Interacting with the Next Wave of Farm Operators: Digital Agriculture and Potential Financial Implications

By Terry W. Griffin, LaVona S. Traywick, and Elizabeth A. Yeager

Digital agriculture and the utilization of technology on the farm has garnered increased attention in recent years. Farmers, lenders, advisors, and researchers frequently ask whether additional technology can increase productivity and the resulting profitability of the farm operation, and lenders and marketers ask whether they should focus on the demographics of their customers differently—considering, for example, how different generations respond to or adopt new technology. This paper looks at the adoption of various precision agriculture technologies by Kansas farms and breaks the adoption down by sole proprietor and multiple-operator farms. We find that adoption indeed varies across generations as well as by generation mix for multiple-generation farms. We also predict that the current younger generation will control the majority of farm operations at an older age than previous generations.

The economics of digital agriculture have been evaluated since the advent of global navigation satellite systems (GNSS), but the consensus has been that the economics are site-specific—analogous to a high-tech version of "it depends" (Griffin and others 2004; Lowenberg-DeBoer and Swinton 2015). The profitability of precision agriculture, including reduced input usage, has been reported at the national level based on

Terry W. Griffin is an associate professor and cropping systems economist in the Department of Agricultural Economics at Kansas State University. LaVona S. Traywick is associate professor of physical therapy at Arkansas Colleges of Health Education. Elizabeth A. Yeager is an associate professor and Director of Undergraduate Programs in the Department of Agricultural Economics at Kansas State University. The authors appreciate Kansas Farm Management Association economists and member farms for supporting the applied research, and Extension programs within the Department of Agricultural Economics at Kansas State University, including informal discussions with Kevin Herbel and Mark Dikeman. The views expressed are those of the authors and do not necessarily reflect the positions of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

data from the U.S. Department of Agriculture (USDA) Agricultural Resource Management Survey (Schimmelpfennig and Ebel 2016; Schimmelpfennig and Lowenberg-DeBoer 2020; Schimmelpfennig 2016, 2018). In their study of farmers' adoption of precision agriculture technologies, Ofori, Griffin, and Yeager (2020) report that the farm debt-to-asset ratio was an important factor in predicting farms' adoption of technology, and that younger, more profitable farmers were more likely to make capital investments for digital agricultural technologies. Generation, or birth year, of farm operators was also important in describing the adoption path of technology, emphasizing that younger farmers tend to favor technology. Younger operators were also more likely to embrace farm data, such as yield monitor data and soil maps, as an intangible resource (Ofori, Griffin, and Yeager 2020).

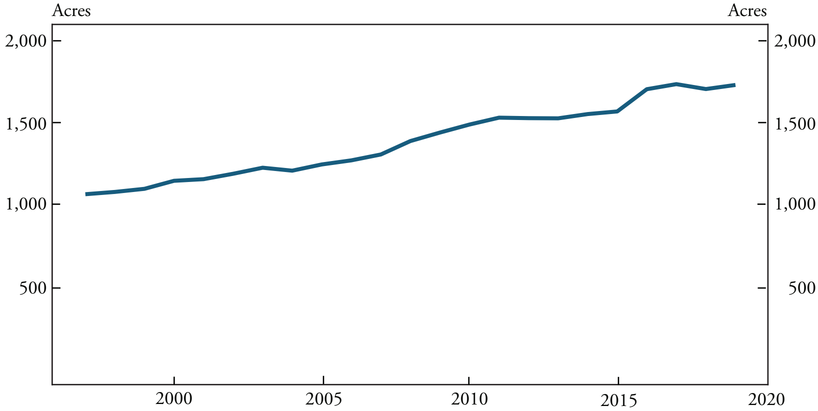
Numerous studies have shown that the utilization of precision agriculture technology can increase productivity and profitability. The presence of yield maps and soil maps has been shown to increase technical efficiency marginal effects by 1.1 to 7.2 percent and 0.4 to 2.3 percent, respectively (McFadden 2017). Yield monitors with variable rate technology have been associated with a 4 percent reduction in fertilizer costs (Schimmelpfennig 2018). Farms fully utilizing automated guidance could increase farm size from 3,000 to 3,335 acres using the same equipment and still complete field operations in a timely manner, thus reducing fixed per-acre equipment expenses (Griffin, Lowenberg-DeBoer, and Lambert 2005). Adopters of soil testing with variable rate application had 33 percent higher nitrogen productivity than non-adopters on below-average soils (Khanna 2001). It is generally expected that data-endowed farmland will command higher rental rates once the "Big Data" system in agriculture is operational (Griffin and others 2016). Researchers predict similar relationships for farmland with adequate wireless broadband connectivity.

