An investigation into the use of social media for knowledge exchange by farmers and advisors

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Abstract. As social media provides the opportunity for communication and knowledge exchange among rural actors and with better access to mobile devices and broadband, its popularity has grown in the rural sector. This paper explores rural actors' knowledge exchange from a preliminary investigation of advisors and farmers' social media use in a United Kingdom pasture-based dairy farmer Facebook group with 1208 members and the Twitter activity of 48 New Zealand farmers and advisors. Results suggest that rural actors are engaging in international social media networks for knowledge exchange that supports on-farm decision making. The analysis revealed that network hotspots and opinion leaders were key to this knowledge exchange. Although not an exhaustive investigation, the research suggests that social media provides a valuable tool for rural innovation by acting as a communication platform that stimulates individual and collective learning and promotes weak ties necessary for innovation.

Keywords: Social media, knowledge exchange, rural actors

Introduction

In recent years, there has been increasing interest in how Information Communication Technologies (ICT) and internet-based applications and tools may support decision making, learning and innovation in agriculture (Shanthy & Thiagarajan 2011; Sulaiman et al. 2012; Poppe et al. 2013). However, only recently have social media and software applications (apps) been explored as channels for information exchange between rural actors (Poppe et al. 2013; Jespersen et al. 2014; Materia et al. 2014; Munthali et al. 2018; Steinke et al. 2020). Many apps have been created specifically for agricultural purposes, but as Steinke et al. (2020) note, often these fail since they do not meet user requirements.

Social media provides a platform by which individuals and communities can engage in online networks to share, co-create, discuss and modify user-generated content, which is typically media rich (Kaplan & Haenlein 2010; Piller et al. 2012). In these communities, members can construct an identity within a bounded system - which may or may not be made public, engage with other users with whom they share a connection, make visible their own connections and view other members' connections (Boyd & Ellison 2007).

While the growth in personal use of social media has been extraordinary, there is a small but growing scholarship exploring its use among farmers and rural professionals such as advisors (Kaushik et al. 2018; Munthali et al. 2018; Nain et al. 2019). Research has explored farmers and other rural actors use of social media platforms for building networks (Kaushik et al. 2018), and for engaging in knowledge and information exchange (Materia et al. 2014; Mills et al. 2019).

However, there still remains a need to understand more about rural actors use of social media and specifically the roles social media play in farmer learning, as well as how advisory systems may connect to social media (Klerkx et al. 2019; Klerkx 2020). This article seeks to contribute to the growing scholarship about farmers and rural advisors use of online communities for knowledge exchange, by exploring two cases of rural actors' social media interactions to examine how these may contribute to knowledge exchange among farmers and advisors. In doing this the article asks: How does knowledge exchange occur in farmer learning networks on social media? To answer this, this article presents an analysis of conversations from two social media platforms used by farmers and rural professionals. The first case involves a Facebook conversation in a 'closed' pasture-based dairy farmer group coordinated from the United Kingdom, where the content is available only to members. The second case follows the Twitter activity of 48 New Zealand rural actors over five months.

The article begins with an exploration of the literature on farmer learning in real world and online networks. The methodology for investigating social media conversations is then explained, including a novel methodology for Facebook analysis to manage the complexity of these conversations. This is followed by the findings from the analyses of two cases of social media activity among rural actors. The discussion then explores how farmer knowledge exchange via social media might contribute to on-farm decision making. The paper concludes by recommending areas for further research.

Learning in farming networks in the real and virtual world

Farms exist in complex environmental, social, economic, political and cultural systems (Darnhofer et al. 2012). Farmers are not isolated individuals but are part of numerous social networks in which they build support networks to create their constructions of reality (Kelly 1955, Bannister & Fransella 1971) to operate and enact change on their farms. Farmers' perceptions of what is 'true', what they can aspire to, and what they are able to do, are influenced by their daily routines, past events and feedback they receive (Leeuwis 2004). Their strategic, tactical, and daily decisions are influenced by a body of knowledge that has evolved over time (Shadbolt & Martin 2005). Shadbolt et al. (2013) argue that farmers increase the resilience of their farm business by using 'buffer capacity' to make the existing systems stronger; 'adaptive capacity' to make small changes to existing systems; and 'transformability' to create completely new systems by making radical changes to cope with the volatility and uncertainties they increasingly face.

Social networks have long been recognised as influencing an individual farmer's decision making (Phillips 1985) and self-directed learning (Tough 1978). Prior to the Internet, farming networks were typically small and neighbours formed tight social ties and often worked collectively at seasonal peaks while also socialising together. These social networks provided social capital, which Bourdieu & Wacquant (1992, p. 14) define as 'the sum of the resources an individual "accrues" on the basis of belonging to durable networks … of mutual acquaintance and recognition'. Networks are recognised for creating bonding capital, which occurs from connections with like-minded people, and bridging capital, which occurs from association with others outside one's immediate social network (Bhandari & Yasunobu 2009). Social capital is importantly shown to support farmer learning (Tedjamulia et al. 2005; Tregear & Cooper 2016; Cofré-Bravo et al. 2019).

