New Zealand case studies of automatic-milking-systems adoption

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Abstract

Case studies were undertaken of six New Zealand farmers who have adopted automatic milking systems (AMS). Data were collected during spring 2014. Farmer experience with AMS ranged from one to four years. Three farms were in the Waikato and three were in Canterbury. Two farms use barns with fully-confined cows, two use pasture-based systems with year-round pasture access, and two use hybrid systems where cows confinement for varying times depending on season. The key focus was on documenting farmer experience. All six farmers met innovator criteria and were driven by the challenge of making the system work. Farmers reported per cow production above their previous dairying experience and expectations. Cows-per-robot ranged from 50 to 80 and were higher on pasture systems where daily milkings per cow were lower relative to confined systems. Annual milksolids production ranged from 30,000 to 42,900 kg per robot. Total labour requirements did not always change but the type of labour did change. Initial training of cows was stressful for farmers and time consuming. Farmers emphasised that it was a total change of system requiring new ways of thinking. Farmers perceived capital cost as the major adoption constraint but remained positive about the future of AMS.

Keywords: automatic milking systems; AMS, robots; innovator behaviours; innovation adoption

Introduction

Automatic milking systems (AMS) were first developed in Europe in the 1970s with a focus on farm systems where cows are confined in barns (Woolford et al. 2004). In New Zealand, robotic technology was first introduced in 2001(DairyNZ, undated). This New Zealand introduction was within a research environment and with a focus on pasture-based grazing systems. The New Zealand project, known as the Greenfield Project, continued through to 2009, by which stage it was apparent that pasture-based systems were technically feasible but at that time financially unattractive (Jago & Burke 2010). More recently, approximately 20 innovative New Zealand farmers have invested in AMS on their farms. These farms range from non-housed pasture grazing farms with spring calving through to fully-confined barn systems with non-seasonal calving, and 'in between' hybrid systems where the cows have barn access for part of the year and/or day, and with calving typically split between spring and autumn.

In this paper we draw on the experiences of six of these innovative farmers across the three systems (fully confined, grazing, and hybrid). Our purpose is to identify the factors that influenced these innovators and to report on their experiences. As with all innovations, the introduction of AMS to farming systems is an ongoing learning process. Accordingly, the findings should be interpreted as early-stage outcomes within an ongoing innovation system in which developments will continue for many years. The data were collected and initially analysed as a Bachelor of Agricultural Science Honours Project at Lincoln University (Brakenrig 2014).

Methods

The research was undertaken within a case-study paradigm. Case studies aim to investigate real-life issues in situations where outcomes are likely to be context dependent (Yin 2003). A key philosophical stance is that richness of findings comes from in-depth analysis, typically of a small number of cases, and that it can often be the outlier that is the most interesting case. Diversity of context is therefore considered both relevant and important, and the data focus is on range and factors that influence this range rather than on averages. Numeric data are used for descriptive analysis but not subjected to inferential statistical analysis, and generalisations are therefore analytical (i.e., relating findings to context) rather than statistical (Yin 2003).

Sample selection

Purposive (judgmental) selection was used to obtain diversity of region (Canterbury and Waikato) and farming system (grazing, barn-confined and hybrid). Five of the six farmers were in their second to fifth years of AMS operation. The remaining farmer was completing his first year of AMS operations. Selected farmers were identified through a range of industry contacts.

Data collection and analysis

Semi-structured face-to-face interviews were conducted on-farm with open non-leading questions from a pre-prepared interview guide. The interviewer typically spent half a day with the farmer, together with follow-up telephone discussions as needed for confirmation and clarification. Interviews were recorded digitally and summarised responses subsequently transcribed. The key focus was on documenting farmer experience and allowing farmers to tell their own story. Cross-case analysis was undertaken using themes that were both prior-identified from literature and also emergent from the data as identified by the study authors.

