although a minority of participants considered the model to be not useful. Our results therefore support previous research finding that the process of using models is considered more valuable than the model itself (Jakku & Thorburn 2010; Lempert 2015).

However, previous studies generally only focus on contrasting model results vs process. We extended the analysis by investigating three specific aspects of a model that may influence its usefulness for extension planning: understanding the system, forecasting adoption and evaluating alternative outcomes. Kalra et al. (2014) identified those three areas in which parties to a decision often do not know or cannot agree on but did not provide an evaluation of how a model can assist each one.

In line with previous studies (e.g. Phillips & Linstone 2016), our results showed that the model's predicted diffusion curve (i.e. model results) was ranked by participants only as the third most useful component. Even though ADOPT was able to generate adequate predictions of adoption, more participants found the other two components even more valuable than the predictions per se.

The most useful model component was the conceptual model. Participants used it to discuss how the system works and to identify the key driving forces and relationships behind the adoptability of an innovation, identifying how drivers affect either the likelihood of adoption, the speed of adoption or both.

This was followed by the sensitivity analysis. Participants were able to evaluate alternative outcomes, identifying drivers that where under their control (e.g. advisory support, improve awareness) and those they cannot control (e.g. the priority given by the farmers to issues such as profit, risk and the environment). They used sensitivity analysis to discuss how different adoption strategies could work in practice.

We thus consider that this study can move the discussion of model usefulness further by offering a more nuanced analysis of a model's ability to generate focused technical discussions, as proposed by Forester (1999) and reduce uncertainty in decision making (Kalra et al. 2014).

There are two points not covered in this study that could limit its findings. We did not investigate how planning occurs in the absence of a model and we did not investigate the role of models in participants' learning. Regarding the second point, we believe there is an opportunity to further understand models as learning tools. Participants in our workshops reported a change in their understanding of adoption, suggesting that their participation was useful in deepening their knowledge of the adoption process. They also indicated an intention to change their current practice because of the workshop, either by reassessing their current practice, changing their approach or advice, or seeking extra information or training.

Conclusion

The objective of this paper was to improve our understanding of the 'usefulness' of models in planning for extension, and whether extension officers perceived the model or the process of using it to be more useful. We conducted a series of workshops using ADOPT as the model to analyse the adoption of well-known practices and asked participants in our workshops to evaluate the model and the process of using it in assisting extension planning. Our results support previous research finding that the process of using models is considered more valuable than the model outputs, but we also offer a more nuanced understanding of model usefulness that goes beyond using models as 'black boxes' to produce adoption projections.

In our workshops, we found that participants have pragmatic attitudes towards the use of models in planning, even when some felt that extension planning should not be 'run by models'. At each workshop, there were multiple discussions about the general use of prediction models and the 'strengths and weaknesses' of using them for extension planning. It was concluded that ADOPT was useful to think about the 'adoptability' or 'adoption potential' of an innovation, but that external factors that are outside of the scope of any model should also be kept in mind when using the results.

Lastly, this study highlights the importance for model developers considering a full range of model features to better assist extension planning to improve the uptake of beneficial agricultural innovations.

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