The profitability of farm data has been relatively more elusive to quantify than the digital technology generating that farm data (Coble and others 2018). Network externalities (the demand for a good or service being a function of the number of users of that good or service) complicate the valuation of farm data, especially when considering perspectives of only one agent—for example, farmer, data platform, or society (Griffin and others 2016). Farm data valuation is further complicated by ownership, access, and permissions to control, share, and access data arising from digital agriculture technologies (Ellixson and others 2019). Although a market for farm data has yet to develop, utilization of farm data by the agricultural industry is not likely to be a temporary phenomenon but an enduring segment of how farmers interact with suppliers, customers, and peers (Griffin and others 2016; Ferrell and Griffin 2018). The complexities of farm data valuation isolated for use by the farmer within the farm gate, as opposed to within an aggregated community for use by other agents in the agricultural community, remain a problem to be solved (Ferrell and Griffin 2018). Similar to digital technology, farm data favor larger-acreage farms that can spread out associated fixed costs.

Long-term trends indicate that the consolidation of farm acreage will likely continue, and the additional acreage requires farmers to either devote more labor hours, or human capital, to working the land or adopt technologies to decrease the workload. Decades of evidence suggest nearly constant acreages of farmland are being managed by fewer operators each year (MacDonald and others 2018). Average acreage on midwestern Corn Belt farms was relatively stable until the 1950s, when consolidation began to occur presumably in conjunction with the mechanization of row crop agriculture (Hart 2003). The total number of farm operations in the United States fell from nearly 7 million in 1940 to 2 million in 1980 (MacDonald and others 2018). Farm consolidation has been documented with each USDA Census of Agriculture since 1982. Lin and others (1980) forecast that the consolidation of farms and acreage being controlled by fewer farm operators would continue for the foreseeable future. Over the last 20 years, average crop acreage on Kansas farms has steadily increased from 1,100 acres to over 1,700 acres (Chart 1).

The adoption of labor-saving technologies has contributed to consolidation (MacDonald and others 2018). Digital agricultural technology may not only favor larger-acreage farms due to the fixed costs of adoption but may be most beneficial for farm operators prepared to add new tracts of farmland to their existing acreage (Hart 2003). Skilled operators willing to devote human capital are more likely to expand their operations by utilizing technology (Langemeier and Shockley 2019).

Chart 1
Average Crop Acreage of Kansas Farm Management Association Member Farms



Source: Kansas Farm Management Association.

Full utilization of digital agricultural technologies and farm data are not simply a matter of farm-level adoption decisions. One leading barrier to realizing the benefits of digital agriculture is the lack of sufficient wireless broadband connectivity, especially in regions where agricultural commodities are produced (Whitacre, Mark, and Griffin 2014). In addition to the policy implications for connecting rural schools, hospitals, libraries, and residences, substantial market pressures exist for farm equipment to be wirelessly connected via the "internet of things" (Köksal and Tekinerdogan 2019). Farmland without adequate wireless connectivity may suffer lower land values and rental rates due to operators not being able to fully enjoy telematics capabilities.

In addition to highlighting that the economics of digital agriculture are site-specific, the proportion of cohort farms' acreage and local wireless connectivity are important determinants used in farm data valuation. Wirelessly connecting to mobile devices empowers farm operators to take more control of digital agriculture and participate in networks of farm-data utilization. Although the aforementioned digital technologies were developed before the advent of modern smartphones, connected devices have increasingly facilitated digital agriculture within and beyond the farm gate due to ever-increasing capabilities and flexibility. The United Soybean Board (2019) reports that nine in 10 farm operators use smartphones. At the American Farm Bureau Federation's 2020 Annual Convention, 86.5 percent of participants reported connected technologies with applications (mobile apps) as essential. By 2018, 70 percent of farmers had downloaded agricultural apps to their smartphones (Farm Journal 2018). The Purdue/CropLife survey of agricultural service providers reports the increased prevalence of telematic utilization by service provider, from a low of 7 percent in 2011 to 37 percent by 2020 (Erickson and Lowenberg-DeBoer 2020). How will the agricultural industry interact with, market to, and service wirelessly connected farm operators in the next generation? To contribute to this discussion, we evaluate the demographics of Kansas farmers with respect to their technology adoption.

