Journal of Rural Studies 41 (2015) 109–117

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Robotic milking-farmer experiences and adoption rate in Jæren, Norway

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ARTICLE INFO

Article history:
Received 18 November 2014
Received in revised form
12 August 2015
Accepted 30 August 2015
Available online xxx

Keywords:
Automatic milking systems
Technology adoption
Diffusion
Dairy farming
Farm management
Technology domestication

ABSTRACT

Robotic milking or automatic milking systems (AMS) are becoming increasingly popular in Norway as well as in the other Nordic countries. To explore what motivates farmers to invest in AMS and what the consequences for farmers' lifestyle and management are, we (the researchers) visited and interviewed 19 dairy farmers in Southern Norway. Fourteen of the farmers are situated in a region of Norway (Jæren), where the adoption rate of AMS is significantly higher than in the rest of the country. Therefore our main interest was to explain the high adoption rate in Jæren. The findings suggest that to succeed with AMS farmers must be motivated, behave proactively and adapt the new technology to their specific needs. Saved time on milking, more interesting farming, more stable treatment of the cow and less need for relief are some of the advantages. Farmers experience to be constantly on call and information overload as the greatest disadvantages of AMS. The main reasons to invest in AMS are increased flexibility and reduced workload, and AMS has allowed a more modern lifestyle. The high adoption rate of AMS in Jæren can be explained by human and social capital, socio-cultural factors and the well-developed agricultural knowledge system in the area. Close relations with the farm machinery industry in the area, a strong belief in technology, high wage rates and difficulties of getting skilled labor are other factors which can explain the high adoption rate of AMS.

1. Introduction

Robotic milking machines milk cows automatically at any time, without the need for a human worker to be present. AMS is not only a new milking system, but rather a completely new management system. Manufacturers claim that AMS can potentially raise milk yields, and is beneficial in terms of animal health, welfare and for working conditions of the farmer. In 2008 AMS was in use on about 5500 milk farms worldwide (Svennersten-Sjaunja et al., 2008). More than 90% of all dairy farms using AMS are located in north-western Europe where investments are driven by high labor costs, a continuous increase in the average herd-size and a dominance of the family farm structure (Mathijs, 2004). Robotic or automatic milking systems (AMS) are also becoming increasingly important in Norwegian dairy farming. Installing an AMS is a huge investment, approximately 1.2 million NOK, still almost all Norwegian farmers who refurbish their cowsheds install AMS. By the end of 2012 there were 1032 milking robots in Norway and 1636 in Sweden (TINE, 2013), and the majority of Norwegian dairy farmers (94%) deliver their milk to Tine cooperative dairy company. On average robots milked the cows on 11.1 percent of all Norwegian dairy farms and handled roughly 25 percent of all milk. Thus Norway is among the countries in the world with the highest frequency of AMS in dairy farming. The figures indicate that robotic farms are significantly larger than the average farm. Except from this we know very little about what Norwegian farmers' experiences with AMS are. Therefore my first research question is: What are Norwegian farmers' experiences with AMS? Exploring farmers' experiences will also contribute in answering my second research question. The statistics from Tine (TINE, 2013) show that the adoption rates of AMS differs substantially throughout Norway. In Jæren, a district in the Southwestern part of Norway, 18 percent of the farmers had an AMS, seven percent above the national average. The figure is even higher than in the Netherlands, where more than 10% of the farmers have applied the AMS technology (Steeneveld et al., 2012). Most research on diffusion of AMS is done at a national level, comparing adopters with non-adopters. Less is known about why the diffusion rate in one geographical region within a country can differ significantly from the country's average diffusion rate. For

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http://dx.doi.org/10.1016/j.jrurstud.2015.08.004
0743-0167/

example we have limited knowledge of what particular sociocultural and human factors in a geographical area that can explain a high adoption rate of AMS. Therefore it is in my interest to study why the adoption rate in Jæren is so high, as compared to the rest of Norway. My second research question is: What can explain the high adoption rate of AMS in Jæren?

The paper is organized as follows: First I provide the readers with a general background to AMS and what farmers' reasons for adopting AMS are. Then I present relevant theory which can explain differences in adoption rates, particularly innovation diffusion theory and theory on social and human capital. Next I describe the empirical material and the methods I used. In the empirical Section 1 use the interviews to answer what Norwegian farmers' experiences with AMS are, and why the adoption rate of AMS in Jæren is particularly high. Finally I discuss the findings and conclude.

