Data Power: Understanding the Impacts of Precision Agriculture on Social Relations

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Abstract. Precision agriculture has been greatly promoted for the potential of these technologies to sustainably intensify food production through increasing yields and profits, decreasing the environmental impacts of production, and improving food safety and transparency in the food system through the data collected by precision agriculture technologies. However, little attention has been given to the potential of these technologies to impact social relations within the agricultural industry. This paper argues that for precision agriculture to deliver its intended benefits the social consequences are imperative to consider. This article begins by mapping and analyzing the current precision agriculture technological landscape in Ontario in order to understand the current state of adoption. It then further examines the changing relationship between precision agriculture retailers and primary producers due to the introduction of precision agriculture through a qualitative analysis of interviews. By understanding the shifting power relations between these two actors along with the political and economic motivations for technology adoption, I highlight the social impacts of precision agriculture adoption, focusing on issues of cost, labour, and data as a new form of capital on the farm. The results emphasize the pressing need for knowledge transmission and capacity development in precision agriculture as the vast majority of agriculture data collected is underutilized. This research focuses specifically on data gathering technologies in the crop and dairy sectors in ten counties with the highest adoption rates of precision agriculture in Ontario.

Keywords. *Precision agriculture, big data, social relations, capacity building, Ontario*

Introduction and Background

Industrial agriculture is facing a crisis in terms of being able to sustainably produce enough food to feed a growing world population. There have been negative environmental externalities from industrial production (Tilman et al. 2002; IPCC 2014). However, new technologies, hold a promise of improving our food system by gathering data to allow farmers to make more sustainable choices in management (Balafoutis et al. 2017), increase productivity and profitability of farming (Griffin et al. 2004), and increase transparency in our food system through the collection of data (Opara 2003). A whole new suite of technologies, such as robotic milking machines in the dairy sector and driver-less tractors that know exactly where to plant crops based on algorithms and data analysis, are being developed to revolutionize the way that our food is produced (Eastwood et al. 2012; Gebbers and Adamchuk 2010). Collectively, these technologies are often referred to as precision agriculture, which is defined as the use of technologies gather data to help farmers make more site-specific management decisions (Zhang 2016).

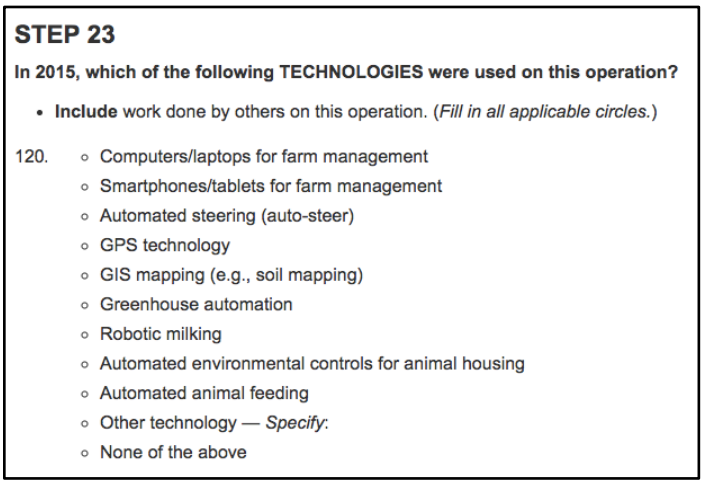
While precision agriculture technologies present an exciting opportunity to decrease agriculture's impact on the environment, increase profitability in farming, and create more transparency and traceability in our food system through the use of data, there is a need for more social science research to understand if these benefits can be realized and how precision agriculture will impact social relations (Carolan 2016). This paper attempts to investigate this knowledge gap by understanding the social impacts of precision agriculture, particularly in terms of education and outreach. These social impacts have been understudied by the literature, however due to the potential for precision agriculture to impact social relations, it deserves scholarly attention, as Bronson and Knezevic (2016) note – "big data is poised to reproduce the relationships between food system players – between farmers and corporations" – which is the focus of this research.

Specifically, the research question this paper addresses is: "how will social relations between agricultural technology retailer and producers change, if at all, in light of new agricultural technologies?" Reflecting on these changing social relations, this paper will specifically focus on a set of results relating to education and capacity building in precision agriculture. This study had two objectives – the first was to document and interpret current technology use in Ontario and secondly to characterize the relationships between producers and agricultural technology retailers and examine the impacts of technology adoption on this relationship.

