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Farm Data Collection and Software Adoption in Commercial Scale U.S. Corn-Soybean Farms

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Abstract
A survey of 800 commercial scale corn and soybean operations was conducted to examine farm data collection and analysis practices among large farms. Results indicated that collection of data from yield monitors, soil samples, and aerial imagery were common, but varied depending on farm size and operator characteristics. Over 40% of commercial scale farms which collect data use at least one ag-data technology software. Farms that use ag data software are larger, have younger operators, and higher levels of educational attainment. The majority of software adopters use more than one software product, highlighting the importance of inter-operability in ag-tech.

Keywords: farm data, precision agriculture, technology adoption

Background
Digital agriculture appears to be exploding in terms of the number of firms providing digital agriculture tools and software as well as the investment dollars the sector is attracting. Large agribusiness firms have made major investments including Monsanto's (now Bayer) purchase of The Climate Corporation in 2013 and, more recently, AGCO's purchase of Precision Planting and DuPont's (now Corteva) purchase of Granular, both in 2017. Despite the sector's growth, there is a paucity of information available regarding factors that influence today's farming operations' adoption of digital agriculture technology to make decisions and, possibly, improve farm productivity.

To learn more about how U.S. commercial scale corn and soybean farms are actually gathering and using data on their farms, a telephone survey of U.S. commercial corn and soybean producers was conducted from August 5 to August 30, 2019 (Purdue University Institutional Review Board approval #1906022382). Previous research confirmed that larger scale farming operations are more likely to use various precision agriculture technologies (Daberkow and McBride, 2003; Fernandez-

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Cornejo et al., 2001; Roberts et al., 2004; Schimmelpfennig, 2016). Since the survey's purpose was to learn more about the key factors influencing adoption and use of digital agriculture technologies, rather than simply the adoption rate of various technologies, the survey intentionally targeted commercial scale farms that are most likely to use digital technology.

Commercial scale farms for the purpose of this study are defined as having farmland of 1,000 acres or more with a corn and/or soybean enterprise as part of the farming operation. However, USDA-NASS (2020) data indicates that over half of the farms with more than 1,000 acres of farmland actually operate less than 2,000 acres. To ensure that survey responses were representative of truly larger-scale farms as well as mid-size farms, the survey was designed to ensure that half of the responses were from farms operating between 1,000 and 1,999 acres and half of the responses were from farms operating 2,000 acres or more. The final sample included 400 respondents farming 1,000 to 1,999 acres and 400 respondents operating 2,000 acres or more of farmland.

The advantage of a phone survey is that researchers can keep calling until enough responses are gathered to meet sampling targets and generate reliable results. The disadvantage of a phone survey is it needs to be short and relatively easy to respond to, or else respondents are unlikely to complete the survey. With that thought in mind, the survey design focused on three types of data: yield monitor data, grid or zone soil sample data, and aerial or satellite imagery data to learn more about the factors influencing agriculture data software adoption and management practices.

Farm Characteristics and Data Collection Practices

Table 1 displays summary statistics of the sample's farm and operator characteristics. Eighty percent of all survey respondents were over age 50 and just over one-third (35%) were over the age of 65, which compares to NASS' estimate that the average age of U.S. farmers is 59. Forty percent of survey respondents had a bachelor's degree and an additional 30% of respondents attended college.

Table 2 summarizes precision agriculture adoption and data analysis practices of sampled farms. Usage of well-established precision agriculture technologies was high as 92% of respondents reported using GPS guidance/autosteer technology while 71% and 59% said they used variable rate fertilizer and variable rate seeding, respectively. Unmanned aerial vehicle (UAV) (i.e., drone) usage among respondents was much lower than the other technologies as just over one-fourth (26%) of respondents reported using a UAV. Eighty percent of respondents reported having high-speed internet access and just over two-fifths of survey respondents reported using Microsoft Excel (43%) and/or a farm data software application (44%) to analyze farm data. While guidance technology usage among our sample was comparable to representative estimates for similar size classes (e.g., USDA Agricultural Resource Management Survey (ARMS)), use of variable rate technology (VRT), UAVs, and software were far higher, suggesting our sample is more advanced relative to the general population of commercial farms in terms of precision agriculture adoption.