1.1. Background to AMS

The adoption of AMS implies that farmers structure their time and their farms around the demands of the robot, and to be able to access, analyze and respond to the large amounts of data the AMS is capable of generating (Butler et al., 2012). According to Butler et al. (2012) there is a need for more training to be given to farmers in the use of AMS- generated data. AMS also affects how farmers relate to their cows, and on how they identify themselves as stockpersons (Seabrook, 1992). Thus Stuart et al. (2013) found that a production system where cows graze on pasture and choose when to be milked by AMS involved less alienation to dairy cows as compared to more industrial dairy farms. However, Stuart et al. (2013) conclude that work performed in a profit-maximizing animal agriculture system will inevitably cause alienation, exhaustion, and suffering for the animals. Similarly, Porcher and Schmitt (2012) argue that despite three decades of research and work on animal welfare, farm animals have experienced only small improvements. According to Porcher and Schmitt (2012) alienation and how farm animals perform work must be considered in order to truly improve animal welfare. Similarly, in a study of a conversion from family farms to a huge milking parlor Hansen (2014) points out that the mechanical separation of human and cow during the milking process can lead to affectively shared interspecies and inter-human alienation. The technology of the parlor can separate both from a process formerly dependent upon specialized knowledge, affective empathy, and embodied knowledge. Holloway et al. (2014a,b) also emphasize that introduction of robots has important effects, in terms of removing routine contact between humans and animals, and unsettling the usual ways in which farmers know and understand their cows. Robots also allow the cows to reveal themselves to the farmer in new ways through the use of information technology and behavior monitoring (Holloway et al., 2014a,b). Further, introduction of AMS unsettles the identities, roles and subjectivities of humans and animals and thus shifting the ethical relations (Holloway et al., 2014a,b). Robotic milking opens up new possibilities for managing the cows without being present in the milking parlor. Thus the stockmanship changes from looking at individual cows to looking at herd averages, and there is a concern that reliance on the robot may lead to neglect of cows (Holloway et al., 2014a,b). The technology transforms ways of knowing and spending time with cattle, such as reducing the amount of physical contact between humans and the cows in the milking parlor while potentially increasing the amount of time humans can spend observing their cows (Owen, 2003). In addition to having a good stockman's eye the farmer also has to be computer literate. Thus conversion to milking robot radically changes the work of the stockperson (Butler et al., 2012). This change requires a transformation of the whole management process. Thus a review of AMS studies suggests that differences in management and farm-level variables may be more important to AMS efficiency and milk production than features of the milking system itself (Jacobs and Siegford, 2012). To reap the benefits of AMS farmers need to fully incorporate the AMS into their management routines.

Although AMS provides increased flexibility, some farmers find that the AMS is actually more of a tie than they had envisioned (Butler et al., 2012). As farmers can be contacted by the robot 24–7 in case of problems, they are only a phone call away from having to go and check why the robot called them. To be constantly on call can be a problem. However, this burden can be lessened if the farmers act proactively and adapt the AMS technology to their farm conditions. For example the level when the alarms go off can be adjusted according to their importance. Such adjustment of the alarms is an example of technology domestication, or the practical as well as emotional adaptation to technologies (Lie and Sørensen, 1996).

1.2. Farmers' reasons for adopting AMS

Earlier studies on AMS have focused mainly on economic and labor issues. Farmers have different motives for investing in AMS. The economic benefits of AMS are mainly savings in labor and increased production per cow (Bijl et al., 2007). The milk yield increases about 10–15% on average (Steeneveld et al., 2012; Jacobs and Siegford, 2012). AMS have the potential to significantly reduce the production costs or indeed to change the capital-labor ratio (Steeneveld et al., 2012). In fact, by replacing conventional milking systems with AMS, the estimated saving is 20–30% (Mathijs, 2004; Bijl et al., 2007; Sauer and Zilberman, 2012) of the labor allocated to the milking activities. However, other authors found little difference in labor use but differences in task and work flexibilities (Steeneveld et al., 2012). In a review of AMS studies Jacobs and Siegford (2012) report a decrease in labor by as much as 18%. Recently, Steeneveld et al. (2012) quantified the capital cost of AMS at 12.71 € per 100 kg of milk instead of 10.10 € per 100 kg of milk for conventional milking systems. However, Hyde et al. (2007) and Heikkilä et al. (2012) stress that noneconomic factors such as lifestyle choices including avoiding labor management are at least as important as economic factors for the decision to adopt an automatic milking system. Other studies emphasize the importance of the farmer's risk perception, effects of peer-group behavior, and a positive impact of previous innovation experiences (Sauer and Zilberman, 2012). Recent research from Holland on the adoption of AMS (Floridi et al., 2014) supports the expansion diffusion theory, which is described in the section below. According to Floridi et al. (2014) the adoption and the timing of such a decision, is strongly affected by policy uncertainty and market conditions. The effect of this uncertainty is to postpone the decision to adopt the new technology until farmers have gathered enough information to reduce the negative effects of the technological lock-in (Floridi et al., 2014).

AMS takes care of the milking, so there is reason to believe that AMS will offer the farmer more flexibility and freedom. Mathijs (2004) as well as Hyde et al. (2007) stress that lifestyle choices such as avoiding labor management are important for the decision to adopt an AMS. On average, scholars report a 10% reduction in total labor demand compared to conventional milking systems with two milkings per day (Schick et al., 2000; DeKonig et al., 2003). However, there is conflicting evidence regarding possible time saving (Jacobs and Siegford, 2012). When studying AMS systems Butler et al. (2012) found that work routines changed, but farm families did not necessarily experience the expected improvement in the quality of life or an ‘easier’ lifestyle. In practice farmers found that their work routines changed rather than lessened.

