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Impact of Emerging Technology on Farm Management

Michael Langemeier and Jordan Shockley
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Introduction

Cost economies and the reconfiguration of the value chain are accelerating farm consolidation and structural change in production agriculture. In addition, many economists have described scenarios in which key innovations and technologies could revolutionize business organization and productivity. How does an individual farm's management team cope with these changes?

This paper will have three main sections. The first section will briefly describe current and upcoming technological developments. The second section will discuss the importance of technological change to productivity and financial performance. The third section will describe the challenges faced by farm managers and extension economists when dealing with the technologies described in the first section of the paper.

Technological Developments

Several technologies are on the cusp of being rapidly adopted by businesses and farms. Brynjolfsson and McAfee (2014) refer to this new technology revolution that individuals and businesses are facing as the second machine age. Baily et al. (2013) discuss technological innovations that are going to transform manufacturing. These transformations will also have important ramifications for agriculture. On-going technologies include enhanced broadband access, precision farming technologies, robotics and automation, artificial intelligence, 3-D printing, and big data and the internet of things. Several of these technologies are further discussed below.

Precision farming technologies take advantage of information technology and allow farmers to collect and utilize precise data about their fields and animals (Lowenberg-DeBoer, 2015). Schimmelpfennig (2016) notes that precision agriculture and information technologies such as soil and yield maps, automated guidance systems, and variable rate input applications allow farmers to fine-tune their production practices. The author notes that precision agriculture technologies were used on 30 to 50 percent of corn and soybean farms in 2010-2012. Adoption was positively related to farm size. Soil and yield maps, automated guidance systems, and variable-rate input applications had small, but positive, impacts on net returns and operating profits. In addition to improving profits, precision agriculture technologies can promote stewardship or best management practices (Schimmelpfennig, 2018). However, adoption of precision agriculture technologies, in some cases, may raise operating costs. Thompson et al. (2019) evaluated farmers' perspectives of key precision agriculture technologies such as variable rate fertilizer and seed applications, yield monitors, automated guidance systems, precision soil sampling, drones, and satellite imagery. Eighty-eight percent of the farmers surveyed agreed that precision farming technologies and services are important contributors to their farm's current financial profitability.

In addition to contributing to financial profitability, precision farming technologies influence risk, and machinery and land management. Shockley et al. (2011) revealed how automated guidance systems allowed producers to plant more acres at the optimal time, therefore reducing production risk and income variability. Shockley et al. (2012) highlighted how automated guidance systems allow for the purchase of smaller machinery while increasing

net returns and lowering machinery costs. Furthermore, the authors discussed how automated guidance systems can be purchased in lieu of larger machinery to support land expansion.

Chui et al. (2016) indicate that automation, which includes robotics, will not necessarily eliminate entire occupations over the next decade. However, automation is likely to affect portions of almost all jobs. The authors identify three groups of occupational activities: those that are highly susceptible to automation, less susceptible to automation, and least susceptible to automation. Highly susceptible technologies include data processing and predictable physical work. Least susceptible technologies include personnel management and decision-making, planning, and creative tasks. At least a portion of the activities in production agriculture fit into the data processing and predictable physical work categories. One example of automation that is widely spreading is robotic milkers (Salfer et al., 2017).

3-D printing also has important implications for production agriculture. 3-D printers will allow machinery dealers and producers to manufacture spare parts on-site. This technology will likely change how we think about manufacturing batch size and inventories, and will allow parts to be just-in-time, which could substantially reduce machine downtime.

Big data involves the use and analysis of massive volumes of data emanating from yield maps and similar technologies for decision making. The use of big data tools in production agriculture will likely influence the nature of competition and inter-firm relationships (Sonka, 2016). Value is expected to be created through the application of tools to measure and monitor activities; data analytics, which can integrate and analyze data from multiple sources; and the creation of data sources that can help mitigate detrimental environmental effects. Big data will likely reconfigure the value chain creating opportunities for farms to add value.

Technological Change as a Driver of Productivity and Financial Performance

Production agriculture has been substituting capital for labor for decades (Wang et al., 2018). From 1948 to 2015, output growth (1.48 percent per year) was almost entirely due to total factor productivity growth (1.38 percent per year). Over the 1948 to 2015 period, output tripled, but labor and land declined by 75 and 24 percent, respectively. By comparison, intermediate and capital inputs (excluding land) grew by 134 percent and 78 percent, respectively.