Farm data collection among commercial scale corn and soybean farm operations in the survey sample was also quite high. Table 2 reports the proportion of farms collecting each of the three data types targeted on the survey: yield monitor, grid or zone soil samples, and aerial or satellite imagery data. Ninety-three percent of survey respondents collected at least one form of farm data. However, 7% of these commercial scale survey respondents reported not collecting any of the three data types and, furthermore, few members of that group indicate it is "very likely" that they would begin collecting data in the future. To date, farms that choose not to collect data are referred to as Non-

Data Collectors (NDCs). Farms collecting one or more of the three data types are referred to as Data Collectors (DCs).

Data Collector vs. Non-Data Collector Farms

Although a majority of NDCs used GPS guidance/autosteer on their farms, the percentage was lower (73%) than among DC farms (93%). DCs were also much more likely to use variable rate fertilizer (74% of farms) than NDCs (27% of farms) and nearly three times as likely to use variable rate seeding (62% of farms) as NDCs (22% of farms). DC farms were four times as likely to use a UAV (28%) as NDCs (7%). When it comes to software usage, there were also big differences between DCs and NDCs. Fourteen percent of NDCs reported using spreadsheets (Microsoft Excel) while just 5% of NDCs used a farm data software package. This stands in sharp contrast to DCs, 45% of whom reported using spreadsheets and 47% reported using at least one type of farm data software package for analysis. Given the notable association between the collection of farm data and use of farm data software, the characteristics of software adopters and the types of products they use is examined further.

Ag-data Software Adoption

Overall, 47% of DCs used at least one ag-data software product, but adoption varied by farm size. Sixty-three percent of farms with 5,000 acres or more used one or more software products vs. 36% of farms with between 1,000 and 2,000 acres of cropland. Software adoption was also related to operator age and farm educational attainment. Figure 1 shows that for operators over the age of 65, those with some college were almost twice as likely to use farm data software as those with a high school diploma. A similar pattern emerges for operators aged 51-65, but in their case, the largest difference in adoption was between those with and without a bachelor's degree or higher. Usage of software platforms was common among young operators of all levels of education, but adoption rises sharply for farmers with a post-graduate degree (Master's or Ph.D.). These differences in ag-data software usage by age group may reflect the way educational attainment has changed as a signifier of specialization over time.

Respondents that used at least one type of ag-data software were asked to identify which specific platforms they use. Figure 2 shows the proportion of data software subscribers that used each of eight popular software products. Over half of software adopters used Climate FieldView, a Bayer acquisition, while 44% used John Deere's Operations Center, and 22% subscribed to Case IH's AFS platform. Usage of Operations Center and AFS were generally in line with their respective market shares for farm equipment. Just behind AFS was Trimble at 21% of software subscribers, and Farmers Business Network (FBN) at 19%. Encirca (owned by Corteva) was used by 14% of software users while Granular (also Corteva) was at 9%. Note that, after the survey was conducted, Encirca was integrated into the Granular platform. FarmersEdge, headquartered in Winnipeg, MB, was used by 10% of software adopters. Interestingly, 24% of software users subscribed to a product not included in our survey. This implies a long tail in the farm data software market. Note that reported percentages represent usage among commercial corn and soybean operations that over-index for precision farming practices and, as a result, should not be interpreted as true market shares in the farm data software sector.

There was significant variation in product offerings across software platforms. John Deere Operations Center and Case IH AFS collect telematics and input application data from farm equipment but are capable of integrating other systems. FBN provides benchmarking input cost intelligence to its subscribers in the form of a "club good"—data within the FBN network is non-rival but access to the network is excludable. Other platforms such as FieldView and FarmersEdge provide agronomic insights to improve decision-making. Granular offers solutions for work-flow management. Most platforms offer multiple, sometimes overlapping, solutions making them difficult to classify easily. This may explain survey respondents' propensity to adopt multiple software products. Figure 3 shows that the vast majority of software subscribers in our sample (70%) used more than one product and the average software-adopting farm used between two and three products.