Methodology

A mixed methods approach was used in this study to achieve the research objectives. The first method was an analysis of recent census data which provided information on technology use. In 2016, the Canadian Census of Agriculture added the question: "which technologies were used on this operation?" The analysis focused specifically on two sectors – crop production, looking at

technologies such as automated steering, GPS, and GIS (Geographic Information Systems) mapping, and the dairy production – looking specifically at the use of robotic milkers. Technologies such as computers and smartphones were analyzed for both sectors (See Figure 1).



STEP 23

In 2015, which of the following TECHNOLOGIES were used on this operation?

- **Include** work done by others on this operation. (*Fill in all applicable circles.*)

120.
- Computers/laptops for farm management
- Smartphones/tablets for farm management
- Automated steering (auto-steer)
- GPS technology
- GIS mapping (e.g., soil mapping)
- Greenhouse automation
- Robotic milking
- Automated environmental controls for animal housing
- Automated animal feeding
- Other technology — *Specify*:
- None of the above

Fig. 1: Technology Question added to the 2016 Canadian Census of Agriculture

The Census of Agriculture analysis provided a sampling method for qualitative results through semi-structured interviews with two groups of participants: agricultural technology retailers and farmers using precision technologies. Sampling for interviews with retailers and farmers was based off the top 5 census divisions with the highest users of crop technologies which were located in Huron, Perth, Oxford, Elgin, and Chatham Kent counties (See Figure 2).

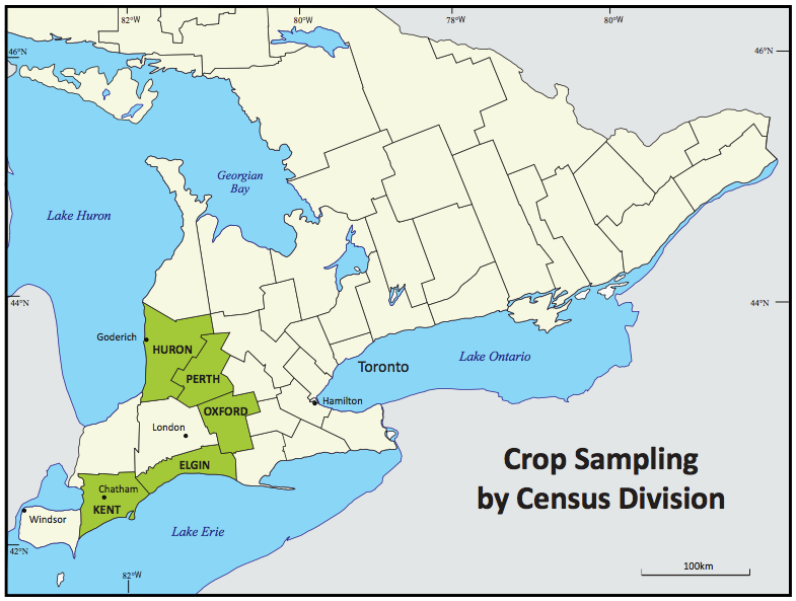


Fig. 2: Counties with the highest adoption rates for crop precision agriculture technologies and selected for interviews with crop farmers and retailers.

For the dairy sampling locations, the same sampling was used resulting in selecting the counties of: Wellington, Perth, Oxford, Durham, and Stormont counties for the interviews as these were the top 5 locations with the highest number of users of robotic milkers (See Figure 3).

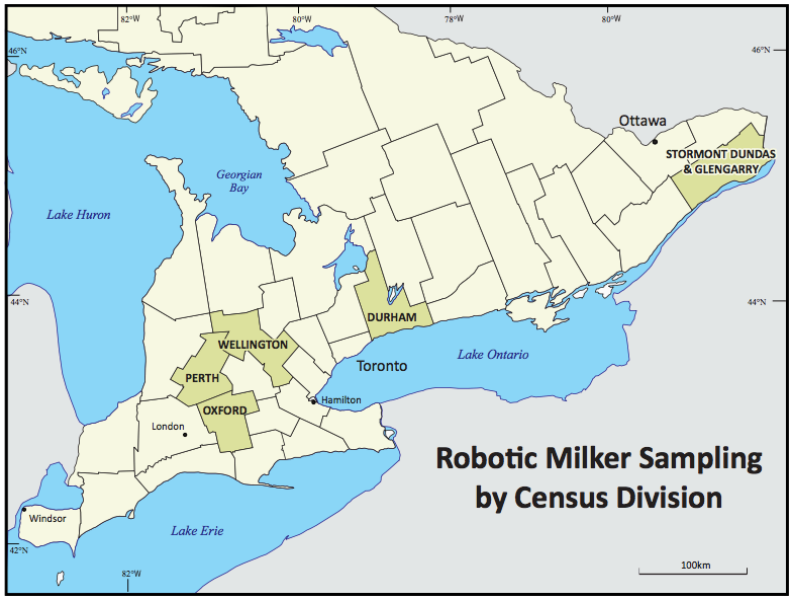


Fig. 3: Counties with the highest adoption rates for dairy precision agriculture technologies and selected for interviews with crop farmers and retailers.

