Assessing the impact of uncertainty in automatic milking innovation systems – an international perspective

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Abstract

The use of automatic milking systems (AMS) is in an emergent phase in Australia with approximately 15 farms using the system in 2011. Dairy Australia, an industry-funded research and development organisation, has acknowledged a future role for this technology in the Australian dairy industry. However, successful uptake of automatic milking relies on farming system adaptation and the existence of appropriate technological, social and institutional system configuration.

An online survey of 82 AMS researchers and service providers was conducted internationally, followed by case studies of non-farmer experts in selected AMS markets (The Netherlands, Denmark, England, Ireland). Results from the online survey were used to form a basis for the semi-structured interview questions in the case studies. An innovation systems framework was used to analyse the results, with particular attention to the mediation of technological learning through structures and initiatives which reduce uncertainty associated with the innovation.

We found that roles in international AMS innovation systems differed through time, with larger roles for research and industry-good early in the development of innovation systems. Technological uncertainty played a major role in adoption initially, along with some impact from political uncertainty. Knowledge development was originally focused around farmers and technology providers, but later there were important (and commercial) roles for knowledge brokers.

The findings suggest that in order to reduce uncertainty in an emerging AMS market, such as Australia, institutional guidance is required to foster knowledge development and exchange, and to establish a basis for ongoing capability development. There is an immediate need for institutional guidance to foster knowledge development and exchange, and to establish a foundation for ongoing capability development. In the emergent phase of the markets surveyed there was a role for industry-funded organizations in delivering broad knowledge development and capability building programs focused on key actors such as nutritionists, veterinarians, banking finance representatives and agricultural consultants. Based on international experience, we can expect these actors to have a pivotal role to play in reducing uncertainty in the emerging AMS innovation system in Australia.

1. Introduction

Automatic milking systems (AMS) are prevalent in several European dairy farming countries such as Sweden, Denmark and The Netherlands, but the use of AMS in Australia has been low to date (de Koning, 2010; Svennersten-Sjaunja and Pettersson, 2008). The AMS concept involves removing manual milking labour by using a milking robot to milk the cows, and adapting the farm system to facilitate 24-hour per day milking where the cows move 'voluntarily' to be milked via incentives, such as feed. Reasons for the limited uptake in Australia include larger farm sizes and the focus on pasture-based grazing systems which add complexity to management with AMS. In the past four years there has been increased interest in AMS with approximately 15 farms now using the approach. The dairy industry has also committed to AMS as an important facet of future options for dairy systems through ongoing investment in a large AMS research and development project at The University of Sydney (Crawford et al., 2007; García et al., 2007). The use of this new farming system requires new skills and knowledge in both farmers and their networks of practice, however the type and demand for knowledge is unknown.

The implications for AMS in Australian farming systems show differences to the challenges faced on European or North American AMS farms, primarily due to the greater focus on grazing based systems in Australia. Under AMS the importance of grazing management practice is heightened, as feed supply is used as a main driver to entice cows to move around the farm, and thus through the milking units, throughout the day. Other factors in the farming system are also affected, such as mating practices and herd testing regimes.

AMS involves not only a reconfiguration of farming practice, but also in knowledge systems in networks around the farmer, for example veterinarians need to adapt their reproductive performance advice to address different under reproductive challenges under AMS. The success of an innovation system can depend on minimizing the uncertainty around the innovation (Meijer et al., 2007b). Poor or haphazard reconfiguration can increase the uncertainty that farmers or their advisors have about an innovation and also impact on its successful uptake and implementation. The aim of this paper is to explore the factors which influenced AMS innovation system development in the northern hemisphere in order to identify potential influences in Australia.

An online survey and subsequent interviews with experts were undertaken to assess the development of AMS as an innovation system in different countries, and the areas where uncertainty existed or still exists. In this paper the research results are presented via the framework of Meijer et al. (2007b) to highlight factors of uncertainty. This is then used to discuss the implications for an AMS innovation system in the Australian context.

2. Theoretical framework

The process of innovation has been described in terms of a systems-based interaction, involving not only organizations but also social networks of institutions and individuals, engaging within a context which includes markets, policy, funding arrangements and infrastructure (Hekkert et al., 2007; Hekkert and Negro, 2009; Klerkx and Leeuwis, 2008). Innovation is underpinned by networking and social learning activities between a wide range of actors (Klerkx et al., 2010). Successful agricultural innovations depend upon factors such as technology development, institutional change, supply chain reorganisation, market development and creating societal acceptance (Klerkx et al., 2010; Morriss et al., 2006). Agricultural innovation systems have historically placed farmers as holding the capability to manage on-farm technological adaptation as shown by minimal funding of development or knowledge brokering capability (Klerkx and Leeuwis, 2009). Ongoing innovation around precision dairy technologies in Australia currently relies heavily on learning and adaptation efforts of farmers and private technology providers, with limited investment in industry-level development or capability building in farmer networks (Eastwood et al., 2012).