Though we did not ask the order in which farms adopted various technologies, we can get a sense of this by looking at the types of software used by farms that adopt multiple products. Figure 4 shows the types of platforms used by farms that adopted a single product and those that had two or more products. Of farms that used more than one type of ag-data software, nearly 70% used Climate FieldView and 53% used John Deere Operations Center. But among those that used only one software product, FieldView came in at less than 19% while Operations Center made up 28%, making Operations Center the most popular product among single-platform users.

These patterns imply that ag-data software products are adopted sequentially based on their complementary offerings. Each platform delivers farm data services that meet the needs of farms at different stages of the farm data pipeline. For example, John Deere Operations Center is primarily a data generation and transfer platform that integrates with multiple other ag-data products. Layering it with Climate FieldView—with its data analysis and prescription capabilities—represents the logical next step in data value discovery.

Conclusions

Farm data collection and use is very high among commercial scale corn and soybean farms. Ninety-three percent of the 800 farms surveyed, referred to as DCs, reported collecting at least one of three major data types: yield data, grid or zone sample data, and aerial or satellite imagery data. Comparing the small percentage of NDCs to DCs reveals that DCs were much more likely to use computer software in the management of their farms and to use a UAV. DCs were also more likely to use precision agriculture technologies such as variable rate seeding and variable rate fertilizer applications than NDCs.

We find that farm data software is popular among commercial scale farms in our sample. Over 40% used at least one software platform and among users, most (70%) subscribed to more than one product. Software adoption was related to farm and operator characteristics (farm size, operator age, and educational attainment). Notably, the relationship between education and software usage depends on operator age, signifying changes in educational attainment over time. It also suggests that the profile of "advanced" farmers may be changing.

The widespread practice of using more than one software product highlights the importance of inter-operability in precision farming and data usage. The types of software used together and individually suggests that farms adopt data generation and transfer systems such as John Deere Operations Center first, which they later integrate with software that provides prescriptive service

(e.g., Climate FieldView). The on-farm benefits that flow from data collection and use likely depend on how well these different tools communicate with one another.

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Figure 1. Farm Data Software Adoption by Age and Education