One of the challenges of cross-sectional case studies, with data collected at only one time point, is data verification. Accordingly, the open-ended and conversation style of the interviews was purposefully used to probe and triangulate for internal consistency within the data, and to seek clarification where apparent inconsistencies emerged. Farmers were in general unable to provide detailed quantitative data for comparative purposes of their prior systems. However, farmers were in general confident about the current physical performance parameters of their AMS and the associated wider farming system. Owing to complexities and challenges of financial data collection, the study did not attempt to measure the financial performance of these farms.

Results

Production

It was notable that both production per hectare and per cow were considerably above regional averages for all case-study farms (Table 1). All per hectare data, including regional comparisons and in line with New Zealand industry conventions, are calculated using milking platform area as the denominator. Five of the six farmers had prior dairy experience with non-AMS and reported their cows had improved production considerably after shifting to AMS. Examples were from 430 kg to 500 kg milksolids (MS) (Farmer D), from 360 kg to 460 kg (Farmer E) and from 520 kg to 780 kg (Farmer A). Farmers attributed the increases to the overall system changes rather than the robot technology per se, with increased milking frequency, use of supplements and less animal stress all contributing in specific situations.

Robot efficiency

There was a considerable range (with the maximum 60% greater than the minimum) in the number of cows per robot (50 - 80). This metric was higher for pastoral systems than hybrid systems, which in turn were higher than for the confined systems. However, there was less variation (43%) in MS per robot (30,000 – 42,900 kg MS) due to compensating factors of milking frequency and production per cow.

Animal health

All case-study farmers reported that cows appeared to be less stressed and quieter compared to traditional systems. Three farmers indicated they had raised their production criteria for culling as a consequence of lower forced culls. Two farmers noted that their culls were not only getting higher prices than before related to better condition, but they were also selling some of them to other farmers as milking cows. Farmers also reported that they were identifying sick cows more quickly and also identifying cows in heat more readily because of the integration of sensors and the associated management information system within the AMS technology.

Labour issues

The major change was in the nature of the work rather than the quantity. Also, staff were no longer tied to routines dictated by milking times and this was attractive to a new class of employees who would otherwise not consider working on a dairy farm. However, with seasonal systems, the spring calving period is particularly stressful as the first -calving heifer cohort all have to be trained at the same time. With AMS, there is also a need for someone to be on-call 24/7. One farmer, with four robots, stated that he gets a call-out about five nights per month. Another farmer uses webcams to monitor whether or not a night alarm call needs to be dealt with immediately.

Table 1 Automatic Milking System (AMS) case-study farm characteristics and regional comparisons with New Zealand Dairy Statistics 2013-14 (LIC and DairyNZ 2014)

Farm	A	B	C	D	E	F	LIC regional	LIC regional
Location	Canterbury	Canterbury	Waikato	Waikato	Waikato	Canterbury	Canterbury	Waikato
System	Confined	Confined	Hybrid	Hybrid	Pasture	Pasture	Non-robot	Non-robot
Effective area (ha)	72	114	68	65	78	130	232	112
Number of cows	220	300	300	180	320	480	815	329
Calving	All year	All year	Split	Split	Spring	Spring	Spring	Spring
Robots	4	6	4	3	4	6	0	0
Cows per robot	55	50	75	60	80	80	NA	NA
Cows per ha	3.1	2.6	4.4	2.8	4.1	3.7	3.51	2.96
Milking frequency per day	2.9	NA	2.8	2.7	1.7	NA	2	2
Prodn per cow (kg MS)	780	700	520	500	460	500	397	356
Prodn per robot (kg MS)	42,900	35,000	39,000	30,000	36,800	40,000	NA	NA
Daily milkings per robot	160	NA	210	162	136	NA	NA	NA
Production per ha (kg MS)	2383	1842	2294	1384	1887	1846	1396	1051

Planning and establishment issues

Most of the farmers had been considering AMS for about ten years, but had waited for the technologies to improve and the capital costs to reduce. Most had built a new shed but one had retro-fitted an old herringbone. All had visited other AMS installations in New Zealand and three had visited overseas while they were in the planning phase. Five of the six case-study farmers identified the importance of having multiple farms or other income sources to reduce the early stage risks associated with a new technology such as AMS.