The principle of homophily says that people associate with other groups of people who are most like them (Bontcheva & Rout 2014). Unsurprisingly then, farmers bond with other farmers, who act as their main source of farm management information, despite the availability of agricultural research, extension services and media (Phillips 1985; Evans et al. 2017). Phillips (1985) found that farmers' peer acquaintances act both as a source of information and importantly as a validation for information that is received. Furthermore, he found that intimate peers, such as a farmer's partner or immediate family, play crucial support roles for the primary decision maker. Farmers trust in individuals in their network, influence the level of support they receive from those individuals. Information providers, including extension workers play other roles in the farmer's decision making (Phillips 1985; Gielen & Hoeve 2003; Sligo et al. 2005; Cofré-Bravo et al. 2019), for example enabling access to new sorts of information being derived from research. Peer networks therefore act as effective learning communities in agricultural settings (Klerkx & Leeuwis 2009; Morgan 2011). Networks have been shown to support the transformation of information to actionable knowledge and decision making on the farm (Phillips 1985).

The concepts of 'situated learning' and 'communities of practice' (Lave & Wenger 1990, Wenger 2000) show how knowledge is not purely attained from an individual's accumulation of information, but rather is socially constructed through social interaction and imitation. In communities of practice, members ask questions, request information, seek experience and problem solve within their domain (Wenger 2000). Collective learning and shared competence are an emergent property from these interactions. Collective knowledge is a critical asset of the community and relies heavily on the experience or tacit knowledge of members, while the exposure to tacit knowledge enables the construction of actionable knowledge (Evans et al. 2017). Tapsell and Woods (2008) describe the creative process of knowledge exchange and co-creation in collectives, as an entrepreneurial process of meaningful conversations between the experienced and the opportunist with new ideas. Jespersen et al. (2014, p. 1) recognise the creativity of knowledge exchange when they state, 'Innovation occurs as a result of the creativity and interplay between actors combining new and/or existing (tacit) knowledge'.

Knowledge exchange occurs from a process of social interaction often in transient networks which meet to address specific challenges and tasks, at particular points in time (Klerkx et al. 2009). These learning environments are known to enhance farmer self-efficacy (Bandura 1997) and validate collective learning (Drysdale et al. 2017), indeed in such networks there is a substantial move away from individual thinking to collective knowledge.

Materia et al. (2014) note that communities of practice also occur in the virtual world. Online communities, which can occur on a large scale and scope, expand a farmer's network and enable knowledge exchange between people who may be either unknown to each other or who may be connected to some extent in their offline world (Boyd & Ellison 2007). This knowledge exchange leads to a flow of resources in and out of the online community, which provides opportunities for collaboration (Faraj et al. 2011). Online conversations are recognised as key building blocks that

enhance interactive learning and the knowledge of members within the online community (Raaijmakers et al. 2008; Woolley et al. 2015). As in the offline world, conversations involve exchanges of opinion, or 'constructs' (Kelly 1955). The resulting learning that may occur from the exchange of 'personally relevant and viable meanings' (Thomas & Harri-Augstein 1976, p. 2) may well mean that members' constructs are changed. Since most online knowledge collaboration occurs among members who do not have established relationships, conventional conversation norms such as hierarchy or social conventions may be by-passed (Faraj et al. 2011).

Methodology

To investigate online knowledge exchange by farmers and rural professionals (e.g. farm advisors) using Facebook and Twitter to:

- Visualise what online rural actor knowledge exchange looks like across two different social media platforms e.g. Facebook that does not limit conversation length, compared with Twitter which limits length.
- Examine actors' knowledge exchange to give insight to the contribution social media exchanges make to farmer decision making.

The analyses are not intended to be exhaustive explorations, but rather are preliminary and illustrative investigations of advisors and farmer's social media use.

Facebook analysis

The first analysis examined a Facebook conversation about 'newly sown pastures', which took place during December 2017 and involved 94 'member' exchanges. The conversation was taken from an online group of 1208 pasture-based dairy farmers, farm staff and advisors. The group has no facilitator or chairperson to manage conversations.

Demographics at the time showed that group members came from 15 different countries although 68% of the members were from the United Kingdom, with 949 being male and 259 being female. Conversations are held in what could be called a 'gated' community as an administrator grants 'member' access. This Facebook group was selected because one of this article's authors had access to the group and gained permission from the participants to examine conversations. This online group largely formed to discuss pasture-based dairy farm management. While such groups are not unique, analysis of a conversation from this type of group has not been undertaken before.

Facebook conversations are complex to analyse and interpret, because they appear in threads and not in sequential order, making it a challenge to unravel the detail in these conversations. Furthermore, in general, they have numerous posts with many questions, comments, answers, likes and photos. To address both the complexity of the conversations and the challenge of analysing them, and to add rigour and substance to claims that can be made about Facebook conversations, a methodology was developed.