1.3. Innovation diffusion processes

Diffusion is the process whereby the innovation is spread, or disseminated. Webster (1971) gives a definition that emphasizes the social process by which an innovation spreads through a social system over time. The major point of interest in diffusion theory is how and why (or why not) some agents adopt ideas or phenomena. One of the first studies in agriculture was conducted by Griliches (1957) who explained the diffusion of innovation by means of an imitation process. Earlier works on this issue described innovation diffusion as an S-shape function (Rogers, 1962), where the new technology is firstly introduced by a group of Innovators, then followed by Earlier Adopters, then by the Early and Late Majority, and finally by the Laggards. The process of adopting AMS can be described as an expansion diffusion, i.e. the innovation is adopted by more and more farmers, so that the total number of adopters is growing over time. Expansion diffusion assumes two major forms, contagious and hierarchical. A hierarchical diffusion process is a 'trickling down' process from large to smaller units. The hierarchy may be defined differently. In contagious expansion diffusion the spread is smooth and continuous. Contact with earlier adopters and the quality of communication channels are important factors in this form of diffusion processes. Thus, close physical proximity influences the possibility of adoption, but is not a necessary condition for diffusion to occur.

A classical contribution within the expansion group of diffusion processes is Torsten Hägerstrand's 'Innovation Diffusion as a spatial process' (1967). In his work Hägerstrand created models to describe how diffusion takes place. The models were based on an elaborate set of assumptions and concluded that four stages mark the diffusion mechanism:

1 Primary stage. Innovation appears at its primary source (leaders).
2 Diffusion stage. Rapidly increasing set of adopters.
3 Condensing stage. The remaining area is penetrated.
4 Saturation stage. Marking the slowdown and ending of the diffusion process.

I argue that the diffusion of AMS in Jæren is currently in the condensing stage, while the rest of the country is in the primary or diffusion stage. Agents are often seen as risk-averse and uncertainty-avoiding. However, after some threshold level of adoptions is reached, a 'bandwagon' effect of acceptance may occur, which leads to an unevenness of the diffusion process over time. Characteristically the diffusion curve follows a logistic function or S- shaped function, see e.g. Bradford and Kent, 1977.

In order for diffusion of innovations to take place between agents they must be connected by some kind of relevant communication links, such as magazines, meetings or conferences. There is some evidence to suggest that a person's adoption of a new idea or practice is strongly influenced by the behavior of their social network (Valente, 1995). Thus the behavior of one's peers seems to have an important of one's behavior, but there is considerable variation in how much. Individuals have various thresholds to adoption such that some people adopt an idea when no or few others have adopted, while others wait until the majority has adopted. Another network factor shown to affect adoption is a person's position in a network. Thus opinion leaders, often measured as central members in the network, both reflect and drive the diffusion process (Valente and Davis, 1999; Valente and Pumpuang, 2007). The information field (IF) characterizes the extent of contacts that a potential adopter has made at a given point of time. Barriers in the IF, Hägerstrand realized, were real impediments to interactions and communications. Distance from the innovator is one physical barrier. Similarly, Von Hippel (1994) points out that some information is costly to acquire, to transfer and to use in a new location, so-called "sticky" information. According to Von Hippel (1994) such information stickiness affects diffusion of innovation. Resistance to change, information fields and barriers are all important factors that influence the diffusion of an innovation. These factors are changing through time.

1.4. Social capital

The expansion diffusion theory is closely related to theory on social capital. Lin defines social capital (2001, p. 19): "*investment in social relations with expected returns 138 in the marketplace*". This definition reflects most writings on social capital (Bourdieu, 1983; 139 Burt, 1992; Coleman, 1988; Lin, 1982; Portes, 1998). While there are many different perspectives on the nature of social capital, the fundamental principle is that economic and social transactions are promoted through the quality of the interactions within a community or network. The key role of social capital is that it can promote development-aiding in the accumulation of either economic or human capital, and it can do so without incurring great financial cost. Scholars emphasize that social capital may be instrumental and help actors both in a social and in an economic sense, which often are interwoven and hardly detachable from one other. In relation to diffusion of AMS the following two effects of social capital are of particular interest: 1) Getting information (Granovetter, 1973, 1983); and 2) transfer of knowledge, innovation, and diffusion of technology or practices (Ahuja, 2000; Brown and Duguid, 1991; Wenger, 1998). Thus farmers may learn about AMS from discussing their farming practices in discussion clubs, which have much in common with communities of practice (Wenger, 1998). Wenger (1998) defines communities of practice as "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly". Communities of practice reflect the participants' understanding of what is important generating a common set of thoughts, ideas, and resources to maintain and pass on the accumulated knowledge.