A total of 33 interviews were carried out either by telephone or in person to respondents across these ten counties. It should be noted that there were some overlap as dairy farmers with robotic milkers often also cash cropped and used some of those technologies as well. These interviews were analyzed through a grounded theory approach using open coding through the software NVivo.

Selected Results

This section presents some of the selected qualitative findings from the interviews. The most prominent finding is that agricultural data is underutilized as a decision-making tool. Retailers from both crops and dairy sectors agreed that their customers were not using these tools to their full potential when asked "do you think your customers are able to use their precision agricultural tools to their full capabilities?" the response was a resounding no – here retailers are quoted saying that they were "just scratching the surface of the capabilities" or estimating that almost 50% how much of the data was disregarded. This highlights the importance of the relationship between these two actors in using more agricultural data for decision making.

Secondly, the need for knowledge transmission and capacity development in precision agriculture is highlighted by this study. There is a need for educated retailers to be able to support farmers in using data for farm management decisions, and also so that the next generation of farmers can be effective in managing their own data. Additionally, there were some observed differences between the crop and dairy sectors. Many of the crop retailers of precision agricultural tools did not advise on the data management aspects of using tools, they merely sold and serviced these tools. However, the majority of dairy technology retailers had a designated support staff that focused solely on helping farmers manage their data. Both farmers and retailers predicted that

increasingly there will be more services offered to assist farmer with data management within the industry.

These interviews revealed that there are certain trends driving the adoption of precision agriculture technologies, such as the shortage of labour in the dairy sector, or the need to use data to manage farms that are continuing to increase in size in order to remain competitive. Additionally, there are certain challenges associated with precision technologies, such as how to actually use the data that these technologies are collecting to make management decisions. This lack of knowledge has resulted in the underutilization of the vast majority of data being collected on farms. Therefore, a new line of services is being offered in the agricultural sector to manage and analyze data. Farmers will send their agricultural data to these companies for data analysis, however this in turn, leads to questions over data ownership, privacy, and being able to trust that the algorithms are actually providing them with the best management decisions.

According to the farmers and retailers interviewed, retailers were the primary source of information of how to implement precision agriculture tools on their farms. Retailers described their various strategies for during the adoption process, which typically entailed some training before installation of a new system (whether a robotic milker or yield monitor with DSS), on-farm consultation during start-up, communication over time, and refresher "clinics" during less busy times of the year (i.e. winter). What differed greatly between retailers was the amount of assistance with interpreting data collected from precision tools into farm management decisions. Depending on the brand of robotic milker, retailers took different approaches to data management and decisions support – some had dedicated staff for this role and some were completely uninvolved. In the cropping sector, there was similar variation as the more advanced precision retailers did have a role in data management and interpretation, however the majority of retailers said that they did not have a role in data management and advised their customers to get have their data interpreted by crop advisors. The disconnect between the retailers selling the tools of precision agriculture and those who are the ones interpreting the data will be further explored in the discussion.

Finally, a key point that was raised in regard to the role of the state and PA was that there needed to be more education on the use of these technologies for incoming workers to the agricultural sector and the government should offer extension services that would help increase farmers' capacity to use PA. Suggestions included offering courses in college and universities to help future farmers become more "precision minded". The following quotations demonstrate the need for academia and government to be more involved with extension services and precision agriculture training:

Thomas (crop and dairy farmer): *"We have suggested it several times at our local community college to have a course on agricultural electronics. Just like this yield monitor thing on our combine. We need somebody who is trained on how these systems are put together. Now saying that, now our combine is pretty old. Ours was one the first ones to have one it. They have simplified the systems quite a bit since then. The techs out there at the dealership, they are good but they have never had a whole lot of training in agricultural electronics. I believe, it should be a big uptake for something like that. Just to know how to trace stuff down. Even the robot there, there is electronics on there that have never given a whole lot of trouble but there is sensors that do fail and our principal dealer he has had training on what sensor fails and he knows exactly where to look. He is looking for a guy to help him and he hasn't found anybody yet. He basically has to train the right person himself."*