This involved developing what was termed a 'dialogue network analysis' to analyse the 'newly-sown pasture' conversation where 'conversation fragments' (questions, comments, answers and photos) were entered sequentially on a spreadsheet and a number of variables were recorded for each as follows.

- Date and time conversation fragment were posted.
- Participant who posted the fragment (labelled as P1, P2, P3, P4 etc. according to the order in which each participant entered the conversation). This label was retained for any subsequent posts the participant contributed to the conversation.
- Participant's country.
- Question number (numbered according to the order the question appeared in the conversation).
- Type of conversation 'fragment':
    - question
    - comment
    - answer
    - photo.
- Question reference (the question that each conversation fragment refers to).
- Receiver of conversation fragment (labelled according to the participant's number as noted above (P1, P2 etc.).
- Fragment 'likes': whether the post contained a 'like'.

The variables are not exhaustive and further variables could be added, including for example, 'fragment sentiment' (Positive, Neutral, Negative) as used by Raaijmakers et al. (2008) in face-to-face conversations.

Twitter analysis

The second analysis examined the Twitter accounts and activity of 48 New Zealand rural actors who separated into two distinct groupings of 24 dairy farmers and 24 rural professionals who were predominately farm consultants and industry extension staff. These actors were chosen because they were active, experienced Twitter users from New Zealand accounts with the highest number of tweets. The farmers posted a total of 60,428 tweets (average 2518 per account), while the rural professionals posted a total of 40,174 tweets (average 1674 per account). The farmers had an average of 550 followers each, while the rural professionals had an average of 484 followers per account. There is a potential bias of focussing on active and experienced Twitter users, as also recognised by others (Gaffney & Puschmann 2014). However, as the analysis is driven by research questions rather than simply the capture of large amounts of data to describe broad trends, the analysis still provides a much-needed contribution to the wider scholarship of Twitter investigations.

Twitter's metrics that code the tweets according to an array of variables was captured. A common way of measuring a tweeter's 'engagement' is to add up the number of replies, retweets and mentions (Gaffney & Puschmann 2014). This reveals what can be distinguished as the values for bridging capital (retweets) and bonding capital (replies and mentions). 'Twitonomy' was used to mine data from selected Twitter accounts to collect their scores. Twitter metrics were aggregated to create composite variables that measure online interaction. The analysis did not examine either Twitter forums or the use of hashtags.

Findings

Farmers' knowledge exchange in a Facebook conversation

Conversations in the investigated Facebook group were typically spontaneous and unpredictable, and, on a specific topic, ranged in time from 2-150 hours. Conversation threads typically started with a question that effectively set the agenda.

The Facebook conversation on newly sown pasture that was analysed for this investigation, began with a series of five questions being asked in one post by a United Kingdom participant (P1),

> I'd be interested to see photos & hear comments about newly sown permanent pasture. What was in the seed mix? Has it been grazed? When was it sown? Do you know the cost per hectare? Why are you doing it?

A number of members responded to the original question. To trace this, conversation fragments or posts were sequentially ordered for the complete conversation. This provided the foundation from which a visualisation of the conversation could be drawn by tracing the participants and their contributions to the conversation, as shown below in Figure 1.

This visualisation was created by numbering participants (P1-P13) in the order they joined the conversation. Questions (Q1-Q19) were numbered in the order they were asked and recorded against the participant who asked it. Questions drew responses classified as answers or comments. Answers to each question were recorded against the participant who provided it with some questions receiving multiple answers from multiple participants. In contrast, comments could be made on questions or answers so were recorded as arrows extending from the participant who made the comment to the participant to whom the comment was directed.

By tracking both the participants and their contributions, the complexity and non-linear nature of these conversations was revealed. Focussing only on participants and not their contributions may lead incorrectly to a simplistic linear progression being shown, which as the visualisation and analysis showed, is far from the reality of such conversations.

The visualisation was then summarised in a simple summary chart of participants' activity as shown below in Table 1.

A further analysis of the questions was undertaken to reveal the number of answers provided to participants' questions. Of the 19 questions, seven (37%) received no answers, 10 (53%) received one answer, one (5%) received five answers and one (5%) received two answers. The visualisation (Figure 1), and summarisation of participants (Table 1) and questions provided detail about:

- Who the opinion leaders were.
- Who asked questions; who provided comments; who answered.
- The level of redundancy in conversations (i.e. questions that were not answered).
- Fragments in the conversation that generated higher levels of interest among participants. These were called hotspots.