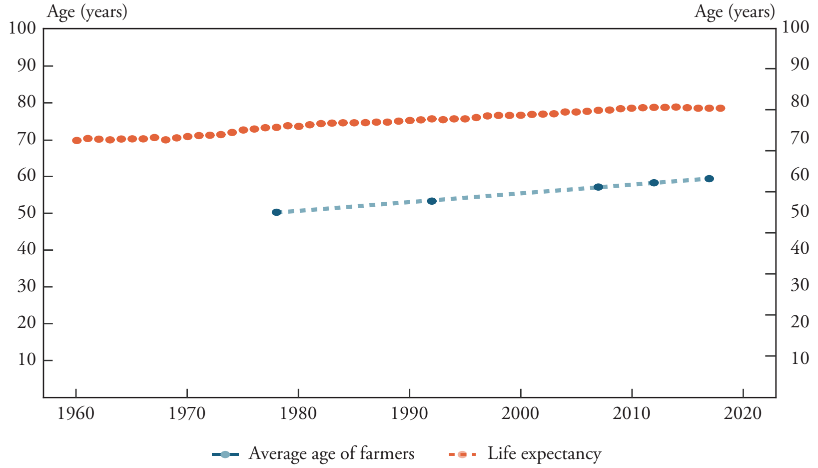
I. Farm Demographic Data and Analysis

Information on farmers' age and experience has long been of interest to the agricultural community. The USDA National Agricultural Statistics Service (NASS) Census of Agriculture reports the average age of farmers every five years. The most recent nationwide statistics report the average age of farmers as 57.5 in 2017, up by 1.2 years from 2012 (USDA 2019). The average age of farmers reported by NASS has consistently increased at similar rates for several decades (Chart 2). The annual increase in average age of farmers reasonably parallels life expectancy.

With respect to technology adoption and utilization, the age and experience (measured in number of years farming) of farm operators have been the focus of marketing efforts by manufacturers and educational programming by the Land Grant University System. Data from the Kansas Farm Management Association (KFMA) were analyzed to provide detailed insights into age and experience as related to digital agriculture technology adoption. The KFMA maintains databases of financial, production, and technology data for farmer members in Kansas. The KFMA data provide the opportunity for detailed analyses of age and experience as related to the adoption of digital agriculture technology. Since 2015, KFMA economists have collected and annually updated technology utilization (Ofori, Griffin, and Yeager 2020).

Chart 2

Life Expectancy for General U.S. Population versus Average Age of Farmers



Sources: World Bank and USDA Census of Agriculture.

Current farm operator demographics and summary statistics of technology adoption

We applied generational attributes as defined by the Pew Research Service to the KFMA data (Dimock 2019). Birth year ranges and proportion of KFMA farms in single-operator sole proprietorship and multiple-operator farms are presented in Table 1. The generational proportions were similar for sole proprietors and multiple-operator farms. Nearly half of farmers on multiple-operator farms and sole proprietors were Baby Boomers (48.5 percent and 51.2 percent, respectively). In 2018, Millennials were 11.8 percent of multiple operators and 9.8 percent of sole proprietors. The Silent Generation and Generation X were similar to each other at 18 to 21 percent for both categories.

