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Abstract

Retail dealership survey data suggests that the lack of a qualified precision agriculture (PA) workforce limits the ability of the PA service industry to provide technological knowledge and services to producers who have adopted PA technology. The key empirical findings suggest that retail dealerships have the greatest difficulty finding workers who have, a) the capability to operate and collect data using specialized PA technology, b) the capability to interpret and develop management strategies using PA generated data, and c) a basic generalized competency in PA technology and its applications. The perceived shortage of skilled workers suggests that there is a need to expand the PA workforce with individuals who have knowledge, skills, and abilities (KSAs). A PA qualified workforce is necessary to provide support for the provision of PA services to current users of PA technology and new PA adopters.

Introduction

The role of labor in agriculture is a long-standing issue of interest to agricultural economists. One issue of consequence discussed in this literature is the linkage among technology innovation in agriculture, the adoption rate of technology, and workforce development (Lambert 2018). The issue of workforce development and labor skill competencies has been an area of research interest in the agricultural education literature (e.g., Colelasure 2020; Osman and Murdad 2020; Easterly et. al., 2017). These studies draw from the human capital literature as a theoretical framework for their empirical survey work using empirical methods like Delphi panels to elicit preferences from industry

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(Colelasure 2020). These studies focus on skill requirements and student characteristics that are in demand by employers of agricultural workers.

Workforce development to support the adoption of precision agriculture (PA) is a topic gaining greater attention within this literature. Kitchen et al. (2002) first raised the issue of PA workforce development. They argued that the PA adoption was encumbered by the lack of well-educated and trained workers in various PA technology areas. They stated that workforce development will be dependent on the number of educational institutions offering PA educational programing.

Erickson et al. (2018) conducted a workforce survey in 2015 of the PA retail services industry and asked dealership management to rank current and potential employees based on PA KSA categories.[5] Erickson et al. reported that survey respondents had a difficult time finding qualified PA workers. In 2017, Erickson et al. (2017) conducted a generalized PA custom services survey of retail dealerships. In this survey, 62% of respondents in 2017 indicate that there is a lack of qualified PA workers (Erickson et al. p.22: figure 28). This represents an increase of 15% in two years. Additionally, 40% of respondents reported that the cost of PA labor was too high and made offering PA retail services unprofitable. This response category was 28% in 2015 (Erickson et al. p.22: figure 27). The reported findings of the two Erickson surveys indicate the retail dealership industry faces a persistent labor issue.

Fausti et. al. (2018) conducted a survey of educational institutions in 2015. The survey focused on PA curriculum, collecting information on PA classes, certificates, or degrees offered by institutions. Fausti et al. (2018) compared the educator survey results to Erickson's 2015 PA workforce survey of the PA custom services industry. Data from the two surveys indicated that there is a divergence between what educators see as a high priority in PA training programs, as compared to the essential KSA training expected by firms in the custom services industry. From this study, one can conclude that there is a potential divergence in educator perceptions versus workforce realities. The Fausti et al. study provides a partial explanation for the shortage of skilled PA labor reported by Erickson et. al. (2017 and 2018).

Lowenberg-DeBoer and Erickson (2019; p. 1554) look at the PA adoption debate in the PA literature, commenting that the literature has not been "particularly useful in explaining or predicting national or regional PA adoption trends." Within this adoption literature, Fausti et. al. (2021), argues that the adoption issue is partially a function, or lack, of PA workforce development. Fausti et al. suggest that the failure to explain regional or national trends in PA adoption is linked to the variability in workforce development at the local and regional level.

The data collected from the 2015 workforce survey of PA retail dealerships (Erickson et al. 2018) were acquired. The data provide a unique opportunity to: a) identify specific KSA skill areas that survey respondents associate with inadequately trained PA workers; b) identify the relationship between retailer perception concerning the difficultly of hiring qualified PA workers and retailer perception of worker knowledge of PA technology and applications; and c) determine if county-level

[5] Erickson et. al. (2018), outlines the concept of expertise in precision agriculture, and defines expertise as *Knowledge, Skills, and Abilities* (KSA) applicable to PA technology to agricultural production.

farm size (economies of scale proxy) is linked to workforce development (labor availability and quality) issues facing the retail dealership industry.