Figure 1. Visualisation of participants' contributions to the conversation

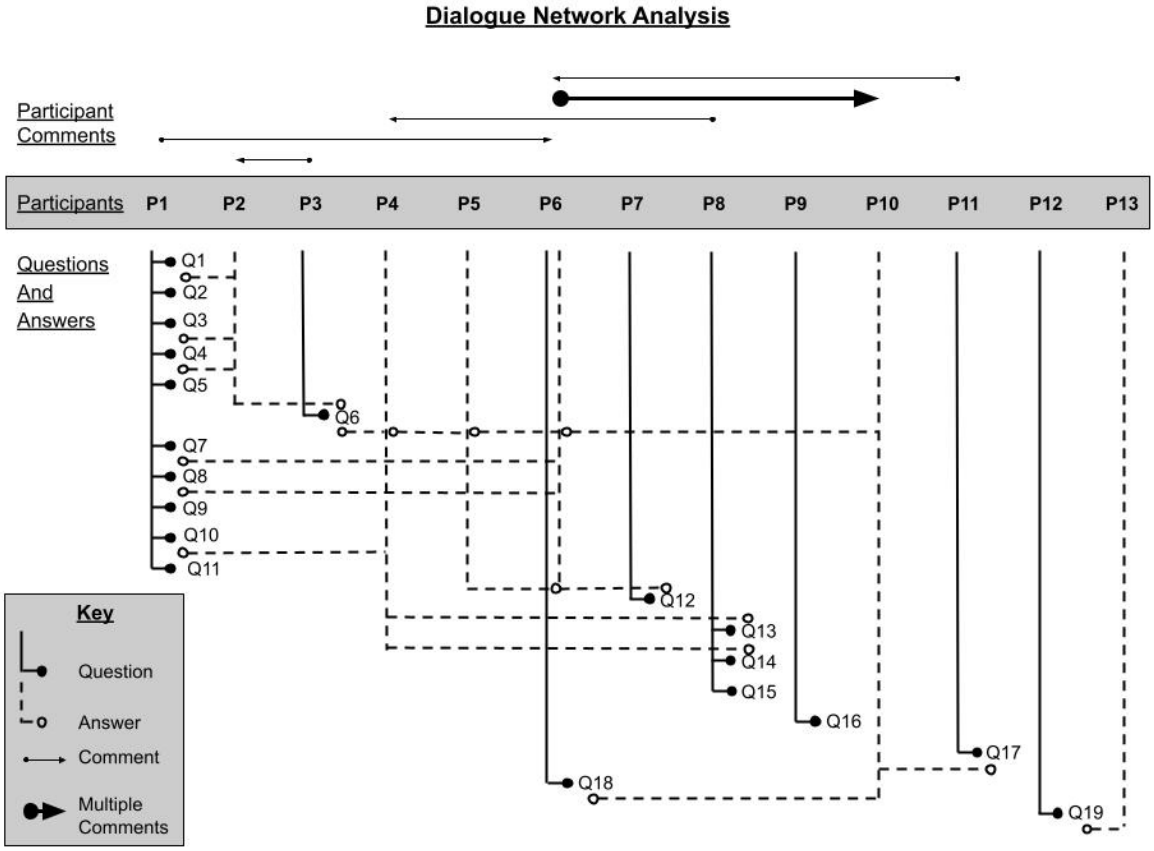


Table 1. Summary of participants' contributions to the conversation

Person	Country	Asked	Answer Gained	Answer Offered	Remark Offered	Remark Gained	Photos Used	Likes Gained	Total
P1	UK	10	6	0	1	0	0	1	18
P2	UK	0	0	4	0	1	6	5	16
P3	UK	1	5	0	1	0	0	0	7
P4	DE	0	0	4	0	1	4	3	12
P5	IE	0	0	2	0	0	0	2	4
P6	NZ	1	1	4	2	2	2	1	13
P7	FR	1	2	0	0	0	0	0	3
P8	UK	3	2	0	1	0	0	1	7
P9	UK	1	0	0	0	0	0	0	1
P10	NZ	0	0	3	0	2	0	1	6
P11	NZ	1	1	0	1	0	0	0	3
P12	UK	1	1	0	0	0	0	0	2
P13	UK	0	0	1	0	0	0	1	2

Abbreviations: UK - United Kingdom; DE – Germany; IE – Ireland; NZ - New Zealand; FR – France

In this conversation, P2, P4 and P6 emerged from the analysis as opinion leaders as they readily contributed answers, comments and photos but generally did not ask questions (only one in this conversation). These opinion leaders' detailed responses were largely drawn from their tacit knowledge. By answering questions, they acted as important knowledge providers with input likely shaped by their experience, status on the farm, and age. Their extensive use of tacit knowledge is seen in the following example from participant 2 (P2) from the United Kingdom:

> £408/ha, sown in the autumn, sprayed with glyphosate left 2 weeks then subsoiled with a sumo GLS, then left a further 4 weeks to avoid fruit fly, slurry applied over this period at 90m3/ha, ploughed with a 4-furrow plough with discs and furrow press, one pass with 3m power Harrow/ Cambridge roller

> combination, drilled with 6m corn drill with pipes removed and flat rolled. Usually go for a high sugar ley but thinking of changing due to cost. Reseed every 8 years as that is when we see performance in the pasture drop.