A feature of the innovation process is the reduction of uncertainty (Hall et al., 2011). Meijer et al. (2007a; 2007b) identify six forms of uncertainty that might occur: technological; resource; competitive; supplier; consumer; and political. Often uncertainty exists at a scale where individuals within the AIS have insufficient agency to influence sources of uncertainty. An example of this could be the ability for farmers to herd test in the future while using AMS – an individual farmer, and even the technology retailers, may hold a high degree of uncertainty over whether herd testing and AMS use are technologically and institutionally compatible. Uncertainty within innovation systems can potentially reduce the uptake of a technology, affect its integration into the farm system or industry, and can prevent some actors from engaging in the innovation system (Meijer et al., 2007b).

While the sources of uncertainty cited by Meijer et al. (2007b) focus on the formation of innovation projects, and in particular the impact on entrepreneurial action, the framework could be applied to the actions of farmers and advisors in respect to new system-changing innovations. An entrepreneur discovers and evaluates opportunity, using this to create new opportunities (York and Venkataraman, 2010). In this paper the farmer is seen as the entrepreneur, charged with evaluating the opportunity presented by AMS and creating opportunities with its use.

3. Materials and method

3.1 Survey design

A mixed qualitative and quantitative methodology involving an online survey and interviews was used to explore the development of AMS support capability. The survey collected responses from people in the 'AMS community' who are involved with farmers using AMS. This included research, development, policy, and sales and support of farmers with the technology. Survey questions were derived from an initial literature review (de Koning, 2010; Khanal et al., 2010; Meskens et al., 2001; Shephard, 2004; Svennersten-Sjaunja and Pettersson, 2008) and through consultation with AMS experts. An online survey method was used and pre-tested amongst a group of AMS experts. The survey was designed around an 'innovation systems' framework (Meijer et al., 2007b; Klerkx et al., 2010) to assess the influence of uncertainty on the use and support of AMS. Questions relating to the six areas of uncertainty were woven into the survey. Overall, the survey questions were targeted at:

Understanding the respondents and their experience, and worldviews in respect to AMS;

Collecting information about AMS use internationally;

Examining the support structures available to farmers at three phases of adoption and implementation; and

Assessing the impact of uncertainty in the AMS innovation system.

This paper is focused on the fourth aim; responses to the survey are incorporated in the results below and represent an initial macro analysis of the data. Data from the survey were entered into Excel™ and aggregated by country of respondent and by stated job category. Data were then analyzed in respect to the uncertainty categories. Results are presented in this paper in qualitative manner.

3.2 Case studies

In-depth case studies were undertaken through semi-structured interviews of non-farmer experts. The interviews were conducted face-to-face in July 2011 and each lasted 1-2 hours. For the purposes of this paper the notes were analyzed using thematic analysis in Nvivo™ software

(Strauss and Corbin, 1998), further analysis of the interview transcripts is being undertaken. The analysis presented in this paper represents preliminary findings from these interviews.

4. Results

4.1 Online survey

There were 82 valid responses from: Canada (24), The Netherlands (14), USA (10), Denmark (8), UK (6), Germany (4), Sweden (3), and the remainder from Israel, Norway, Switzerland, Finland, France, Ireland, NZ, India, Iceland and Japan. Of the 82 responses, 36 people worked for a company which sells, services or supports AMS related equipment, 37 were employed in publicly funded research/advisory roles and 9 were employed in a private support capacity.

There was an even split of day-to-day experience with AMS farmers, with 27 people respectively stating it was either ‘a major part of my job’, ‘often part of my job’, or a ‘small part of my job’. Two respondents said it was not part of their job. There was considerable experience of AMS with 27 people having over 10 years experience, another 27 with 5–10 years experience, 25 with 1–5 years, and 3 with 0–1 years experience. Many (47%) worked internationally and/or nationally (51%). In answering the survey, respondents drew on experience from between 1–1000 AMS farmers, with most interacting with somewhere between 20–100 farmers.

4.2 Interviews

Eight semi-structured interviews were conducted with AMS experts. Those interviewed were from Ireland, England, The Netherlands, Denmark and Germany, and included researchers, technology company representatives and AMS consultants. While each interviewee primarily related to experiences in their country of residence, they also had extensive international experience and were able to speak on AMS-related issues more broadly. Notes from the interviews are used in this paper to add extra depth to the survey results. Further qualitative analysis of the interview transcripts will be conducted at a later date.