Another way to think about the large change in output growth (1.48 percent per year) in relation to the small change in input growth (0.10 percent per year) is that farms are obtaining increasingly higher aggregate output levels using a similar level of aggregate inputs. In other words, the production frontier is shifting upward. Mugera et al. (2016) illustrate the large shift in the production frontier for a sample of farms from 1993 to 2010. Due to their inability to keep up with farms on the production frontier, many of the sample farms saw their relative efficiency decline over the sample period. Despite adopting new technologies, these farms are falling further behind their counterparts. Yeager and Langemeier (2011) examined changes in productivity over a 30-year period (1979 to 2008) for a sample of farms, and determined whether there was convergence or divergence among the farms. Results indicated there was significant divergence in productivity among farms. Farms in the top one-third in terms of productivity had an annual productivity increase that was almost four percent higher than that for farms in the bottom one-third. Differences in productivity among the top one-third and bottom one-third groups was due to both efficiency change (i.e., ability to catch-up) and technical or technological change (i.e., shifts in the production frontier).

Yeager and Langemeier (2009) examined sustained competitive advantage for a sample of Kansas farms for a 20-year period (1988 to 2007). As with productivity, differences in economic efficiency and financial performance among farms is substantial. Economic efficiency was over 50 percent higher for farms with above average efficiency indices than it was for farms with below average efficiency indices. The average operating profit margin for the above average group was 0.212 compared to a ratio of -0.024 for the below average group. Snider and Langemeier (2009) examined the changing structure of Kansas farms. Convergence analysis was used to determine whether small farms were catching up to larger farms or whether the difference in financial performance between

groups of farms was widening. Results provided evidence of divergence in terms of farm size and financial performance between small and large farms. The larger farms were growing more rapidly than smaller farms. Moreover, their relative financial performance was improving over time.

MacDonald et al. (2018) examine the shift of agricultural production to larger farming operations. The authors note that consolidation has been persistent, widespread, and pronounced in crop production. Structural change has also been rapid for the dairy, laying hen, and swine industries. MacDonald et al. (2013) and MacDonald et al. (2018) indicate that technology has played a major role in crop and livestock consolidation. Technologies have often been labor saving and capital using. Moreover, technology has also allowed capable managers to expand and operate larger businesses.

Langemeier and Boehlje (2017) note that large farms may be better positioned to adopt new technologies. Large farms tend to have higher profit margins and retained earnings, increasing the speed with which they can adopt new technologies with benefits that exceed their costs. Larger farms also have the ability to assign one or more individuals specifically to the adoption of new technology.

The upward shift in the production frontier and the divergence in financial performance noted above will almost certainly continue. Indeed, as noted above, many individuals suggest that we are on the cusp of another technology revolution (Brynjolfsson and McAfee, 2014). Thus, it is imperative that technology adoption and its impact on financial performance be on the radar of a farm's management team. One of the ways to do this is to conduct an assessment of farm's management team skill set associated with the adoption of new technology. For example, does the farm use technology that provides the most efficient use of inputs? Do the operators improve their production skills through interactions with similar operations and by attending technology and production workshops? Does the farm identify, monitor, and benchmark key production efficiency measures? Are written equipment and facility replacement plans updated at least annually? Management skill assessment is more fully discussed below.

With the increased importance of technology adoption and business management, it is imperative that extension continues to update farm financial performance standards (Farm Financial Standards Task Force, 2017) and key financial performance benchmarks (FINBIN, University of Minnesota, 2018). These standards and performance metrics allow producers to analyze the impact of adopting specific technologies and management strategies. Spreadsheet tools involving partial budgets, enterprise budgets, financial analysis, and capital budgeting are regularly updated by extension economists and can be utilized in conjunction with educational efforts or as stand-alone tools for producers that are familiar with these concepts. Griffin et al. (2018) provide a resource for evaluating the economics of precision farming technologies, the appropriate methods to determine return on investment, and managing economic risk with precision farming technologies.