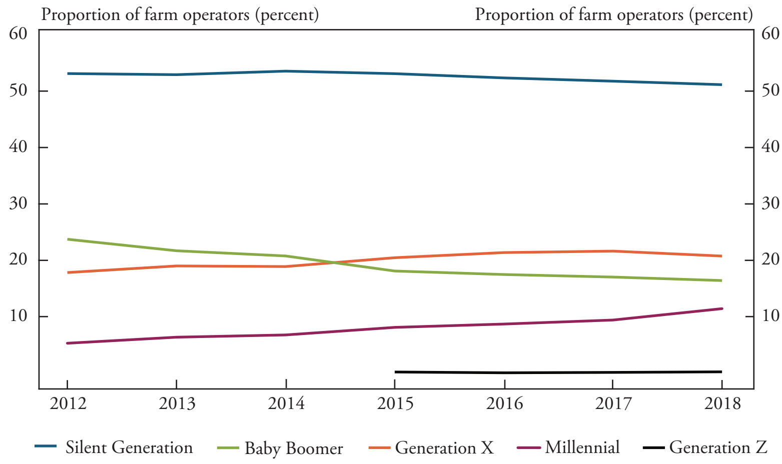
Assuming the linear trend lines presented in Chart 3 persist into the future, Silent Generation operators will have exited management of farms by 2029, when their youngest member will be 84 years old. One-third of farm operators are expected to be Millennials by 2041, when these operators will be 45 to 60 years old. As farm operators age, the agricultural industry must learn to market products and services to middle-age Millennials and Generation Z rather than Baby Boomers and Generation X (Griffin and Traywick, forthcoming).

Table 1
Kansas Farm Operators across Generations in 2018

Generation	Birth year	Multiple operators (percent)	Single operator (percent)
Silent Generation	Before 1945	18.2	20.4
Baby Boomer	1946–64	48.5	51.2
Generation X	1965–80	21.2	18.3
Millennial	1981–96	11.8	9.8

Source: Kansas Farm Management Association.

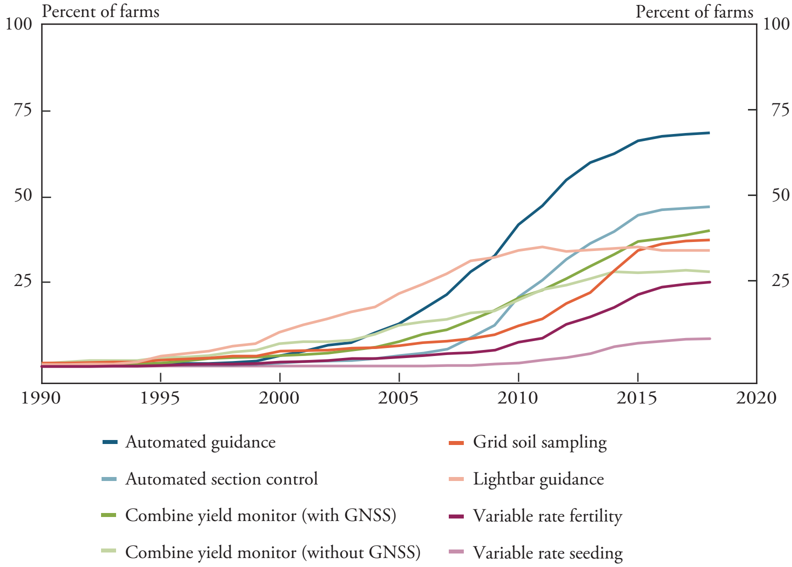
Chart 3
Proportion of Kansas Farm Operators by Generation



Source: Griffin and others (2019).

By January 2019, 84 percent of KFMA farmer members reported having used at least one of eight precision technologies, while the remainder reported having "never used" any technology. The eight technologies evaluated included GNSS-equipped yield monitors, yield monitors without GNSS, variable rate fertility, variable rate seeding, precision soil sampling, lightbar, automated guidance, and automated section control. Chart 4 shows the percentage of KFMA farms adopting each technology by year.

Chart 4
Percent of Farms with Agricultural Technology



Source: Griffin and Yeager (2019).

Defining innovators and early adopters among Kansas farm operators

We assessed characteristics of farms at different points along the adoption path, placing assumptions on the shape of expected adoption curves; specifically, we evaluated the age and experience for "innovators," "early adopters," and "early majority" (Rogers 2003). Rogers (2003) defines diffusion of innovations by percent adopted. "Innovators" are the first 2.5 percent, "early adopters" are the next 13.5 percent, and "early majority" the next 34 percent. This study reports age and experience demographics for each agricultural technology for these categories.