The most important aspects of planning and establishment were identified as farm layout, cow to robot ratio, cow selection and system simplicity. The transition phase of educating cows to the system was particularly stressful. One farmer slept at the shed for the first eight weeks, but subsequently has had few night call-outs. The biggest task was pushing cows to and into the robots and maintaining cow flow.

Factors influencing AMS adoption

The potential to increase production was a key influencing factor for three of the six case-study farmers and was most evident in the confined and hybrid systems. One of the pasture-based farmers specifically highlighted that increased production did not influence his AMS adoption decision.

Four of the six case-study farmers identified a reduction in routine labour and a change in lifestyle as both adoption influences and subsequent system outcomes. One farmer saw AMS as creating a way for him to remain as a farmer as he became less able to undertake prolonged physical tasks.

Both of the confined-system farmers have an interest in animal genetics and take pride in high production per cow. They believed that increasing the milking frequency was important for their high-producing cows, and that AMS was the way to manage this need for increased milking. One of the hybrid-system farmers also believed that it was not possible for animals to express their genetic potential within a pasture-based system. The decision to install AMS was, therefore, linked to a decision to invest in off-paddock wintering and non-seasonal production with premium winter milk prices.

These perspectives illustrate that a full understanding of the AMS influencing factors can only be obtained by interpretation within the context of the whole farm system. In some cases, it was the need to build a new milking shed which precipitated the decision to invest in AMS. In other cases, it was a perceived need to increase production but an unwillingness to increase the time spent milking in the shed which led to the AMS decision. In another case, farm layout and environmental constraints led to a decision to install a barn, which then led to a decision to invest in AMS.

Despite the consequential nature of the decision to invest, all of the farmers had personal characteristics which contributed directly to the AMS decision. Personal interest in technology and the challenge of making the system work were seen as a decision influence for four of the six farmers. For one farmer, the potential to operate the farm system remotely through sensors and cameras was a key attraction. The intricacy and challenge of the pasture-based systems was a particular attraction for the two pasture-based farmers who were determined to prove that these systems can work.

Both of the confined-system farmers identified AMS technology as a means to attract the next generation back to farming following their university studies.

None of the farmers identified profit maximisation as an explicit goal. However, for five of the six farmers it was either implicit or explicit that they believed their AMS adoption decisions were both economically viable and economically rational within the context of their personal goals and risk profiles. One of the pasture-based farmers acknowledged that his adoption decision might be economically questionable, but it was something he very much wanted to do.

AMS system limitations

Cost. All farmers considered the costs of establishing AMS as the most important limitation and potential barrier to adoption. Being in a strong financial position and having other farming enterprises to borrow against was considered an essential element in securing funding.

Operation expenses were also found to be higher with one farmer identifying that any savings in labour expenses were soon offset by maintenance costs of the robots. Electricity costs were also found to be higher. One contributory factor was the need to run the cooling system 24/7. One farmer estimated the electricity bill to be double that of his traditional herringbone system.

AMS feed costs depended on whether the system was pasture-based, confined, or hybrid. For confined and hybrid systems, the feed costs related primarily to other aspects of the system rather than to the AMS per se. For pasture-based farms, the extent of the extra feed costs related to the extent to which in-robot feeding was used to assist with cow flow from the paddocks to the AMS.

Herding and cow flow. Cow flow is an essential element of AMS efficiency. For pasture-based farmers, this was a particular issue in the first year of operations with cows used to travelling as a herd. Also, farmers found that presentation of cows for milking tended to be slow between 2am and 5am, with a subsequent rush of cows at daybreak. The pasture-based farmers have found that these behaviours can be reduced but not eliminated by specific rules for paddock changes and varying rejection parameters during these periods.

Discussion

It is apparent that the case-study farmers perceived the key benefits of AMS as being more productive cows, better animal health, and farmer lifestyle factors. The most important limitation is cost.