Opinion leaders' posts were typically media rich with photos, figures, videos and links. In the above conversation fragment, P2 attached six photos to illustrate and support the information they provided. The following example from an opinion leader (P4) from Germany (DE) included three photos:

> We under-seeded our barley/pea 'Whole crop' with 12kg/ha herbal ley this spring and the sward is great. As we're organic, we just incorporated it into our weed control. We go through our crops with a 6m Köckerling Striegel which has a pneumatic seed drill built on.

An opinion leader (P6) from New Zealand (NZ) supported their post with two photos:

> We have just sown 2 paddocks here in NZ. 2 paddocks apart. 1. Full cultivation- Sprayed with glyphosate-ploughed-heavy rolled-cultivated twice then roller drilled with 22kg/ha Base-tetraploid ryegrass + 3 kg white clover/ha. 2. Sprayed with glyphosate- direct drilled. 21kg/ha trojan ryegrass + 4kg white clover. Our goal is to use all direct drilling on our property for re-grassing and just go through full cultivation if post fodder beet or the paddock is rough, and we want to smooth it out. Photos are from yesterday day 13 since drilling. Since sowing we have had no rain though both are fully irrigated with a centre pivot. For us the big advantages of direct drilling are the limited impact on the soils, it doesn't pull up all the stones!! It's considerably cheaper and the paddock is returned to the rotation a lot quicker for grazing.

While P1 provided the framing questions for the conversation and was a very active participant contributing 18 conversation fragments, this participant only asked questions and so was not an opinion leader in this conversation. A number of participants contributed very little, lying low and observing the conversation or contributing only occasionally.

A summary of the questions and answers within the conversation (Table 2), interestingly demonstrated a significant level of redundancy. Nineteen questions received a total of 18 answers. Six questions (32%) received no answers. A further 11 questions (58%) only received one answer each. One question (5%) received two answers and the remaining question received five answers (28%).

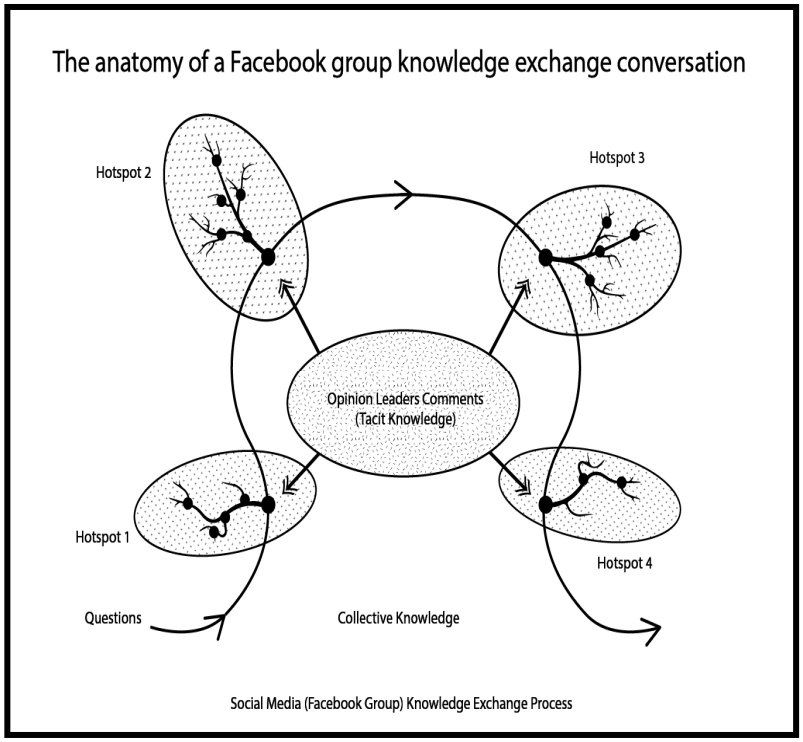
While questions 1-5 (see Figure 1) framed the conversation and set the initial agenda for participants to engage, it was question 6 asked by P3 that generated a significant flurry of activity. Opinion leaders' posts, which are driven by these questions, then generated a further burst of activity. The question and the subsequent opinion leader's input, which is rich with media, created a hotspot of activity. In this conversation opinion leaders P2, P4 and P6 stimulated heightened levels of activity.

The dialogue network analysis reveals deeper understanding of these hotspots of heightened activity, which is visualised in a simplified diagram (see Figure 2). This shows that a question stimulates online interest, which results in a small flurry of activity. An opinion leader assists with answering the question by drawing largely on their tacit knowledge. Qualitative analysis of opinion leaders' comments suggests that their tacit knowledge is informed by a collective pool of knowledge (both tacit and explicit knowledge). The heightened online activity stimulated by the question and the subsequent input from the opinion leader, creates a flurry of activity or hotspot. The intensity of the hotspot is based on the number of posts per day and the degree of media richness from the opinion leader, which encourages more posts. Conversations in these hotspots do not follow a linear progression, as unlike face-to-face meetings, participants are not in the same room at the same time. These online hotspots appear to be the site for intense knowledge exchange - development and co-creation.