Age and experience of technology adopters were calculated for 2018 based on birth year and the year they commenced farming. The average age of adopters was 59.6, substantially younger than 62.7, the average age of non-adopters. The average age of technology adopters and non-adopters in Kansas was higher than the 57.5-year-old average age of all farmers reported by the USDA NASS Census of Agriculture. The average experience of non-adopters in 2018 was 39.7 years, 2.6 years longer than adopters. Tables 2 and 3 show the distribution of technology

Table 2
Average Age of Innovation Group by Technology

Technology	Innovators	Early adopters	Early majority
Automated guidance	49.2	47.5	51.9
Automated section control	47.0	48.6	–
Yield mapping	45.8	47.0	–
Yield monitor	40.0	49.5	–
Grid soil sampling	47.5	52.0	–
Lightbar	45.0	44.9	–
Variable rate fertility	49.9	51.9	–
Variable rate seeding	53.8	58.3	–

Source: Kansas Farm Management Association.

Table 3
Average Farm Experience of Innovation Group by Technology

Technology	Innovators	Early adopters	Early majority
Automated guidance	27.2	25.3	29.3
Automated section control	24.5	26.1	–
Yield mapping	20.9	24.2	–
Yield monitor	18.1	27.1	–
Grid soil sampling	22.7	30.3	–
Lightbar	20.0	22.6	–
Variable rate fertility	25.4	30.6	–
Variable rate seeding	31.2	36.5	–

Source: Kansas Farm Management Association.

adoption status by age and experience, respectively. Although differences exist, similar patterns were observed for both age and experience.

Our tests indicated that age and experience were statistically different from adopters to non-adopters. The null hypotheses that age or experience of adopters were no different from non-adopters were rejected at any conventional significance level when all technologies were evaluated together. We conducted multiple means comparisons to evaluate if average age and experience differed across technologies.

Technology by average age and adoption status

We evaluated the average age of adopters and non-adopters of technology, finding that the average age of adopters was younger than non-adopters for all eight technologies. This supports the finding from other studies that younger generations are more willing to adopt new technology. We compared the age of adopters pairwise across all technologies. Adopters of lightbar were statistically older than adopters of automated guidance, automated section control, grid soil sampling variable rate fertility, and variable rate seeding. The age of adopters of automated guidance only differed for lightbar. Adopters of variable rate seeding were statistically different from adopters of yield monitor with GNSS, yield monitor without GNSS, and lightbar.

Using innovation categories suggested by Rogers (2003), we evaluated the average age and experience of farms for innovators, early adopters, and early majority (where possible). Innovators and early adopters were assessed for all eight technologies. The most readily adopted technology in 2018, automated guidance, is currently being adopted by the late majority. Descriptive statistics for innovators, early adopters, and early majority are provided for all eight technologies.

Automated guidance was the only technology with more than 50 percent of farms adopting, achieving innovator status by 2000, early-adopter status by 2006, and early-majority status in 2012. Automated section control met innovator and early-adopter status in 2005 and 2009, respectively. Combines equipped with GNSS-enabled yield monitors met innovator status by 1997 and early-adopter status by 2009 (Table 4).

Information-intensive technologies took longer to go from innovator to early-adopter status than embodied-knowledge technologies (Griffin and others 2004). The three information-intensive technologies took longer to achieve early-adopter status than the other five technologies. The three embodied-knowledge technologies achieved early-adopter status relatively quickly.

Age and farming experience characteristics of technology adopters

Based on the year that status was achieved, we determined the average age for each innovation phase for all eight digital agricultural technologies. The average age of innovators and early adopters of variable

Table 4
Year Innovation Status Achieved Relative to Commercialization Date by Technology

Technology	Date available	Innovator (2.5 percent)	Early adopter (16 percent)	Early majority (50 percent)
Automated guidance	2000	2000	2006	2011
Automated section control	2004	2004	2009	–
Yield mapping	1994	1997	2009	–
Yield monitor	1992	1995	2009	–
Grid soil sampling	1994	1997	2011	–
Lightbar	1995	1995	2003	–
Variable rate fertility	1996	2003	2013	–
Variable rate seeding	2006	2008	2018	–

Note: As of 2018, automated guidance was the only technology to surpass a 50 percent adoption rate.
Source: Kansas Farm Management Association.

rate fertility was 49.9 and 51.9, respectively. Innovators were consistently younger than early adopters across all eight technologies (Table 2).