1.5. Human capital, interaction between human and social capital, and the agricultural knowledge system

To take advantage of new ideas or practices through networks farmers need human capital. According to Becker (1964) human capital refers to the knowledge, information, ideas and skills of individuals. From Becker's point of view human capital is the most important of all forms of capital in modern economics, and more important than machinery, factories and financial capital (Becker, 1964). His concepts "human capital economy" and the "age of human capital" reflect the importance he attributed to human knowledge, skills and talent. Not only does Becker emphasize the importance of formal education, he also recognizes the fact that much unmeasured learning takes place in firms, and that people need to invest in learning during their lives. Human capital contributes to decision making and problem solving particularly in framing of decisions (Weick, 1995). Framing is an essential part of the problem solving process, and refers to how the problem solver defines and interprets the situation, what alternatives materialize, and how problem solving is implemented (Weick, 1995). Different levels of human and social capital may interact to produce joint effects on productivity. When social capital interacts with human capital, there is a transfer of know-ledge which creates higher productivity. Some people may have less human capital but more social capital, or vice versa. I have discussed human and social capital separately. However, there are obvious links between them. Studies have revealed a link between an individuals' education level and the level of social capital (Huang et al., 2009). The ability to learn depends on the amount of existing related knowledge in the field. New knowledge has to connect to existing knowledge so that people can interpret and put this knowledge into an existing frame of reference (Weick, 1979, 1995). Thus new agricultural knowledge is selected, adapted and turned into practice through a well-developed agricultural knowledge system, Roling and Engel (1991, 1995). This system may be described as stable networks which support agricultural innovation and learning, comprising agricultural schools, advisory services, researchers and dense networks of progressive farmers.

There is an increasing tendency among firms to rely on external sources for innovations. An example is relational governance mechanisms which are based largely on trust and social identification, like teams, shared decision making, and joint development of solutions (Greve and Salaff, 2001; Uzzi, 1996). In adopting innovations, an individual may need much human capital to take advantage of social capital. Therefore I expect an interaction effect between human and social capital, so that much (low) human capital together with much (less) social capital increases (decreases) adoption of AMS. Thus a well developed agricultural knowledge system is important in the adoption of AMS.

2. Data and methods

2.1. Farming and farming culture in Jæren

In this Section I present the geographical area of my research, Jæren, and the farming culture. I think this can contribute to explain why the adoption rate of AMS is particularly high in the area.

Jæren is a narrow strip of productive farmland, about 40 km long, located mostly south of the city of Stavanger, between the shores of the North Sea in the west and the mountains to the interior in the east. Jæren consists of 8 municipalities. Distances to markets are small and the communications are good. Likewise, the physical distances between the farmers are small, allowing close contact and smooth diffusion of innovations. Since the late nineteenth century there are several stories of the enterprising farmers who started with two empty hands and worked out a well-managed farm (Frøyen, 2001). In these stories words like optimism, determination and vigor are common. The farmers defied warnings and constantly tried out new products or new methods of cultivation (Frøyen, 2001; Tveite, 1982). Similarly, they were eager to adopt new technology, and there is little doubt that farmers in Jæren have adopted new technology quickly over the last 100 years, while adopting new niches in the market (Rysstad, 1988). They were not tradition-bound, open to new solutions and hard-working (Tveite, 1982). Work was considered a duty, and idleness and consumption as sins (Tveite, 1982). Thus blaming a farmer of being lazy could end up in court (Frøyen, 2001). What was accomplished through work was the yardstick according to which farmers were ranked. Farmers in Jæren have always had a strong business orientation, they wanted to earn money and expand their business and reinvested the farm surplus in the farm (Tveite, 1982). The key practice among farmers has been to be in the forefront of the national, and to some degree international, development in agriculture. This includes having access to the latest technology.

Jæren can be defined as an agricultural cluster, or “a geographic concentration of inter-connected farmers, specialized suppliers, service providers, firms in related industries, and associated institutions (for example universities and trade associations) in the field of food production that compete but also co-operate” (Sæther, 2014, pp. 2). The emergence of the diligent farmer is related to the religious and moral values prevailing in the region, and has been instrumental to the cluster's identity (Sæther, 2014). Thus Jæren is a deviant case not only in a national, but possibly also in an international context (Sæther, 2014).

Interestingly, agriculture in Jæren has had a close relationship with the farming machinery industry for about 150 years. From the start of the twentieth century on a belief in the machinery culture was a feature of the farmers in Jæren. There is a close connection between the industry, the workers and the farmers (Setten, 2002). A culture for developing agriculture hand in hand with industry was established after the second world war (Thu, 1996). For example the world's first hydraulic excavator was constructed in Jæren in 1956, to cultivate the stony soil in the area (Jæren Museum, 1992). Similarly, another firm localized in the area, Kverneland ASA, has grown into a leading global supplier of ploughs and other farm implements. Particularly interesting is that the dominating firms in the area collaborated on developing an industrial robot already in the 1960s. A local supplier industry has contributed to a belief in machinery and new technology among Jæren farmers that is evident today (Thu, 1996). Local user–producer interaction between farmers and producers was part of the reason behind the success (Asheim, 1992). Jæren is situated in Rogaland, where the oil and gas industry became dominating in the area during the eighties and nineties, many of the traditional firms extended their product range to supply the industry. This also contributed to a strengthening of the whole technological environment in the area.

According to Frøyen (2001) one of the early drivers for agriculture in Jæren was the possibility to compete; To look at the neighbor, to compare, to learn and to have the possibility of becoming equally good at farming. A reputation for being a good farmer could be built through displays of farming ability, such as applying technical innovations. Thus, using the latest available technology has, at least in the past, been seen as an indicator of good farming. This extends to the reputation of the good farmer in UK (Sutherland and Burton, 2011) and the concept of cultural capital (Bourdieu, 1986) or reputation. Similar to the findings of Holloway (2004) cultural capital is evident through the possession of high-status cultural goods and is visible in conventional farming cultures through high-status symbols of production such as modern machinery.