Precision Agriculture Retail Dealership Survey Instrument and Data

Erickson et al. (2018) developed a survey instrument to elicit the perceptions of PA retail dealerships on the quality of educational training in local PA labor pools of skilled workers for which PA retail dealerships were competing. The survey subject pool was drawn from email lists provided by CropLife magazine, a publication of Meister Media, and the Certified Crop Adviser program. The questionnaire was emailed during the summer of 2015. Erickson et al. (2018: p.6) indicated that the contact list contained approximately 10,000 email addresses. They did raise one caveat concerning the nature of the organizations providing the email lists: "likely more reflective of crop protection, seed, and fertilizer retailers and consultants as opposed to others that may be offering precision services such as farm equipment dealers, farmers, or farm managers." Erickson et al. reported a total of 172 usable responses.[6]

The Erickson et al. (2018) survey collected data on PA occupation categories and on KSA categories. Erickson et al. identify the following occupational categories for PA service workers; 1) Equipment Operator, 2) Agronomist, 3) Precision Equipment Technician, 4) Technical Support, and 5) Precision Sales Specialist. The following ten PA KSA categories were identified: 1) Ability to make effective agronomy recommendations; 2) General knowledge of PA technology; 3) Ability to produce accurate digital maps of fields using spatial information within specialized software; 4) Ability to operate PA equipment (monitors, controllers, etc.); 5) Ability to install and repair PA hardware and equipment, including calibration and troubleshooting; 6) Operational knowledge of computer spreadsheet applications to record and analyze agricultural field data; 7) Effective written and verbal communication skills within PA activities; 8) Working understanding of statistical standards to produce means and standard deviations; 9) Operational knowledge of basic business and accounting principles; and 10) Operational knowledge of PA software (database query, interface, and mapping).

Survey Data and Data Transformation

Retail dealership survey and data were provided by Erickson et al. (2018) to the authors. Subject responses for the following retail dealership survey questions were selected for discussion and analysis: a) Q1-zipcode identifying respondent location; b) Q7-level of difficulty finding qualified applicants for PA positions by occupational category; c) Q8- dealership ranking of PA knowledge of interviewees (past two years) across all ten KSA areas; and d) Q9-dealership ranking of importance of specific KSA areas across occupational categories for open positions in their firm.

Survey questions 7, 8, and 9 are Likert Scale qualitative responses. Boone and Boone (2012) provide a discussion on how to evaluate Likert vs. Likert-type question formats. According to Boone and Boone (p. 2) "A Likert Scale… is composed of a series of four or more Likert-type items that are combined into a single composite score/variable during the data analysis process. Combined, the items are used to provide a quantitative measure of a characteristic or personality trait." Survey

[6] The survey referenced is a unique workforce survey conducted using the CropLife database. Traditionally, CropLife surveys focus on PA technologies being offered by the retail dealership industry. Boehlje and Langemeier (2021) provide a discussion of CropLife survey data. The usual caveats apply (Smith, 1983) to a non-stratified non-random sampling procedure (e.g., self-selection bias by respondents, non-representative sample of institutions selected for the survey).

questions 7, 8, and 9 are each aggregated into a single composite variable in a manner consistent with the recommendation of Boone and Boone.

Question 7 provides the data on the question being addressed in this paper (Is there a shortage of qualified PA labor?). The data are represented by the variable PALABOR, and the variable reflects dealership responses to question 7. The subject's Likert Scale response for each occupational category were summed. The difficulty of finding qualified PA workers ranked from 1 = no shortage to 5 = no qualified workers in the local labor pool (area). This Likert Index has a range from 5 (no labor shortage across the five occupational categories) to 25 (no qualified PA workers averaged across the five occupational categories).

In the case of question 8, an index of KSA general competencies is constructed by aggregating retail dealer Likert Scale rankings of the ten PA KSAs for interviewees applying for PA positions in the prior two years and is labeled KSAGEN. Question 8 rankings range from 1 to 4. The KSA qualified PA workers ranked from 1 = deficient KSA knowledge, to 4 = highly qualified KSA workers in the local labor pool (area). Therefore, the Likert Index ranges from 10 to 40. An index value of 10 indicates that the applicant's level of PA knowledge is deficient. A ranking of 40 indicates a high level of knowledge across all 10 KSA areas. It is hypothesized that the Likert Scale Index for Q8 will have an inverse relationship with the Likert Scale Index for Question 7. The higher a dealership ranks interviewees on KSA qualifications, the less difficult it is for that dealership to find qualified PA workers.