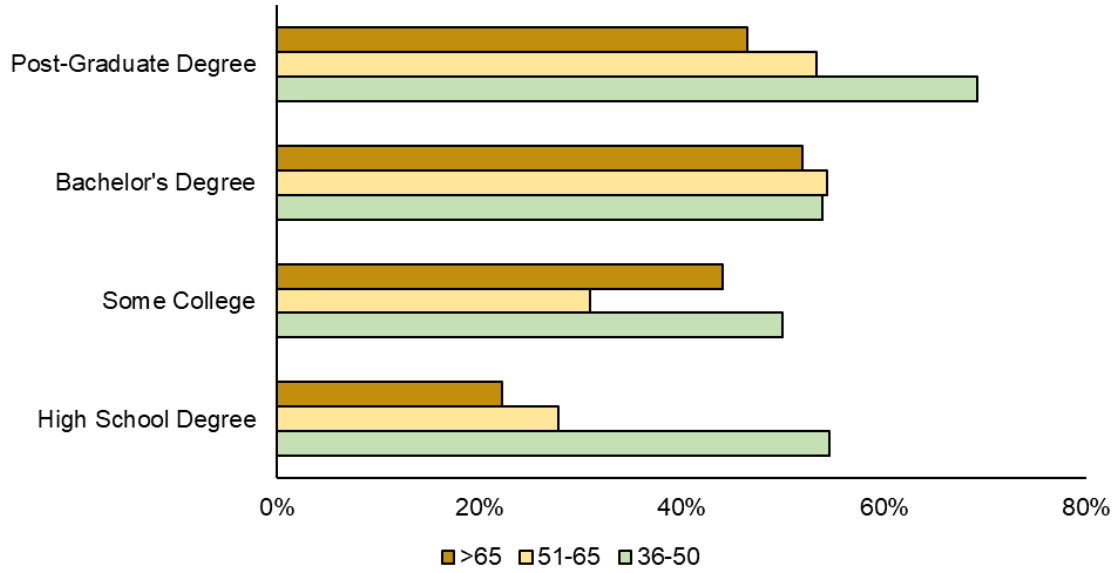

Figure 2. Farm Data Software Products Used by Software Users

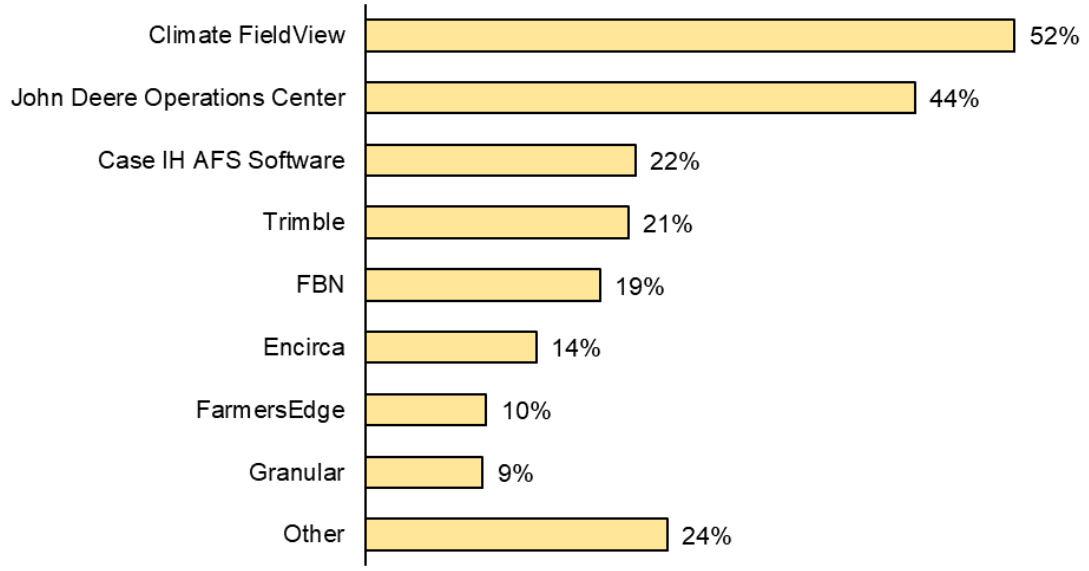

Figure 3. Number of Software Products Used by Farm Data Software Adopters

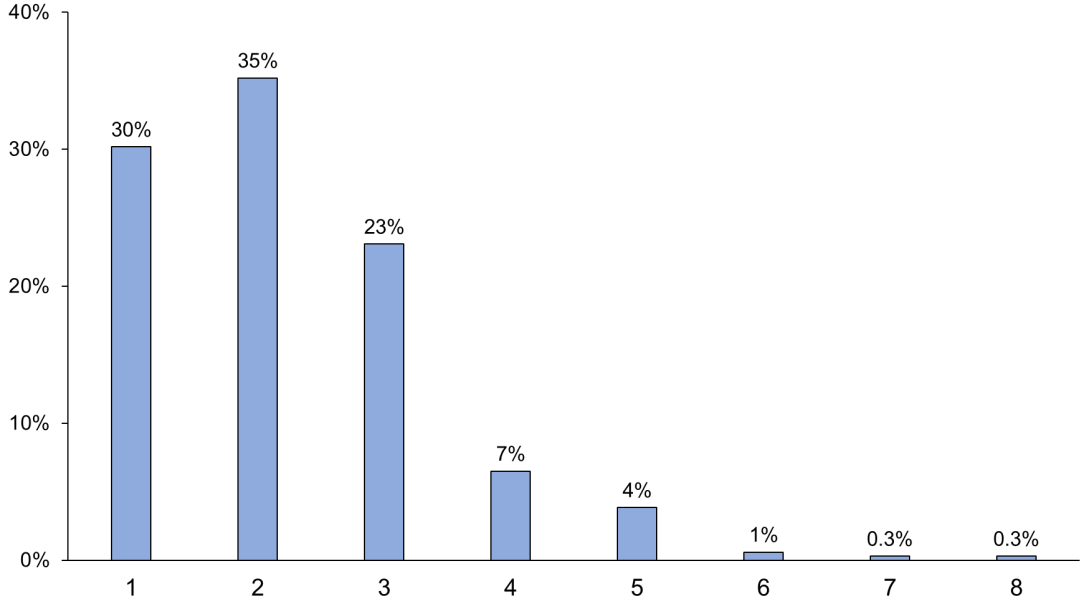

Figure 4. Farm Data Software Products by Number of Products Adopted

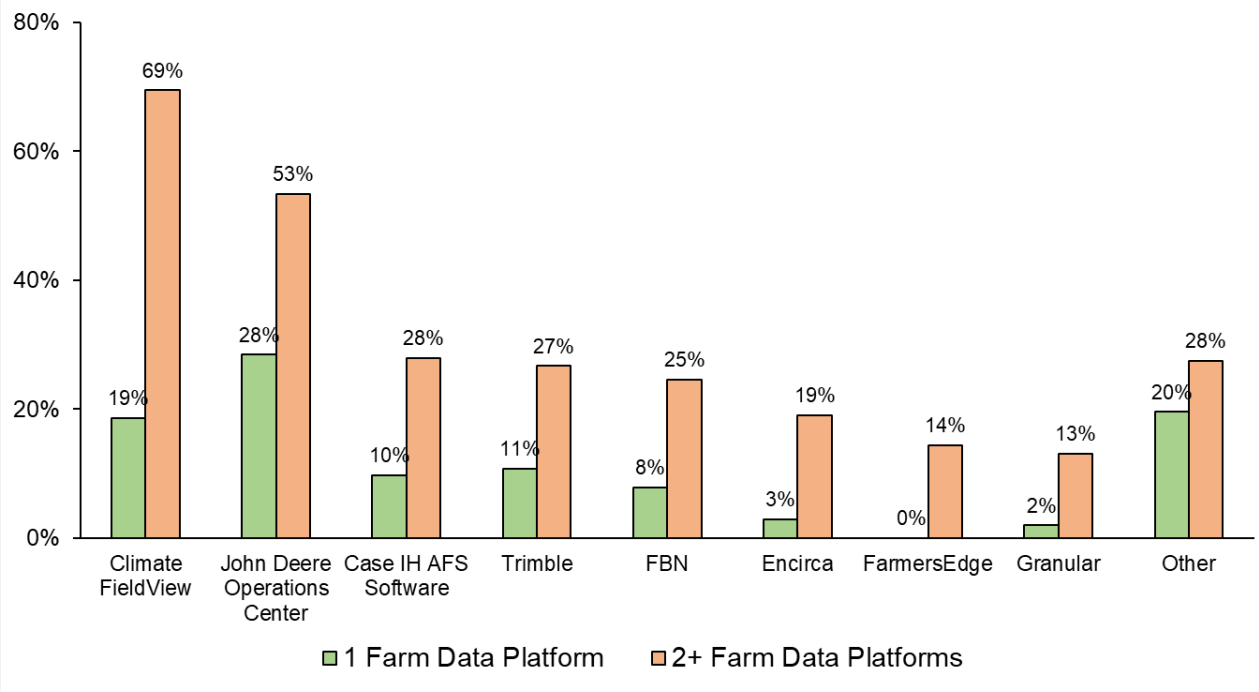

Table 1. Farm & Operator Demographics[a]	
	% of Survey Respondents
Farm size (total acres operated)	
1,000-1,999 acres	50%
2,000-4,999 acres	36%
5,000+ acres	15%
Farm owner/operator age	
<35 years	2%
36-50 years	17%
51-65 years	46%
>65 years	35%
Farm educational attainment[b]	
High school diploma	21%
Some college	30%
Bachelor's degree	40%
Post-graduate degree	9%
Notes: [a] Survey sample includes 800 corn and soybean farms with 1,000 acres or more in operation. [b] Highest level of educational attainment among all full-time employees of the farm, including owner/operators.	

Table 2. Precision Agriculture Adoption, Data Collection, and Sharing[a]	
	% of Survey Respondents
Precision agriculture adoption	
High-speed internet access	80%
GPS guidance/autosteer	92%
Variable rate seed application	59%
Variable rate fertilizer application	71%
UAV	26%
Farm data collection	
Yield monitor data	82%
Soil sample data	77%
UAV/SAT data	47%
Farm data analysis	
Spreadsheets (Microsoft Excel)	82%
Farm data software	77%
Designated data employee	47%
Notes: [a] Survey sample includes 800 corn and soybean farms with 1,000 acres or more in operation.	