The specialization in farming led to the establishment of new networks. Without such good networks it became difficult to be enterprising, and networking thus became embedded in the farming culture in Jæren (Frøyen, 2001). In Jæren it is never far to the next dairy farmer, and from the authors' experience as a farming consultant, the word of mouth ensures that innovations spread rapidly. Both Tine and the farmers themselves organize networks for the exchange of best practice among dairy farmers.

According to Rysstad (1988) access to knowledge in Jæren is due to a well-adjusted agricultural structure or system. What today is known as the Norwegian Institute of Bioeconomic Research (NIBIO), has conducted applied and specifically targeted research linked to plant and animal sciences, soil cultivation, environmental protection and natural resource management in Jæren since 1911. The research staff conducted field trials in close collaboration with local farmers and a well-developed governmental farming advisory service, where the author himself worked for many years. The presence of a research institution contributed to a short distance from research to farming practice. Further, one of the first agricultural schools in Norway was established in Jæren. Thus the agricultural knowledge system had a positive impact on the accumulation of agricultural human and social capital in the area. It is reasonable to claim that human capital has had a large influence on the development within both industry and agriculture in Jæren (Setten, 2002). From my own experience as an advisor I have noticed that agricultural education has a high standing among farmers in the area, and has been almost mandatory for those who aimed at taking over farms. Learning by doing and learning through use have been important ways of transferring knowledge, both in the machine industry and in farming (Høyland, 1998). Thus learning through cooperation has been emphasized as a hallmark of the society in Jæren (Setten, 2002).

The dominating position of the oil sector in the area which has driven up wages and led to shortage of skilled farming labor is also relevant to the adoption of AMS. Thus both the employment rate and the wage level are among the highest in Norway (Statistics Norway, 2014). Further, farms in Jæren are larger than the average in Norway and have a herd size that is well suitable for AMS. Thus many herds in Jæren have a size comparable to farms in e.g. the Netherlands, where the AMS technology is also widespread (IFCN, 2013). Finally, it is common to combine dairy farming with other livestock.

2.2. Empirical material and methods

To answer the research questions empirically I needed a quasi-experimental setting, in which the subjects' decisions affect the outcomes with minimum impediments to people's motivation to develop and use their skills. The context and research situation should be close to the real world context to ensure both internal and external validity. The context and research situation should be close to the real world context to ensure both internal and external validity. The aim was an informal setting with personally experiences and practical behavioral solutions. The farmers should be allowed to speak about how they run their farm, with whom they interacted, and their experiences with AMS in their own words. Therefore the research team, consisting of the author and two dairy consultants from Tine, visited and interviewed 19 dairy farmers located in Southern Norway who had invested in robotic milking from 2005 to 2011.

The average year of investment in AMS was 2007. Eleven of the farmers had a Lely robot and eight had a robot from DeLaval. On average the farmers had 15 years of farming experience, ranging from three to 30 years. All farmers had attended an agricultural school. On average their milk quota was 440,000 L, ranging from 190,000 to 680,000 L. In comparison the average milk quota in Norway in 2012 was approximately 169,000 L (Statens Landbruksforvaltning, 2012). This means that the farms in the sample are two and a half times the size of the average Norwegian farm. The majority of the farmers had expanded their production significantly and built new cowshed or refurbished their cowsheds as part of installing the AMS. The milk yield per cow was on average 8478 kg, ranging from 5827 to 10,474 kg. Fourteen of the nineteen farmers are situated in Jæren, in the Southwestern part of Norway. The farmers had volunteered to discussion clubs for AMS- farmers organized by the cooperative dairy company TINE SA in autumn 2011 and winter 2012. The research team attended all four gatherings in these two clubs, and the notes we made during these gatherings and the interview transcripts are parts of the foundation for this paper. The last five farmers were selected because the dairy advisors informed us that they had both positive and negative experiences with conversion to robotic milking and were willing to share their experiences.

The research team used a largely unstructured interview to capture the respondents' thought processes, the frame of reference, and the feelings about an incident or set of incidents, which had a meaning to the respondent. All interviews were recorded and transcribed.

3. The empirical study

In this Section 1 will answer the two research questions by exploring the interview data.

3.1. Norwegian farmers' experiences with AMS

The management program in the robot offers the farmers huge amounts of data, and for five farmers like this male in his thirties, this stimulated their interest in farming (3):

> Robotic milking has definitively made farming more interesting. You get a lot of information about each cow …, it's really a good management tool.

However, the huge amount of data can result in information overload. Thus several of the farmers had made a deliberate choice and combined only a few reports from the AMS with data from the national herd recording (4):

> I use a few reports from the robot which I have learnt on my own … .cows too late to milking and so on, but for managing the herd I actually use the national herd recording rather than the management program in the robot. I find it easier.

Only two farmers think that the AMS offers a good management tool, and find it difficult to utilize all the data the robot provides them.

To succeed with AMS the farmers pointed out several issues which farmers who consider investing in AMS should keep in mind. A male farmer in his forties put it this way (8): "*You have to enjoy looking after cows and you have to spend time on it, those two issues*". A male farmer in his fifties also underlined the relationship between effort spent in the cowshed and farming results. He realized that he himself did not spend enough time in the cowshed (9):

> The results you achieve depend heavily on how much time you spend with the cows outside the daily duties ….and there I still have some distance to walk …... but in the end it is a matter of what kind of life you want to have.