Question 9 asks retail dealerships to place a ranking of 1 (least important) to 3 (most important) for each KSA by each occupational category when the dealership is screening new employees for PA positions. As a result of how the question is structured, a Likert Scale KSA index is constructed for each KSA across occupation category. Each KSA index has a range of 5 to 15 and is a quantitative measure of the retail dealership's view on the importance of an interviewee's level of competency for each KSA area.[7] An index value of 5 indicates that for a particular KSA category across the five occupational areas, this KSA competency is not important. An index value of 15 indicates that this particular KSA-specific competency is the most important (averaged across the five occupational categories). It is hypothesized that the ten KSA Likert Scale Index variables (KSA1 to KSA10) which are constructed from Q9 will have a positive relationship with the Likert Scale Index for Question 7. These hypothesized relationships are based on the PA labor force literature supposition that the lack of KSA training has resulted in a lack of qualified PA workers in local labor markets.

Non-Survey Data

The research team collected USDA data on county-level economic variables that are hypothesized to affect the demand for PA services in the county where the retail dealership resides (USDA 2017).[8] To capture these local influences on PA adoption and thus, the derived demand for PA labor by retail dealerships who serve local farmers, the selected county variables are the difference between the

[7] In the Erickson et al. (2018) manuscript, a copy of the survey instrument is provided. Respondents answered question 9 as 1=most important, and 3=least important. For this study, the rankings are reversed from the original instrument: 1=least important and 3=most important.

[8] It is assumed that county-level median and average farm acreage statistics did not change significantly from 2015 when the Retail dealership survey was conducted and the reported values for those variables in the 2017 Ag Census.

average farm acreage minus the median farm acreage (Skew) in the county where the retail dealership resides. The second proxy variable is average farm sales (Avgsales). Avgsales is defined as total farm sales in a county divided by the total number of farms in the county. They are a proxy for skewness with respect to farm size in a county.[9] It is hypothesized that these proxy variables will capture the relationship between county-level economies of scale of agricultural operations and retail dealership views of PA labor issues. Schimmelpfennig (2016) provides empirical evidence that indicates a positive relationship between farm size and PA adoption rates.

Positive skewness indicates large-scale farming operations dominate agricultural production in the county where the dealership is located. Negative skewness indicates small-scale farming operations dominate agricultural production in the county. Given the empirical evidence provided in the literature on the relationship between farm size and adoption rates (e.g., Schimmelpfennig 2016), the demand for custom PA services will be higher in counties dominated by large farming operations. Schimmelpfennig and Ebel (2016) report that producers who adopt multiple PA technologies tend to operate larger farms and incorporate other modern technologies such as GMO seed and soil testing. This suggests PA custom service firms providing PA services to sophisticated PA adopters require a high-quality workforce. Based on this discussion, it is hypothesized that county-level scale economies are associated with PA retail dealership perceptions of PA labor availability and quality.