4.3 Respondent perceptions in relation to sources of perceived uncertainty

a) Technological uncertainty

Uncertainty around the characteristics of an innovation, related infrastructural implications, the level of adaptation required and the impact on future options are all aspects of technological uncertainty (Meijer et al., 2007b; Klerkx et al., 2010). Relevant factors to AMS could be the degree of technological lock-in (including the ability to expand herd sizes and resale value), the specific challenges of adapting farming systems to AMS and the impacts on milk quality.

In this study, respondents felt that farmers were well supported when making AMS investment decisions but were not always certain of the implications AMS had on factors such as expanding their herd size or reverting back to a conventional milking system.

b) Resource uncertainty

This category focuses on the availability of resources, such as human, financial and material, and also encompasses organisation of the process of innovation. In an AMS context, resource uncertainty could relate to the ability to get finance for the AMS investment, uncertainty around milk price and its impact on viability, along with other factors such as uncertain pricing of second-hand AMS technology.

Respondents perceived relative certainty for farmers accessing finance for AMS, but that ascertaining the depreciation value of the technology was more difficult. Access to staff to work on AMS farms was highlighted as an area of uncertainty, however once they had staff, farmers were sure of the allocation of roles on an AMS farm.

c) Competitive uncertainty

The behaviour of competitors in the innovation system can impact on its success. This relates to the competition between retailers of AMS technology (i.e. is there competition in a market dominated by two main players) and how each competitor might refer to each other's product. We assessed this by asking questions around the availability of independent advice on technology and the adequacy of advice provided by technology retailers. Respondents agreed that retailers were providing good advice on investment decisions but were less positive about the ability of farmers to source independent AMS advice in general.

d) Supplier uncertainty

This source of uncertainty relates to perceptions around the reliability of the supplier. In respect to AMS, we asked questions around the availability of AMS technology (was there sufficient supply to match demand), the access that farmers had to back-up service for both technical and learning support, and whether farmers knew where to access advice about farming with AMS.

Responses showed that in internationally there is a ready supply of AMS technology as the key suppliers have expanded their production facilities to match demand; therefore uncertainty of supply is not a factor. The perceptions of support offered by suppliers showed that while farmers can be certain about the extent of technical support they will receive, they may be less aware of the learning support available from their retailer. However, this is compensated by farmers having access to AMS farming system advice from other actors in the AMS network. This network of support on 'how to farm with AMS' has taken two decades to develop and while there are commercial opportunities for suppliers of specialised AMS farming systems advice, this has really only existed for around ten years in the more established AMS markets.

e) Consumer uncertainty

Consumer uncertainty is one aspect of the Meijer et al. (2007b) framework which has less applicability when taking the farmer perspective in an AMS innovation system. It concerns the preferences consumers might have for an innovation, the characteristics of consumers, and the development of demand for the technology – features which are more applicable to entrepreneurs looking to work with consumers (farmers) rather than the consumers themselves. Thus for this factor we asked industry-related questions such as uncertainty around future patterns of AMS adoption, the nature of technological development, and the fit of AMS with farmer typologies.

Respondents perceived little uncertainty over the future adoption pattern of AMS, although this primarily reflects a European view where the technology is now an accepted alternative to conventional milking systems and where installation rates are already high. They also perceived that there was relative certainty regarding the characteristics of farmers who were matched with the skill and knowledge demands associated with AMS. Again this reflects the stable nature of AMS in Europe where many of the 'teething issues' have been worked through and knowledge and understanding of AMS use is relatively widespread within the dairy industries.

f) Political uncertainty

The policy environment can have a major impact on the innovation process for example the interpretation of policy, existence of regulations, and uncertainty regarding government and policy changes (Meijer et al., 2007b). In respect to AMS this may include the implications of milk quality and food safety regulations, general political and community support for AMS, and the existence of incentives.

Respondents perceived a lack of awareness within farmers as to future regulations which may impact on AMS use, and felt that farmers were moderately aware of the current regulations that related to AMS use. There was a strong perception that current regulations did not act to make farming with AMS easier. Also there was a perception that financial incentives at an industry level had not played a role in the uptake of AMS. In terms of the role of public and industry-good organisations, respondents identified a lack of industry-level extension programs related to AMS use but perceptions were mixed as to whether there was actually a role for the dairy industry or public organisations in the learning support space.

In this paper, the survey and interview responses are in the context of a relatively mature AMS innovation system in Europe, and had similar questions been asked ten years ago when the system was in more of a developmental stage, the perceptions of respondents may well have been different. The expert interviews were able to provide more of this historical picture of the innovation system development over time. They indicated that roles in the international AMS innovation systems differed through time, with larger roles for research and industry-good early in the innovation system development. Technological uncertainty (for example, due to problems with the reliability/functionality of some early version of AMS) initially played a major role in adoption along with some impact of political uncertainty (for example, the impact of milk harvesting regulations in Germany). Knowledge was originally focused around farmers and technology providers but more recently there have been important (and commercial) roles for knowledge brokers.