Several farmers underlined that adapting to AMS takes some time, like this male in his fifties (10): "*It takes one year until the robot, the farmer and the cows are run in*". A male in his forties stressed that robotic milking implies a completely new way of working, and some of the saved time on milking has to be spent on monitoring both the cows and the AMS (1):

> Well there's a lot of things that turn around … and it helps looking after you know.…It helps to wash I think ….when you walk around with the broom you soon detect if there is a hole in a hose.

Investing in AMS requires a minimum of interest in technical matters. A male farmer in his thirties commented particularly on computers (11): "*And then you have to be patient and spend time on the robot, particularly in the beginning, and not have pc-refusal*".

The farmers underline that the AMS can never take over the job for a good stockperson. These two statements from male farmers in their forties point out that with AMS the farmer must be even more proactive as compared to conventional milking (12) (5):

> You have to monitor the cows carefully, be structured and follow up immediately whenever there's a deviation....It's so easy to put it off until tomorrow.

> What I find challenging with AMS is that you place yourself right below the cell count limit, and you do not take the necessary initiatives to bring the cell count down immediately….I should have contacted the veterinarian more often…

These statements indicate that the AMS might induce the farmer to wait and see what will happen next, instead of acting on problems immediately. A male farmer in his forties underlined how important it is to be proactive or act in advance with AMS (13):

> And then it's about hygiene….to check that the udders and the boxes are clean…It's all about acting in advance you know.

As Butler et al. (2012) comments converting to AMS involves looking at herd averages, but the farmers emphasizes that AMS requires to keep both the herd average and the individual cows in mind, more in line with the views of Stuart et al. (2013) (11): *"You have to follow up the individual cows closely, to see the single cows behind the figures, not only the herd average"*. This quote indicates that the alienation that can occur during introduction of new large scale technology is perhaps not as dominant as reported in other studies (e.g. Hansen, 2014).

According to the farmers the decidedly greatest advantage of AMS is the flexibility. This is the main reason why eighteen of nineteen farmers would recommend AMS to other farmers. The following quotation reflects what flexibility means in practice (10): *"We visited some friends for coffee at four o'clock on Sunday, and then we managed the cows when we came home"*. Everyone who has been involved in dairy farming knows what this statement is about. Sunday afternoon is perhaps the most boring time of the week to be at work, just as many people visit each other for a cup of coffee. Several of the farmers appreciate being able to follow up their kids better than they did before. A male farmer in his thirties put it this way (2): *"I'm more accessible for the kids while they are awake"*.

Not only do AMS allow greater flexibility, it also allows these two male farmers in their forties to get more sleep (7) (5): "*After I got the robot I have got a completely different life, I am always rested". "I got read of the constant sleep deficit I used to have"*.

Only five of the farmers mention reduced workload as an advantage with AMS. I think this female farmer in her forties explains why many of the farmers work just as much as before (14):

> We work more hours now, but that is due to increased production. The number of cows is twice as high, with the same milk quota the workload would have been reduced.

It is not always straightforward to tell how the AMS affects the number of working hours (13): *"I' m not quite sure about the number of working hours now as compared to before, … . it depends on whether you include the things you ought to do or not"*. What this farmer gives a hint of is that one cannot leave the cowshed completely to the AMS. To succeed with AMS farmers still need to spend time together with the cows, but in a different manner than in conventional milking systems (3):

> Farmers who consider investing in a robot often ask me: How much time do you need in the cowshed? I answer: As long as possible….You get more flexibility, but it's freedom with responsibility.

An interesting finding is that the AMS not just adopt the new technology. They have explored and domesticated the technology to their needs (10):

> Alarms do not stress us now, but it did in the beginning, because then we did not know how important they were, and what alarms we should respond to or not. To get an alarm in the middle of the night just telling you that the robot will run out of detergent in five-six hours doesn't make much sense….so we changed that. Now we only get alarms at nighttime if the robot stops, and then we have to get out of bed.

Another farmer had also made some adaptations (8):*"I have learned a few tricks to avoid some of the alarms"*.

Being constantly on call was considered as the dominating disadvantage besides high investment costs and running expenses. The finding suggests that increased flexibility comes at a price (1): *"It (the robot) runs all the time, you are never really off duty"*. The following statement deepened our understanding of what never being off duty is all about (3):

> Earlier you could close the door to the cowshed behind you in the evening, and you knew that at unless something extraordinary took place you were off duty till the next morning. That has changed now.

However, some farmers have found creative solutions to this problem. A male farmer in his thirties told us that they are several farmers in one area who have the same type of robot. When they go on holiday they simply put the alarm calls over to each other, and this works quite well.

To sum up the farmers have behaved proactively and not just adopted, but also adapted the new technology to their specific needs. Increased flexibility, more interesting farming and less need for relief are the main advantages of robotic milking. The main problem is to be constantly on call, and to some farmers information overload is also a problem. However, some farmers have found creative solutions to the problem of being constantly on call. To succeed with AMS, farmers need to act proactively in following up the individual cows, and to get familiar with the herd management system. Thus some of the saved time must be spent monitoring the cows and the AMS.