Innovators were generally less experienced than early adopters across the agricultural technologies evaluated. Innovators of seven of the eight technologies were younger than the early adopters. The exception was automated guidance. The experience for adopters of automated guidance was nearly the same for innovators and early adopters at 27.2 and 25.3, respectively. However, it should be noted that the innovators averaged more than 20 years of experience, such that they were not considered inexperienced (Table 3).

Automated guidance reached early majority in 2011, when 50 percent of Kansas farms adopted the technology (Table 4). The early majority averaged 51.9 years old, ranging from 20 to 82 years old (standard deviation of 12.2) (Table 2). Operators meeting early majority status for automated guidance had 29.3 years of experience ranging from zero to 63 years (standard deviation of 13.5) (Table 3).

II. Farm Data Valuation

The utilization of digital technologies has generated a large volume of site-specific data. Spatial data analysis requires specialized skills and human capital investment, so it is not a core competency of most agriculturalists. One solution to this problem has been the development of a potential market for farm data analytics. Analysis is often provided in the form of field-level prescriptions, yield and variable rate mapping, or farm management recommendations collectively referred to as "Small Data."

Small Data within the farm gates

Little is known about the marginal benefits and costs that accrue to the economic agents (farmers, retailers, analytics platforms, or manufacturers of crop protection chemicals, seed, and equipment) for participating. The theory of economic networks suggests, however, that as more farms provide data in such a market, the analysis offered by the community analytics platform, or "Big Data," becomes more valuable to each individual farmer. Uncertainty exists regarding the number of farmers and data platforms providing analytics participating in the market. Currently, there are a large number of platforms offering services and vying for farmers to contribute data, with no firm prevailing over others, and a relatively small share of farms participating in the market.

Participation in digital services provides benefits for farm management, especially agricultural lenders. Secondary benefits exist with automated tracking of input application, specifically automatically populated financial statements built from connecting to planning tools provided by farm management information systems. When seed or fertilizer are purchased and applied with automated controllers such as variable rate, as-applied maps are created that provide details that populate enterprise budgets, but with detail sufficient to create a budget for every acre on the farm. The cost half of cash flow statements could easily be updated in real time as rates and prices change and with electronic permissions set to be shared with agricultural lenders.

Big Data beyond the farm gates

An analysis of data from a single farm commingled with data from thousands of farms can provide benefits for every participant. This "beyond the farm gate" data analysis has been referred to as "Big Data" (Coble and others 2018). If data service analyzes observational planter and yield monitor data from thousands of farms coupled with information about the management practices of those farms, "G × E × M" (genetics × environment × management) analysis could be conducted to determine how factors work together to influence crop performance (Ferrell and Griffin 2018). The resulting information could help consultants provide better insights and recommendations to their farmer clients about how to optimize their operations. Scouting and soil sample data collected across geographic regions could provide important information about the potential for nutrient runoff to pollute nearby water bodies or provide advance warnings of pest or disease outbreaks that could prevent many farms from experiencing any productivity loss at all. Analyzing the data of many farms can create products that provide value to individual farms and also provide value to a "community" of data-sharing farms.

Data aggregators and analysts will likely command a share of that value and may create value completely separate from that of the farm operator. With enough data, analysts may be able to provide agricultural retailers with an abundance of asymmetric information to allow targeted laser marketing efforts to the farmer. Although this might benefit some farmers by helping identify products that are a best fit for their operation, asymmetry may lead to pricing practices that are disadvantageous to the farmer. Knowledge of how bundles of products perform in a specific region empowers manufacturers and retailers to improve supply chain management and lower their costs. With enough information from aggregated data, aggregators and analysts may derive insights important to commodity markets before government reporting agencies and obtain an advantage in commodities trading.

III. Future Farm Operators

The age and length of farm experience continues to be associated with technology adoption. Younger, less experienced farm operators tend to adopt technology more readily than their older, more experienced counterparts. In fact, these characteristics are such strong indicators of predicted adoption that manufacturers may use this information to target specific individuals. Educational programming on the returns of adopting individual technologies may be aimed at specific age groups.