Jessica (dairy farmer): "*But I think this group, that I would consider ourselves being a part of, you know, who has adopted the technology and is generating the data would like a little bit more training as to what to do with the data and we definitely need to make more management*

decisions based on the data. That group is just going to get bigger and as it does and as the demand becomes greater of that group as it gets bigger hopefully we are going to have more pull and get more results. That is just over time and there is a lot of it too that is self-training and self-initiative, right? Like you just have to…it is not like before where you could just do what you did and that is what you did, and it worked or it didn't work and you kind of went on with it. We have this data now so why not make, but the thing with data is it removes feelings from decision making. And there is a lot of people that cannot do that. There is a lot of people that enjoy to do that and there is a lot of people that struggle with that. As you move towards wanting to run your business as a business, it will get easier to make those decisions without feelings based on what the data says…I think that something really that the precision ag dealers really need to look at if they want to push the adoption of these technologies further is there is huge lack on the education side of the farmer. Huge. I really do think that is a crutch for pushing it a lot further than we are or pushing it quicker than we are. Because like you said earlier, it is all about risk, right? Well the more educated you are about a risk, the more likely you are to take that risk than to not take that risk. So, if you at least understand, you know have a better understanding of what is going to be brought back to you, then you are more willing to take that risk."

This section highlights that there is a need for more education and capacity building for farmers, especially given the previous result that the vast majority of data is underutilized. This responsibility should be a role of public institutions, not just the private retailers who are selling PA tools. While incentives and regulations may prove to be contentious policy issues, farmers and retailers alike agree that education is key to moving PA forward in Ontario.

PA Education and Capacity Building

As this study is one of the first to fully scope the technological landscape in Ontario it has several practical contributions. It provides a realistic scope of the limited use of PA technologies in this area and that could have potential implications for how these technologies are marketed in the future. Most importantly, the practical contribution of this study is that it draws attention to the need for institutional support for farmers as they continue to adopt more PA technologies.

In terms of recommendations for institutional support for PA technologies, this research finds that developing extension services and training the next generation of agriculturalists to be adept in using PA tools would most likely be the most effective. In the case of extension services, one dairy farmer lamented the absence of an extension service that is able to provide another perspective outside of the retailer:

George (dairy farmer*): "Well we can see something is going on…We kind of knew our parlour system just over time, and there are some things and I am not a technician and there is no independent person or company. We have hired independent people to come and trouble shoot when we had problems with our milking parlours but there is no independent person that I am aware of that will come in that is familiar with all these robotic systems and can give you – just a third party opinion. I am going off my technician from the dealership and if they are not telling me something or they are not aware of something, we are all scratching our head going "why is this happening?"*

While past studies noted the domination of the PA market by private corporations (Wolf and Buttel 1996; Wolf 1997; Piesse and Thirtle 2010), however more recent studies have noted the role of public institutions in being advocates for open-data, innovations driven by data, and attention to data governance issues (Wolfert et. al 2017). Therefore, there is definitely a role for organization such as Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) to play in providing extension services and assistance in helping farmers to make successful management decisions for profitability and sustainability. As noted from the results, there is less of a role to play in providing incentives for adoption and for increasing environmental regulations based on digital agricultural data at this time.

Secondly, educational institutions need to enhance their role in providing the next generation of farmers, advisors, and technicians with the right training and skills to utilize PA in farm management. Programs in colleges and universities catered to students who hope to have a career in the agricultural industry should focus on developing the interdisciplinary skills from agricultural sciences, environmental sciences, geography, and computer sciences. This study recommends that educational opportunities should be geared towards producing future employees who will be able to be "precision-minded" and able to use PA.

Conclusion

The expected contributions from this research will add the literature looking at the social impacts of precision agriculture. It allows us to rethink the connections between technology and power by demonstrating that it is already large and capital intense farms that are adopting these technologies causing a need to pause and consider how the introduction of precision agricultural technologies can be achieved equitably and sustainably for diverse farms across Ontario. In addition, the power of data for farm management decisions currently resides with the technology retailers as farmers are not able to fully utilize their data without the support of these retailers. The practical implications of my research demonstrate that there is a need for increased public involvement in the precision agriculture revolution to help farmers have more control over their data. This highlights the need for institutional support and extension services to promote the adoption of precision agriculture by actors other than private industry.

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