This section has provided an overview over the pros and cons of AMS and what it takes to succeed with AMS. I think it provides a good background to the next section, namely to understand why farmers invest in AMS and why the adoption rate in Jæren is particularly high.

3.2. What can explain the particularly high adoption rate of AMS in Jæren ?

The farmers in Jæren had very diverse reasons for investing in AMS, and most of them had more than one reason. The single most important reason was to become more flexible (3) (10) (1): "*I wanted to manage my working hours myself*". "*I wanted a good working day*". "*I wanted a more family friendly job*". The second most important reason was to save workload. Eleven of the farmers in Jæren have other productions besides milk production, e.g. beef cows, pigs, sheep and potatoes. Therefore they need to reduce the time spent in the cowshed. Yet another reason for investing in milking robot was that robot is a way to develop the farm for the future and to keep up the spirit (1):

> To keep up the interest as a farmer something new must take place on the farm from time to time … you have to develop the farm, you can't just stand still.

Three of the farmers were particularly motivated by the thought that the AMS could make dairy farming more interesting (2): "*Well you know, milking wasn't exactly my favorite work*". Half of the farmers appraised investing in milking parlor before they decided to invest in AMS. Three of them commented on that the AMS does not cost more than a milking parlor. The main reason was that they could save space in the new building with AMS. In addition the AMS has a significant second-hand value, as compared to a milking parlor. This is an advantage if they should decide to quit dairy farming in the future.

The interviews revealed that the AMS- farmers in Jæren have access to much social capital. We asked them how many farmers they discuss farming with, and only two had less than five discussion partners. The rest had more than ten discussion partners, or quite a few. They draw on their network resources to develop expertise, to get new ideas and to get inspiration and motivation. One of the farmers illustrated how important his network was to him, both to solve problems and to capture new ideas (9):

> We are some buddies who phone each other every week and we have a discussion club where we meet and discuss the soil and the livestock or whatever we have in mind. I have got many tips from them how to use the AMS.

A couple in their fifties who both worked on the farm emphasized how important the network was both when they decided to invest in AMS and in the daily operations (10):

> We visited a lot of farmers who had invested in loose- housing and AMS….And we haven't utilized all the possibilities the AMS offers yet, we get new tips from our colleagues all the time.

The farmer who had the largest network of all the interviewees emphasized (8):

> I discuss with a lot of other farmers, we are not afraid to talk about the problems we face, that's the main reason why things are going well around here … .We engage in each other's problems and try to solve them, we are lucky to live in this area, that's why we thrive so well around here.

Clearly, social capital has been important in the diffusion of AMS in Jæren. Likewise, human capital has also played a vital role. Thus all the farmers we interviewed in Jæren have agricultural education. Half of them also have a technical education, mostly related to farm machinery, and this is one reason for adopting AMS (8): *"My technical education and work experience made me fascinated by the robot"*. Technical education also makes it easier to manage the AMS, and increases the likelihood of successful implementation and operation (11) (3):

I have benefited a lot from my technical education, it gives me a better understanding of the technical aspects of farming.

My mechanical education has been very useful in terms of maintaining the technical equipment.

From the quotations it is clear that technical education gives farmers a sense of empowerment related to new technology, which can lower the threshold of adopting it.

Not only are the farmers in Jæren eager to take agricultural education, they also participate regularly in different courses. These courses are typically set up by the well-developed research and advisory service in the area, and cover different disciplines from farm buildings to feeding and rearing calves. More than half of the farmers mentioned different courses they had attended after they took over the farm. In general they found these courses useful, sometimes even more useful than the agricultural school (13): "*Back then I was too young and unexperienced, you need some experience before you sit down at school*".

Participation in courses and continuing education increases the farmers' social capital (13): *"The technical education was a useful, it makes me seek more help whenever I have a problem in farming,…e.g. with the robot"*.

However, the usefulness of social capital depends on the level of relevant agricultural knowledge (12) (8) (5):

The agricultural education provides a foundation for further learning. However, much of the learning has taken place after I took over the farm. The high number of courses I have attended through the years have created many relations and have given me a better understanding of what I'm doing…it gives me the big picture.

I think the agricultural education was quite useful, it gave me a foundation for further learning from other farmers and consultants.

My agricultural education has been very useful, particularly in network building and thus the skill to collect new relevant knowledge when needed. I accumulate experiences through discussions with other farmers.

These quotations show that farmers use their human capital both to acquire and utilize social capital. For example they use their technical education to consider others' experiences with AMS. Thus the interaction between human and social capital plays a role in the adoption of AMS.

To sum up farmers have diverse reasons for investing in AMS. The main reasons are greater flexibility, reduced workload and to keep up the interest in farming by developing the farm for the future. The combination of relevant agricultural and particularly technical knowledge, and large and dense networks have played an important role in the adoption of AMS in Jæren. Thus both human and social capital and the interaction between them have contributed to the high adoption rate of AMS in the area.