In our sample, multiple-operator farms tended to adopt more technology than sole-proprietor farms. For single-operator farms, Millennials adopted less technology than Baby Boomer or Generation X, most likely due to less financial ability (Table 5). Millennials on multiple-operator farms adopted much more technology than Millennials on sole-proprietor farms (Table 6). Having a Baby Boomer or Generation X on multiple-operator farms providing financial stability may explain the influence Millennials had on investment decisions. The Millennials on multiple-operator farms may have also received additional education, training, or knowledge of digital agriculture technologies before joining the farm operation.

Even though the most recently available agriculture technology has been utilized for 14 years, the low percentage of farmer usage could be because not all current farmers are likely candidates for agriculture technology (Ofori, Griffin, and Yeager 2020). In general terms, Baby Boomers' technology lags behind that of younger generations for multiple reasons. Baby Boomers are less accustomed to technology than younger cohorts, and remaining current with new technology requires human capital expenditures, so they tend to be late adopters (Kamin, Lang, and Beyer 2017; Van Volkom, Stapley, and Malter 2013; Shen 2020). Although it is unlikely that Baby Boomers, the generation currently comprising the majority of farm operators, will ever adopt a complete bundle of technologies without the influence of younger operators, nearly all acreage is expected to be managed with some sort of precision technology after a sufficient number of farm consolidations occur. In the future, technologies such as variable rate fertilizer application are likely to be ubiquitous, especially if site-specific decisions are passed to the operator.

Less discussed is the mental capacity needed for adaptation to technology. Adopting technology necessitates sensory, cognitive, and motor resource investment, and physiological or cognitive decline, more than age itself, has been shown to determine rates of adoption of technology (Lindenberger and others 2008; Shen 2020). The physiological declines associated with aging could be offset by aging farm operators adopting labor-saving technologies, such as automated guidance; however, the cognitive decline associated with aging would lend itself to not adopting data-intensive technology such as variable rate technology (Feder, Just,

Table 5
Proportion of Single-Operator Farms with Technology by Generation

Technology	Silent	Baby Boomer	Generation X	Millennial
Yield mapping	4.7	14.0	16.3	8.8
Yield monitor	8.1	14.8	15.5	7.5
Automated guidance	12.8	24.2	24.4	13.1
Automated section control	7.4	16.1	18.7	10.0
Lightbar	10.8	22.2	18.7	10.0
Grid soil sampling	7.1	14.1	13.8	7.5
Variable rate fertility	2.0	9.1	9.9	6.2
Variable rate seeding	1.4	5.5	5.7	1.9

Note: As of 2018, automated guidance was the only technology to surpass a 50 percent adoption rate.
Source: Kansas Farm Management Association.

Table 6
Proportion of Operators from Multiple-Operator Farms with Technology by Generation

Technology	Silent	Baby Boomer	Generation X	Millennial
Yield mapping	14.7	36.2	26.9	14.9
Yield monitor	25.3	38.3	25.7	12.8
Automated guidance	40.0	62.8	40.4	22.3
Automated section control	23.2	41.7	31.0	17.0
Lightbar	33.7	57.6	31.0	17.0
Grid soil sampling	22.1	36.6	22.8	12.8
Variable rate fertility	6.3	23.4	16.4	10.6
Variable rate seeding	4.2	14.1	9.4	3.2

Source: Kansas Farm Management Association.

and Zilberman 1985). The perceived ease of use, or learning curve, of the technology must be weighed with the perceived usefulness or benefits. If the learning curve seems too steep, it may hinder technology adoption for older farmers, especially before these technologies become sufficiently passive to the user or equipment operator.

Older farmers may not be able to devote necessary human capital or may be unwilling to accept the profitability risks of unproven technology. However, one subset of farm operators who are likely to adopt technology include those belonging to the younger, experienced, more educated, higher-farm-acreage demographic. Farm operators with these characteristics are generally Millennials or members of Generation Z.

Millennials, in general, are technologically savvy, readily look for new technological advances, value their family time, lack job loyalty, and are environmentally and socially conscious (Barroso and others 2020; Howe and others 2000; Suh and Hargis 2016). Millennials may see agricultural technology as less intimidating than their older counterparts, a way to protect the environment by preventing fertilizer overuse and possible runoff, and time-saving—providing more family time.