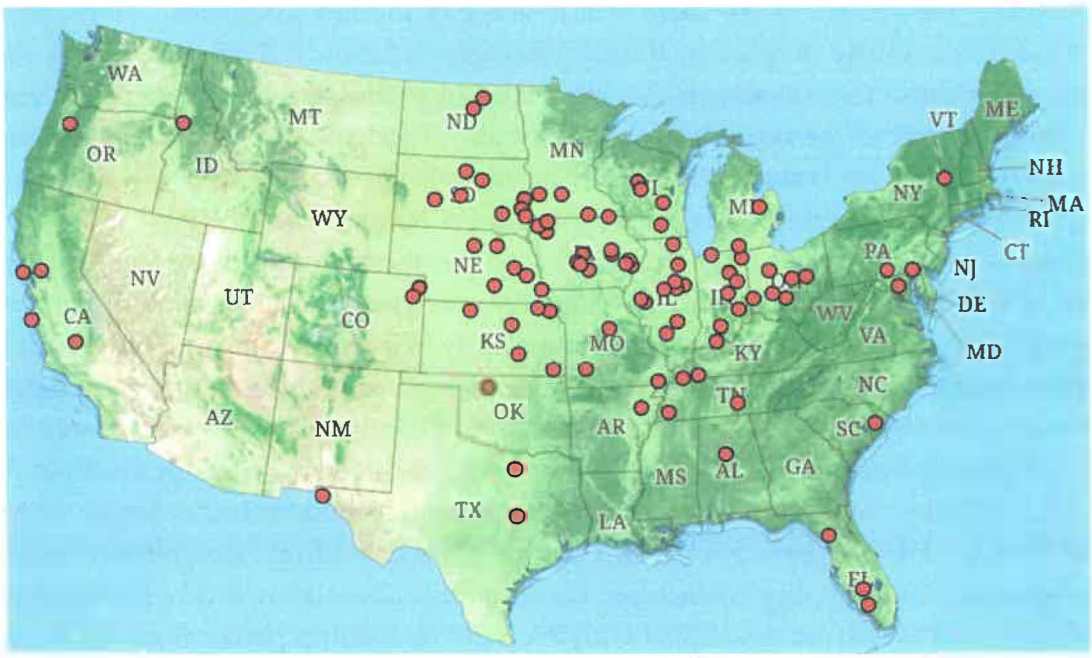
Data Source and Scope

Complete survey responses across ten KSA's queries for question 9 varied between 64 and 66 observations. Complete responses for question 7 totaled 102, and question 8 totaled 96. The Skewness questions totaled 101. As a result of incomplete subject responses to questions, the data set used in the empirical analysis discussed below contains various total observations for questions used in the correlation analysis. Figure 1 provides a graphical depiction of the 102 observation locations that are identified by zip code (survey data).

Empirical Methodology and Results

The Likert Indices data are ordinal. Therefore, Spearman Correlation Analysis (Newbold et al. 2013) was selected to evaluate the statistical associations between PALABOR, KSAGEN, SKEW, and the ten KSA variables constructed from question 9 in the survey. Spearman Correlation estimates for PALABOR, KSAGEN, SKEW, and KSA2, KSA3, KSA4, KSA6, and KSA8 are reported in Table 1. Please note that correlation does not imply causation.

[9] A common empirical measure for skewness (defined as the 3rd moment of the probability density function) is the Pearson's second skewness coefficient (median skewness) or Pearson 2 measure of skewness (Doane and Seward 2011). It is defined as: $\mathbf{3} * \frac{mean-median}{Std.Deviation}$. It is assumed here that the mean minus the median provides a rough measure of the distribution of acres operated in a county and relative farm size. Data on the standard deviation are not available. It is assumed that farm sales are positively correlated to farm size and farm size is correlated with scale economies. A positive skewness proxy value implies that large farms dominate acres operated in a county. We view this as an indication of an economies of scale effect that is affecting the distribution of acres operated in a county by farm size.



Statistical Results[10]

Correlation analyses (Table 1) indicate a negative association between PALABOR and KSAGEN.[11] The negative statistical association indicates a retailer dealership finds it more difficult to find qualified PA applicants as the level of retail dealer assessed KSA knowledge of interviewees declines. This implies that the lack of trained PA labor is contributing to the PA labor shortage. The statistical association between SKEW and Avgsale with PALABOR is negative, and the statistical association between KSAGEN and Avgsale is positive. This suggests that as county's average scale economies increases, local PA dealerships have less difficulty finding qualified PA workers. This is an interesting correlation. It implies that dealerships with farming operations with smaller scale economies in their county will have greater difficulty finding qualified PA workers. For those dealerships, their customer base would contain a higher proportion of small farms relative to dealerships in counties with greater scale economies.

Given the literature discussion, economies of scale appear to be a factor associated with PA labor supply (Fausti et al. 2021). This implies custom service firms operating in counties with a preponderance of small and medium-sized farms will have a greater difficulty providing PA services, and this would have a negative effect on PA adoption rates in those counties. This discussion provides a plausible explanation for the Lowenberg-DeBoer and Erickson (2019) query concerning the lack of trend in the PA adoption data. PA labor supply is positively associated with average scale

[10] Regression analysis was initially selected as the statistical tool for data analysis. However, during the regression diagnostic evaluation of regression models, endogeneity was found to be an issue for models containing PALABOR, KSAGEN, and KSA2. A search for appropriate instrument variables to resolve the problem was unsuccessful.

[11] The caveat of the non-random sampling selection process used in the retail dealership survey may be subject to self-selection bias and implies that the results of the empirical findings are valid for the sample only. The data are non-normal and so Spearman Correlation analysis was used (Newbold et. al. 2013).

economies, and it appears that average scale economies play a role in determining county or regional adoption rates.