Conversations were international, drawing participants with knowledge and experiences from a variety of contexts across a broad range of countries. The small segment of dialogue from the newly sown pasture conversation, drew participants from the United Kingdom (UK), Germany (DE), France (FR), Ireland (IE) and New Zealand (NZ). The opinion leaders were also international, contributing their knowledge from the United Kingdom, Germany and New Zealand.

Conversations end abruptly either because the conversation has run its course, or the members move to a new topic. Rarely is a conclusion drawn or a summary of the conversation provided. However, the archiving of the conversation on Facebook ensures that there is a 'permanent' record of the knowledge exchange and collective learning in the group.

Figure 2. Simplified visual conceptualisation of the social media knowledge exchange among Facebook users



Twitter Activity by New Zealand dairy farmers and rural professionals

Twitter activity among the selected group of farmers and rural professionals in New Zealand shows an active community of practice. This is most evident in the high proportion of replies and suggests Twitter use among rural professionals and farmers is well evolved with open participation, collaboration (retweeting) and full engagement (asking questions, providing answers/replies) compared with lower levels of one-way messaging (new/ original tweets) as shown in Figure 3.

However, the analysis revealed key differences in Twitter use between rural professionals and farmers. Rural professionals made greater use of retweeting, links, and being retweeted themselves, all forms of bridging capital. Farmers were engaged more in bonding capital activities such as being active 'repliers', likely to include 'mentions' in their replies, being favourited, and were frequent followers as well as being followed themselves. Initial findings suggest farmers used Twitter more conversationally by engaging in questions and answers. The questions also acted to set the agenda. Conversations were fast and could rapidly engage multiple players worldwide.

Rural professionals used Twitter to disseminate information rather than as a platform for actively engaging personal responses. Distinctions were evident among rural professionals and farmers in terms of impact as indicated by the incidence of tweets being retweeted (see Figure 4) and content as indicated by the inclusion of externally created content.

A low level of content being retweeted by other users may suggest a small, well-defined community with content being narrowly targeted at specific users (see Figure 5). A low inclusion of links has some correlation with the high proportion of activity generated through 'replies', rather than new or retweeted material.

Twitter enabled rural actors to stay connected according to their daily routine. Twitter's accessibility via a smartphone enabled tweets to be posted throughout the day. Dairy farmers who were active users would tweet from 4am till 10pm, seven days a week with peak tweeting occurring after morning milking. Farmers sent 5-11 tweets per day, whereas rural professionals only sent 1-3 tweets per day. Farmer Twitter users ask questions and offer tacit knowledge in replies, to assist other farmers to problem-solve.

Figure 3. Twitter activity among selected farmers and rural professionals in New Zealand