Future technologies are expected to reduce the reliance on human capital necessary to make technology work. These expectations are especially true for Generation Z, who value cutting-edge products over industry status quo. If the product or service does not perform as anticipated, farm operators of Generation Z are expected to move on to the next technology (Johnson and Sveen 2020). Another insight that the agricultural industry must anticipate is how future generations may express loyalty differently than previous generations. Commodity produced, education level, and age have been associated with farmers' perceived brand loyalty (Harbor, Martin, and Akridge 2008). Millennials already in the workforce tend to change jobs every few years and do not hold the same brand loyalty as members of the Silent and Baby Boomer generations (Suh and Hargis 2016).

A counterargument to the generational divide is how people of a certain age behave similarly to previous generations at that same age. Although Millennial and Generation Z farm operators are younger, with greater interest in technology, at some point in the future they may behave similarly to how operators born in the Baby Boomer generation behave (Pitt-Catsouphes and others 2012). However, Millennials and members of Generation Z were born during an era with the internet, which has influenced their thought processes, trust, and risk aversion levels.

Discerning farm operators (Millennials and Generation Z) who place less value on loyalty than previous generations are unlikely to readily trust site-specific prescription recommendations from retailers profiting from increased sales of inputs (Gurau 2012). Members of Generation Z have already differentiated themselves from

Millennials with respect to media preferences; they are known to actively block advertisements. Separation of input sales (fertilizer, for example) from custom applications and site-specific prescription recommendations may be necessary before younger farm operators trust variable rate technology services.

As a whole, members of Generation Z are also technologically savvy, as they have grown up with smartphones and other gaming devices, but they also seek financial value in their choices, are interested in finding practical ways to complete tasks well, and desire individualizing experiences for themselves (Johnson and Sveen 2020). With these characteristics, it is possible that they will accept agriculture technology for its potential financial value, its practicality, and its ability to allow the farm operator to maximize individualization to specific needs. Variable rate fertilization is a prime example of individualization, where fertilizer is applied only where needed and not across the whole field. The same need for individualization may be seen when purchasing other forms of farm technology. It is predicted that Generation Z operators will not be content with technologies that come standard as original equipment, but will desire to customize which technologies they use and to what extent.

Moving forward, manufacturers of agriculture technology must consider how Millennials and Generation Z behave with respect to technology adoption rather than expecting similar adoption paths as the Silent and Baby Boomer generations. While there is scarce literature on the family farm inheritance skipping generations, there are many business and tax reasons for transferring farm ownership to the grandchild instead of the child. Unlike other family-owned businesses, with farming, much of the wealth is in equity, not cash, and the physical demands and long hours are very different from traditional desk jobs. Thus, skipping a generation for farm inheritance may include the factor of age along with financial factors. The average age of farmers is increasing at a higher rate than the life expectancy in the United States (Chart 2). While the average retirement age in the United States is 62, 49 percent of Kansas farm operators are beyond retirement age, and 69 percent of all non-operator agricultural landlords are age 65 or older (Mather, Jacobsen, and Pollard 2015; Bigelow, Borchers, and Hubbs 2016). It makes sense to turn farm operations over to a grandchild in midlife rather than a child at retirement age when the farmer finally retires. With this foreseeable trend ahead, the decision makers of tomorrow may not follow a traditional pathway through the generations.

IV. Conclusions and Future Research

The generational cohort farmers belong to may have more influence on their adoption of farm technologies than many other factors previously studied. When looking at the profitability of technologies, the farmer considers more than just financial gain; human capital, social ties, and environmental stewardship all play a role in adoption rates. To market farm technologies successfully, the age or generation of the farmer—more than the crop—should inform the advertising message.

We find that the adoption of precision agriculture has varied across generations as well as by generational mix for multiple-generation farms. While discussions of operator age, experience, and technology adoption are of interest on their own, policymakers are likely to consider generational attributes of current farm operators and those who will be making the majority of farm decisions in five or 10 years, as well as how farm data, or Big Data, influences decisions within the farm gate and in a community of aggregated agricultural data. Agricultural lenders are leaning more on insights provided by farm data in addition to general customer attributes to reduce loan risks.

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