The KSA variable KSA2 provides a ranking of the importance a dealership places on the level of "Knowledge of Precision Agriculture Technology" for potential new employees averaged across all five occupation areas. KSA2 is positively correlated with Avgsale, KSAGEN, and SKEW (Table 1). Scale economies appear to be associated with a dealership's desire for new employees to have a strong general knowledge base of PA technology in counties with greater scale economies relative to counties with lesser scale economies. The positive statistical association between KSAGEN and KSA2 suggests that those dealerships which value a high level of general PA knowledge will rate those interviewees higher with respect to their level of overall KSA training. This suggests that PA educational curriculum needs to provide students with a comprehensive general education course in PA application and technology that is scaffolded into more advanced PA courses.

The last issue to be addressed is how dealerships view the importance of a specific PA knowledge (KSA) area for potential new employees in the context of the dealership's view on the level of difficulty of finding qualified PA workers to hire. Correlation analysis finds that four KSAs (3, 4, 6, and 8) are statistically significant and positively correlated to PALABOR (Table 1). This suggests the higher the ranked importance of these four KSA areas, the more difficult retail dealerships perceive hiring qualified PA workers.

KSA areas 3 and 4 involve using specialized PA equipment and providing production management information upon which PA management decisions will be based. KSA areas 6 and 8 denote the skill set necessary to interpret and apply the information generated by KSA areas 3 and 4. The empirical results suggest that key focus areas of PA education initiatives should be on the development of curriculum which directly support KSA areas 3, 4, 6, and 8. These conclusions, based on correlation analysis, are consistent with the discussion provided by Erickson et al. (2018). One final comment on KSA 8, correlation analysis indicates a negative association with SKEW and Avgsale. This suggests dealerships located in counties lacking scale economies have a greater need for workers with statistical skills.

Conclusion

Non-random survey data was used to empirically test whether there is evidence to support the supposition that PA workforce constraints are associated with the ability of the retail services industry to supply PA custom services. Preliminary empirical evidence presented implies that a lack of KSA training in the specific skill areas is perceived as an issue by the PA retail services industry. These KSA areas include the ability to operate PA equipment, generate PA map and data output, analyze PA data, and interpret statistical PA output. These particular skills are associated with the perception held by custom service operators as areas where there is a lack of qualified PA labor needed to meet the labor requirements of the industry.

The key findings suggest that retail dealerships have the greatest difficulty finding workers who have the following KSA skills: a) the capability to operate and collect data using specialized PA technology; b) the capability to interpret and develop management strategies using PA-generated data; and c) a basic generalized competency in PA technology and its applications. These are the PA educational curriculum areas the retail dealership industry associates with their perception that there is a lack of skilled PA workers in local labor pools. We suggest that PA educational curriculum needs

to provide students with a comprehensive general education course in PA application and technology that is scaffolded into the more advanced PA courses which focus on the application of PA technology and how the information from applications is integrated into a farmer's production management plan.

Also note that empirical evidence suggests that farm size within a marketing area (county) where the retail dealership resides is associated with the dealership's access to qualified labor. This suggests that those dealerships which reside in counties with greater scale economies have less difficulty finding skilled PA workers. This implies that in counties where small and medium-sized farms represent the majority of farm type, producers may have greater difficulty finding PA custom services to act as a guide during the PA adoption process.

To answer the question inferred by the title of the paper, "Is the Custom Service Industry's Role in Precision Agriculture Linked to Workforce Development?", survey results suggest the availability of qualified PA workers is a constraint on the PA retail dealership industry's ability to provide PA services to current and potential adopters of PA technology. The literature suggests that the current structure of PA education in the United States is a contributing factor to that constraint.

Table 1: Spearman Correlation Analysis				
	PALabor	KSAGEN	Avgsales	Skew
PALabor	1.00	-0.34	-0.17	-0.17
P-Value	NA	0.00	0.08	0.09
OBS. #	102.00	96.00	101.00	101.00
KSAGEN	-0.34	1.00	0.23	0.11
P-Value	0.00	NA	0.03	0.30
OBS. #	96.00	96.00	95.00	95.00
Avgsale	-0.17	0.23	1.00	0.52
P-Value	0.08	0.03	NA	0.01
OBS. #	101.00	95.00	101.00	101.00
Skew	-0.17	0.11	0.52	1.00
P-Value	0.09	0.30	0.01	NA
OBS. #	101.00	95.00	101.00	101.00
ksa2	-0.10	0.27	0.29	0.21
P-Value	0.42	0.03	0.02	0.09
OBS. #	66.00	64.00	66.00	66.00
ksa3	0.27	-0.01	-0.10	-0.19
P-Value	0.03	0.91	0.45	0.13
OBS. #	66.00	64.00	66.00	66.00
ksa4	0.22	0.06	0.01	0.05
P-Value	0.08	0.64	0.91	0.69
OBS. #	66.00	64.00	66.00	66.00
ksa6	0.24	0.18	-0.03	-0.06
P-Value	0.05	0.16	0.82	0.63
OBS. #	66.00	64.00	66.00	66.00
ksa8	0.25	0.00	-0.30	-0.26
P-Value	0.04	0.99	0.02	0.04
OBS. #	66.00	64.00	66.00	66.00