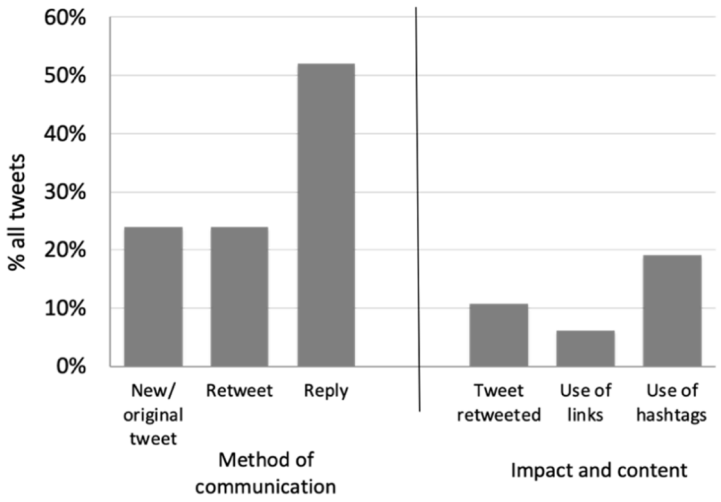


Figure 4. Comparison of tweets retweeted by farmers and rural professionals

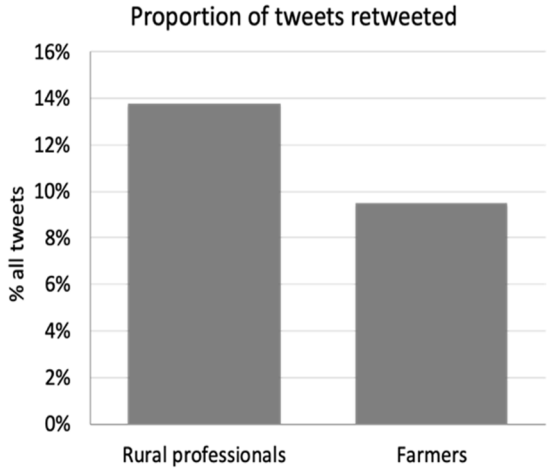
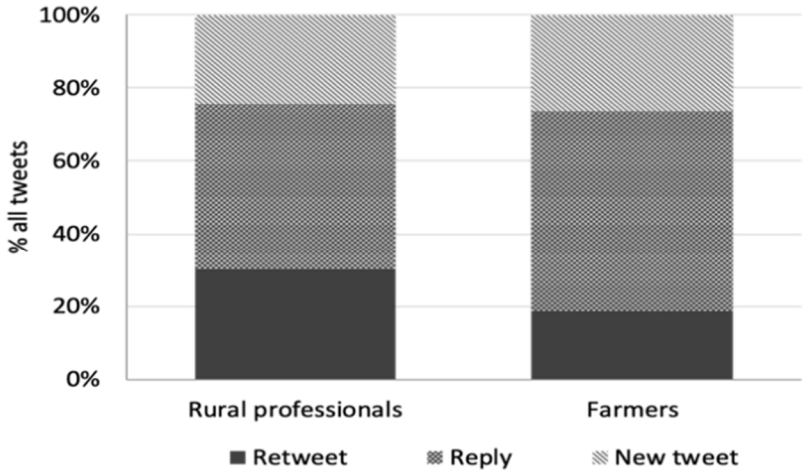


Figure 5. Comparison of farmers' and rural professionals' tweet types



Users gauge audience reception and acceptance of their Twitter streams by the number of followers they have, the level of re-tweets their messages receive and how often tweets are 'favourited' by followers. This suggests that users are aware of their audience even if there is little direct feedback from them.

Users' intensity of engagement was assessed using the following scale (Pang et al. 2018).

1. Just observation (users who mainly read, but rarely post).
2. Low engagement (one-way messaging).
3. Open participation to collaboration (retweeting).
4. Full engagement (creating two-way conversations).

This broad assessment enabled a comparison to be made between farmers and rural professionals. Farmers used all four levels of engagement, especially engaging in two-way conversations whereas rural professionals mainly used one-way messaging with little evidence of higher levels of engagement.

Tweets were frequently written as informal comments about life on the farm. Sometimes tweets included links to interesting media stories and websites and pictures were used to share with others about 'life at the office', as the following tweet, which was accompanied by three photos illustrates:

> #MangaRa Station looking good yesterday. Weaned lambs get lost in the grass and cows are putting on weight and condition.

Discussion

This work reveals that social media enables rural actors to share knowledge in online conversations or posts. Users post text, photos, videos, links and icons to make their knowledge publicly visible or within gated or restricted networks. The posting of knowledge is effectively for the collective good of the social network, where recipients are free to interpret, modify and use the knowledge. From here people can comment, reply, like, or share. Social media appears to connect farmers and rural professionals to inform and advance on-farm decisions. The following key findings have emerged from this research.

Rural actors use social media to engage in knowledge exchange

Virtual problem-solving discussions in the virtual world, such as the one analysed in the Facebook conversation in this research, like real world on-farm discussions, illustrate the constructed nature of knowledge production. This work illustrates that in both the real and virtual world, knowledge that is not readily available is developed and adapted 'on the spot' through interactions between rural actors (Leeuwis 2004). Knowledge exchange in the virtual world like in the real world is therefore likely to be valuable for innovation as Kaushik et al. (2018) has similarly shown. Farmers using Twitter have in a relatively short time moved from simple observation where they largely read but did not actively participate through posting, to using Twitter for two-way engagement in online communities.

Both Twitter and Facebook conversations in this research facilitated knowledge exchange. However, they achieved this in different ways. Farmers in this research used Facebook to solve problems, gather information and converse with virtual networks on topical and relevant issues. Problem solving discussions were largely designed to enhance on-farm decisions. Facebook provides more scope than Twitter for conversations, with an expectation from users that posts will be answered, though surprisingly the analysis showed many questions remained unanswered. Twitter, on the other hand is an open and loosely connected network of like-minded communities brought together for discussions and problem-solving.

The analysis however, revealed differences between farmers' and rural professionals' knowledge construction and exchange on Twitter. The Twitter analysis suggests rural professionals' social media engagement favours linear and more traditional 'top down' approaches to 'extension'. This suggests rural professionals, unlike farmers, may not be maximising and optimising the collaborative potential of social media as a platform for knowledge exchange, a finding which Kamruzzaman et al. (2019) have also observed in advisors in developing countries.

Social media network hotspots are key places for exchange and opinion leaders are key providers of knowledge

The research shows the key importance of hotspots in the knowledge exchange Facebook conversations. Hotspots are a space for knowledge exchange, where opinion leaders hold an important knowledge provider role whose input stimulates the development of the hotspot. They become influencers in these social media networks, a finding which others have also recently observed (Phillipov & Goodman 2017; Rust et al. 2020). Opinion leaders' exchanges display self-

efficacy which likely underpins their confidence in knowledge sharing. Their recording of on-farm activities with photos and video and sharing these in the online exchanges, indicates their willingness to engage in knowledge diffusion. Hotspots are therefore rich collaborative spaces for knowledge exchange which it could be suggested are likely to play a role in fostering change.