4. Discussion

Since the sample of farmers is not random, this study does not claim to give a representative picture of all Norwegian dairy farmers with AMS. For example no farmers were interviewed who had reverted back to a conventional system; their response might have been different. Increased flexibility is the main advantage of AMS, a finding which indicates that farmers appreciate to have a lifestyle more similar to that of other workers. Thus investing in AMS implies a more modern lifestyle, clearly a noneconomic factor. Here my finding is in line with the findings of Mathijs (2004) and Hyde et al. (2007). A more modern lifestyle can make it easier for the farmers to get successors, an issue worthy of further examination. The finding that farmers get more sleep with AMS can have potential health benefits, and this could also be explored more in detail. Finally, reduced work load and less need for relief are other benefits of AMS.

Interestingly, the farmers have behaved proactively and adapted the AMS technology to their needs, reducing the number of alarms significantly. To the author's knowledge this study is among the first to explore how farmers domesticate the AMS technology to their specific needs. Future studies could explore this domestication process in more detail. Up to now the AMS technology is adopted by the innovators, the early adopters and the early majority in many countries, according to the framework of Rogers (1995). Future studies could therefore explore how the late majority will cope with the AMS technology, including adapting it to their needs.

The findings also point out some shortcomings of AMS. Particularly important is that the farmers feel they are never off duty. This can be a potential source of stress, and I think that not all farmers cope equally well with this. To collaborate with other farmers who have the same kind of AMS is one possible solution, but this requires that farms are not too distant. Future studies should explore the effect of being constantly on call and how farmers differ in dealing with this challenge.

This study suggests that to succeed with AMS farmers must behave even more proactively than with conventional milking systems. Differences in management may be more important to

AMS efficiency and milk production than features of the milking system itself. Here my findings support the findings of Jacobs and Siegford (2012). Future studies should therefore explore how differences in management practices, particularly proactive behavior, influence how well farmers succeed with AMS. The farmers also emphasize that to succeed with AMS one has to follow up the individual cow. Further, from 2014 on all Norwegian dairy farmers are required to let the cows be out-door for at least eight weeks per year. These factors can counteract some of the potential risk of alienation to the cows with AMS reported by Porcher and Schmitt (2012) and Hansen (2014). Thus the findings are in line with those of Stuart et al. (2013), that the combination of AMS and cows that graze on pasture involves less alienation as compared to more industrial dairy farms.

The finding that social networks are important in the adoption of AMS is in line with the contagious expansion diffusion theory (Hägerstrand, 1967) and network models of diffusion (Valente, 1995). It also relates to the findings of Floridi et al. (2014). Close physical proximity, rapid contact with earlier adopters, good quality communication channels and relevant technical knowledge contributes to a high diffusion rate in Jæren. Interactions between human and social capital has also played an important role in the diffusion process in Jæren, in line with the findings of Greve et al. (2010) and Hansen (2013).

Unlike Sutherland and Burton (2011) this study does not support the finding that social capital intervention is most likely to be beneficial in remote regions and when targeted at small-to-medium and low-input farms. A possible reason might be that the farms in Jæren are more similar in size than the farms in Scotland. Thus farmers in Jæren are more inter-dependent and therefore more willing to share their knowledge.

The description of the main features of the farming culture in Jæren, based on the secondary sources, indicate that technological innovations are likely to spread rapidly in the area. With a high density of active farmers, well-functioning arenas for knowledge spillover and specialized service providers, the environment for diffusion of new technology in Jæren is good. It is reasonable to argue that sociocultural norms like e.g. the notion of the diligent farmer, and the importance of being in forefront of the technology, has contributed to the rapid adoption rate of AMS. Similarly, one may argue that a long tradition for close relationship with the farming industry has played a role. Future studies may explore further how such characteristics of a geographical area promote or hamper the adoption of new technology in agriculture.

5. Conclusion

To succeed with AMS farmers must spend some of the time they save on monitoring the cows and the robot. AMS also requires a high motivation in dairy farming and proactive behavior. Further, farmers need a minimum of interest in technology to succeed with AMS, as well as proactive behavior to adapt the technology to their specific needs. The greatest disadvantage of AMS is to be constantly on call. Further, although more data about the herd has a potential to stimulate farmers' interest in dairy farming, several find themselves drowned in data.

The main reason why farmers in Jæren have invested in AMS is to become more flexible. They also wanted to reduce the workload and to develop the farm for the future. The adoption process in Jæren is in line with contagious expansion diffusion theory or network models of diffusion. High levels of human and social capital, and a well-developed agricultural knowledge system in the area, are important reasons to explain the high adoption rate of AMS. Sociocultural norms and a long tradition for close cooperation with the farming machinery industry also play a role. Finally an appropriate farm size for AMS, high workload, high labor wages and difficulties of acquiring skilled labor also contribute in explaining why the adoption rate in Jæren is higher than in the rest of Norway.

This paper shows how human and social capital, the agricultural knowledge system, socio-cultural norms, a close relationship with farming industry and specific macroeconomic factors in an area together contribute to technology diffusion. Thus the paper contributes to the innovation diffusion literature.

Acknowledgments

The author acknowledges the Norwegian Research Council for funding the study, and Sven Martin Håland and Jon Kristian Sommerseth in Tine for help with the interviews. Tove Rita Øvstebø is also acknowledged for transcribing the interviews.

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