References

Boehlje, M. and M. Langemeier. 2021. "Adoption of Precision Agriculture Technologies." *farmdoc daily* (11):47, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.

Boone, H. N. and D. A. Boone. 2012. "Analyzing Likert data." *Journal of Extension* 50(2): 1-5.

Colelasure, B. 2020. "Entry-Level Workplace Competencies Needed by Graduates of a Community College Agriculture Program: A Midwest Case Study Using the Delphi Technique." *Journal of Research in Technical Careers*, *4*(2), 3.

Doane, D. P., and L.E. Seward. 2011. "Measuring skewness: a forgotten statistic?." *Journal of statistics education* 19(2).

Easterly III, R. G., Warner, A. J., Myers, B. E., Lamm, A. J., & Telg, R. W. 2017. "Skills Students Need in the Real World: Competencies Desired by Agricultural and Natural Resources Industry Leaders." *Journal of Agricultural Education*, *58*(4), 225-239.

Erickson, B., J. Lowenberg-DeBoer and J. Bradford. 2017. "*2017 precision agriculture services dealership survey.*" Dept. of Agricultural Economics and Agronomy, Purdue University, Lafayette, Indiana." https://ag.purdue.edu/digital-ag-resources/wp-content/uploads/2019/11/CropLife-Purdue-2017-Precision-Dealer-Survey-Report.pdf. [Accessed March. 2, 2021].

Erickson, B., S. Fausti, D. Clay and S. Clay. 2018. "Knowledge, Skills, and Abilities in the Precision Agriculture Workforce: An Industry Survey." *Natural Sciences Education* 47(1): 1-11.

Fausti, S. W., B. Erickson, S. Clay, L. Schumacher, D. Clay and D. Skouby. 2018. "Educator survey: Do institutions provide the precision agriculture education needed by agribusiness?" *Journal of Agribusiness* 36(1): 41-63.

Fausti, S. W., B. Erickson, S. Clay, and D. Clay 2021. "The Custom Service Industry's Role in Precision Agriculture Adoption: A Literature Review." Forthcoming *Western Economic Forum.*

Kitchen, N. R., C.J. Snyder, D.W. Franzen and W.J. Wiebold. 2002. "Educational needs of precision agriculture." *Precision Agriculture* 3(4): 341-351.

Lambert, D. K. 2018. "Workforce education and technical change bias in US agriculture and related industries." *American Journal of Agricultural Economics*, *100*(1), 338-353.

Lowenberg-DeBoer, J., and B. Erickson. 2019. "Setting the record straight on precision agriculture adoption." *Agronomy Journal* (11):1552-1569. doi:10.2134/agronj2018.12.0779

Newbold, P., W.L Carlson and B. Thorne. 2013. *Statistics for business and economics*. Boston, MA: Pearson.

Osman, W. H., & Murdad, R. 2020. "Graduate Employability in Sabah's Agriculture Sector: Perception and Expectation of Employers and Graduates." *PalArch's Journal of Archaeology of Egypt/Egyptology*, *17*(6), 10747-10767.

Schimmelpfennig, D., 2016. "Farm profits and adoption of precision agriculture." ERR-217, U.S. Department of Agriculture, Economic Research Service, (No. 1477-2016-121190).

Schimmelpfennig, D., and R. Ebel. 2016. "Sequential adoption and cost savings from precision agriculture." Journal of Agricultural and Resource Economics (41): 97-115.

Smith, T. M. F. 1983. "On the validity of inferences from non-random samples." *Journal of the Royal Statistical Society: Series A (General)*, *146*(4), 394-403.

USDA National Agricultural Statistics Service. 2017. Census of Agriculture. Complete data available at www.nass.usda.gov/AgCensus. [Accessed Jan. 15, 2021].