Social media acts as stimulus for individual and collective learning

The importance of real-world social networks for fostering change in the agricultural sector is widely recognised (Phillips 1985; Ridley 2005; Kroma 2006; Sligo & Massey 2007). The Facebook conversation in this research which centred around a problem-solving discussion, appears to provide a useful channel for fostering important weak ties. Weak ties are deemed necessary for innovation (Gielen & Hoeve 2003).

Social media appears to support and encourage farmer learning. Farmers are using social media in online networks mostly with other farmers to advance their self-directed learning strategies. The nature of these knowledge exchanges therefore suggests a strengthening of both buffer and adaptive capacity although the preliminary nature of investigation limited the ability to see transformability (Shadbolt et al. 2013). There is also evidence in the conversations of the creative processes of 'acknowledge, adopt and advance', as described by Woods (2018), which are deemed necessary for learning and innovation. These problem-solving networks on social media highlight a move away from individual thinking to collective knowledge, where assumptions are being challenged by the tacit knowledge of others (Drysdale et al. 2017).

The online Facebook communities of practice in this research can be described as self-organising networks as described by Morgan (2011). While group administrators may act as gatekeepers to membership and set the tone for discussion, the research reveals that social media provides a place for self-directed learning in an online community. Knowledge exchange does not reflect a 'top down' model and as the Facebook conversation analysis shows, it can bypass traditional extension models and extension professionals. This has profound implications for rural advisors and agricultural extension agencies.

The conversations and the growth of these online farmer groups that exhibit high levels of activity, suggest the farmer members see a perceived value in asking questions and contributing in the knowledge exchange either as active participants and/or as observers. Tedjamulia et al. (2005) suggest a participation and response ratio in a conversation of 1% lead initiators, 9% highly active responders, and 90% least active or silent observers.

Social media allows knowledge exchange on a global scale

Farming is noted for its social isolation caused by its geographical remoteness and long working hours (Alston 2012). The analysis in this research suggests that social connections enabled by social media platforms are likely to provide channels for breaking down farmers' social isolation, by acting as a space for sharing and knowledge exchange, while they work in remote locations. Social media does not require real time audiences with conversations typically starting in the evening once work on the farm had ceased for the day.

Farmer knowledge networks and advisory systems are now international (Klerkx et al. 2017). This research shows that social media enables global communities of practice as it makes it easy to engage with international counterparts. The participants analysed in this research engaged internationally. Local discussions become global discussions in the virtual world and this occurred both in Facebook groups and on Twitter. Facebook 'closed' communities in particular, act as a conduit for problem solving interactions that are likely to contribute to participants' pool of knowledge that may be used for instigating on-farm action and change.

Conclusion and further research

This investigation into rural actors use of social media shows farmers use social media for knowledge exchange to address and support on-farm decisions. Knowledge that is not readily available to rural actors is discussed, questioned and validated within online communities, which suggests that social media can provide a valuable tool for rural innovation. While social media provides a conduit for knowledge exchange, more research needs to be undertaken to show the effect these exchanges have for farmer learning and on-farm management practices.

This research contributes to understanding about farmers' knowledge exchange in the online world. Farmers using both Facebook and Twitter have mastered the skills of social media engagement and have embraced the concept of collective knowledge-making. The research suggests, however, that rural professionals while using social media platforms, may not yet have fully embraced the collaborative opportunities offered by social media, preferring instead to use it for the dissemination of information. The comparison in this research between farmers and rural

professionals use of Twitter, suggests that further investigations need to consider comparisons between different rural actors.

The role of Facebook opinion leaders has emerged as being important in online conversations. Opinion leaders share media-rich tacit knowledge and can generate high-intensity discussion in hotspots of activity which appear as ripe sites of potential innovation. Opinion leaders are the influencers, demonstrating high levels of farmer self-efficacy and a willingness to share their learning.

More focussed research needs to explore the social capital potential of social media. Trust is one of the distinguishing features of face-to-face farmer problem solving. Since social media knowledge exchange appears to take place in the absence of existing social relationships, there needs to be more research into the role trust plays in these networks, as well as the effect these networks have on trust-building. There is also tentative evidence of both bridging and bonding capital. However, further analysis with much larger samples would be required to more deeply understand the contribution of social media to social capital in agricultural contexts. Doing this will give further insights to how social media activity and communities contribute to agricultural innovation.

The dialogue network analysis developed for this research provided a simple and effective tool for analysing Facebook conversations within a network of participants that initially appeared chaotic due to its non-linear nature. However, the methodology's use in larger conversations, and with other social media platforms, needs further investigation to provide more empirical evidence of its effectiveness at revealing network characteristics and aiding analysis of the nuances and group dynamics of dialogue within a network. Further research is also required to understand the on-farm application of knowledge gained from social media conversations.

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