For confined systems within New Zealand, and regardless of whether AMS technology is incorporated, there is a lack of New Zealand professional expertise in relation to nutrition and the specific New Zealand forage-crop opportunities that are feasible within these systems. In relation to AMS and pasture grazing, both professional and farmer knowledge as to optimal grazing systems remains limited.

Some caution is appropriate in relation to the interpretation of overall labour requirements. Although on most farms the overall labour requirement did not decline, this was in the context of increasing milk production. Hence, labour inputs per unit of milk produced may well have declined, but it was not possible to quantify this.

In contrast, overseas studies (Sonck 1996; Dijkhuizen et al. 1997; Rodenburg 2012) are all indicative of substantial labour savings being achieved. However, those studies relate to farms that are of modest scale and which exhibit considerably different features to New Zealand farming systems.

A key metric for AMS efficiency is likely to be the MS production per robot. This is likely to be more useful as a generalised performance indicator than the number of cows per robot, which will vary considerably according to the specific system.

Within the case-study farms, there was no convincing evidence that MS production per robot is higher under non-seasonal calving systems (be they confined or hybrid) than seasonal production systems. However, lower output per robot with seasonal systems would seem logical given the need to supply sufficient robots to manage peak spring production in a seasonal system. It is notable that one of the pasture-grazing farmers was considering moving to a hybrid system to obtain winter milk price premiums and better robot utilisation.

Five of the six case-study farms were small in area relative to regional averages. This does not in itself imply that AMS are only appropriate on small farms, and we are aware of AMS technologies on one large confined system in New Zealand, with others planned. However, it is notable that AMS can achieve scale efficiency on farms that are too small to obtain the full benefits of a rotary shed. Linked to this, AMS can be a key element in intensification of the farming system on these smaller farms. In relation to grazing systems, we foresee significant issues in successful incorporation on large farms, given the expected interaction between walking distances and milking frequency. These findings in relation to scale efficiencies with AMS run counter to the general perception with most other precision agriculture technologies that economic benefits are more easily achieved in association with larger rather than smaller farms (Yule and Eastwood 2012).

Although two of the farmers self-identified as ‘early adopters’, in terms of observed behaviours both current and historical, and linked to accepted adoption theory (Rogers 1983) all could be classed as genuine ‘innovators’. Innovators are generally classed within adoption theory as having a risk tolerance that allows them to adopt unproven technologies that may ultimately fail, and with financial resources that may help them absorb those failures. In contrast, early adopters are characterised as people who quickly adopt a technology once it has been proven in a similar context. For the confined-system farmers, the overall farm system does mimic well established European and American systems. However, considerable adaption to the New Zealand environment is still required, and investing in these systems requires farmers to operate outside accepted industry norms. In regard to the pasture-based and hybrid systems, the farmers are essentially developing the systems as they go. Rogers (1983) has suggested that only about 2.5% of farmers typically fit within this genuine innovator category.

One limitation of this study was that no attempt was made to collect financial information. This was purposeful. Rather, the focus was on farmer motivations and decision influences, and on some empirical outcomes as identified by those farmers. A further limitation of the current study was that it was not possible to document the environmental impacts of AMS on the farm system. Accordingly, the importance of future wide-ranging studies is acknowledged. These studies should be longitudinal as well as cross-sectional, and within a whole-of farm systems framework that recognises physical, biological, environmental, social and economic elements.

In summary, key conclusions of this study are that farmer practitioners believe that AMS have positive impacts on animal health, on per-cow production, and on lifestyle. Although AMS changes the characteristics of the labour requirements, it does not necessarily reduce total labour costs. The largest perceived constraint to adoption is capital cost. Unlike many technological innovations, AMS have potential to be incorporated on relatively small farms. Although commercial firms are skilled in the provision of the AMS technology, there is a lack of professional expertise to guide farmers in the incorporation of AMS within whole-of-farm systems.

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