The uptake trajectories of AMS were different in the case-study countries. Where the Netherlands and Denmark saw a relatively steady expansion in uptake, England and Ireland have had a more varied history. Ireland in particular had several installations which were then removed due to issues with technology and farming system adaptation. The decommissioning created a level of uncertainty in the local farming population about the suitability of AMS which remains even now in Ireland.

5. Discussion

The framework of Meijer et al. (2007b) provided a good lens with which to look at the AMS issues internationally and apply them to the Australian context. While most of the factors of uncertainty were relevant to the ‘farmer as entrepreneur’ perspective adopted in our analysis, some of the factors relate better to other actors in the network. For example, consumer uncertainty relates more to the technology provider and their uncertainty of the farmers needs, or a consultant and their uncertainty whether there is a business case for them to become involved. The results show a relatively mature and stable innovation system internationally, however, further analysis of the results may highlight differences between countries, especially when comparing Europe with the less developed markets in North America.

Technological uncertainty was historically an important issue around the early development of the AMS with interviewees indicating that uncertainty over technological performance had a significant impact on uptake in the 1990s. An equally important factor was uncertainty regarding best-practice for integrating AMS into the farming system. These factors are less important currently due to technological improvements and a vast increase in the knowledge around successful AMS farming in European systems, however they signpost potential areas of uncertainty for Australian dairy farmers. The prevalence of pasture-based grazing systems in Australia presents different challenges and the uncertainty over best practice, or even the basic ability to succeed with AMS in a pasture-based system, is a source of uncertainty for farmers. This has prompted a focus on production of specific AMS knowledge which is applicable in an Australasian context (Donohue et al., 2010; García et al., 2007; Jago and Kerrisk, 2011).

The political environment can have a large impact on innovations such as AMS through even apparently minor regulations or policies. One example highlighted during this research was food safety regulations in Europe requiring a person to be present at milking, which was not feasible under the 24-hour milking cycle of AMS. Altering such industry-wide regulations can take considerable effort and time, and the resulting uncertainty can act to discourage farmers from investing in the new technology. Other institutional arrangements can also be affected, for example, herd test protocols which require two milk samples at 12-hour intervals have had impacts on the ability of AMS farmers to participate in herd improvement schemes. In Australia, this issue could act to restrict uptake of the AMS innovation.

Obviously there is uncertainty around AMS investments currently in Australia which is to be expected for any ‘new’ innovation. The potential issue for the dairy industry, assuming it views AMS as an important option for farmers into the future, is the impact of negative stories about AMS from farmers who struggle with the adaptation process. Based on the experiences of England and Ireland, such occurrences may act to stall the uptake of AMS. This initial summary of the survey and interview results indicates some lessons for the configuration of the Australian AMS innovation system. In particular, we can see the need for further discussion regarding the role of private providers of advice to farmers, and the related role of public or industry-good AMS support programs. The development of commercial roles for consultants in providing advice to AMS farmers took some time to occur in the established markets in Europe. In Australia, the market size (currently only 15 AMS farms) is too small and too widely spaced geographically to enable a viable business proposition for specialized consultants. However, there is potentially a role for public organizations to ‘jump start’ the capacity development of key consultants over the next five years as the market expands.

The needs and roles of stakeholders will evolve over time. In the short term we expect a gap in private service provision until both the market size/density builds and the capability increases amongst key service providers. A cost effective path for the next 5–10 years could be to focus on development of service providers with farm systems knowledge who also understand the concepts of AMS. In the near-term, a network of service providers with AMS knowledge would be very useful in enabling farmers to make appropriate AMS choices prior to the investment decision and also during the purchase and installation phase.

6. Conclusion

Using the concept of perceived uncertainty, we were able to analyze important features of the AMS innovation system internationally, particularly in European and North American markets. The analysis showed a relatively stable technological innovation system, particularly in the more established AMS markets in Europe, but highlighted the importance of research in the early phase of technology uptake, and the current roles of private knowledge brokers such as consultants and nutritionists. This suggests that in order to reduce uncertainty in an emerging AMS market, such as Australia, institutional guidance is required to foster knowledge development and exchange, and to establish a basis for ongoing capability development. In the emergent phase of the markets surveyed there was a public or industry-good role in delivering broad knowledge development and capability building programs focused on key actors such as nutritionists, veterinarians, banking finance representatives and agricultural consultants. Based on international experience, we can expect these actors to have a pivotal role to play in reducing uncertainty in the AMS innovation system in Australia.

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