Farm Management in a Rapidly Changing Environment

Extension has a long history regarding technology transfer in production agriculture. The plethora of potential new technologies and the increasing role of business management as farm size increases augment the importance of lifetime learning. Extension continues to have an important role in transferring knowledge. The analysis of new technology adoption and the teaching of business management skills will require educational opportunities that are in-depth or involve multiple meetings, webinars, or distance education modules. It is important to note that more training is available from agribusinesses and trade associations than in the past. However, extension remains a trusted source of unbiased information. In many cases, agribusinesses and trade associations are interested in partnering with extension economists when delivering programs.

Educational needs pertaining to technology adoption are manifold. However, there are several management areas such as business planning, transition planning, personnel management, financial analysis, capital budgeting, and management skill assessment that will be essential. The components of a business plan include a strategic plan, an operations plan, a marketing plan, a personnel plan, and a financial plan. Strategic planning involves the articulation of goals and mission, and the determination on whether a farm is going to pursue a low cost or product differentiation strategy. Historically, pursuing a low cost strategy has been very common for farms. As

value added opportunities arise, it is also important to evaluate whether a product differentiation strategy would be more beneficial to a farm than the low cost strategy.

Extension farm management personnel have expanded educational efforts pertaining to transition planning in recent years. When transferring a farm business, it is important to analyze the feasibility and profitability of adding one or more family members, and to determine how management responsibilities will be shared (Kay et al., 2015).

In addition to business planning and transition planning, many farms have limited experience managing personnel, computing accrual net farm income and financial performance ratios, and with the use of capital budgeting tools. In the authors' experiences, evaluating investments using capital budgeting tools is one of the largest skill gaps in production agriculture. Given the importance of evaluating potential new technologies, and the fact that this topic is typically not addressed by others providing training to farmers (i.e., agribusinesses and trade associations), extension has a role in improving this skill set. Resources such as Griffin et al. (2018) can be utilized to aid in the educational efforts of evaluating potential new technologies.

As capital and technology become an increasingly important part of the resources utilized on farms, assessing management gaps becomes essential. One of the tools that can be used to assess management gaps is to use management assessment scorecards. Financial management skills such as computing and analyzing key performance measures, utilizing partial and enterprise budgets, using capital budgeting tools, analyzing competitive terms for loans, and setting policies for withdrawals of capital and the division of earnings need to be assessed. If any of these skills is relatively weak, the farm will either need to engage in professional development or obtain the skill from an outside party. Similarly, examining strategic positioning skills is important. These skills include identifying key resources and factors critical to success, capitalizing on new and emerging markets, assessing the farm's strengths and weaknesses, and utilizing action plans and equipment and facility replacement plans.

The challenges pertaining to management gaps are exasperated by current farm organization. Sole proprietors and partnerships are still very common. For many reasons, including problems associated with wearing numerous management hats, these farms tend to focus on tactical or day-to-day management issues. As farms continue to grow, particularly in an environment in which technology and market opportunities are rapidly changing, strategic management becomes just as important if not more important than tactical management.

Due to different learning styles and resource constraints, educational methods will need to be diverse. There is still demand for traditional extension meetings. However, many of the topics that will need to be addressed, due to the complexity of the topics and time needed to learn the concepts, are better suited to workshops spread over several weeks, webinars, and distance education. The nature of the topics place a premium on programs that extend beyond state boundaries, and the involvement of multiple economists with various specialty areas.

Concluding Comments

This paper discussed emerging technologies and their impact on farm management. The better utilization of current technologies and the adoption of new technologies will create opportunities for production agriculture to improve productivity and efficiency, while reducing economic risks. These changes will make it imperative that farms more fully utilize skills pertaining to business planning, transition planning, personnel management, financial analysis, capital budgeting, and management skill assessment.

What does the surge of potential technologies that may be used in production agriculture mean for extension programming? First, the demand for in-depth programs that discuss how to evaluate the adoption of new technologies will increase. Second, programs will need to address the differences in farm management educational backgrounds. Both basic and advanced programs will be needed. Third, given financial constraints, programs that effectively reach large audiences in a timely fashion such as webinars and distance education will be important. Fourth, given that a growing share of agribusiness personnel do not have a strong production agriculture background, this audience will also be seeking farm management educational opportunities.

The points pertaining to extension programming noted above are not necessarily new. Extension farm management has a rich history of discussing topics such as technology adoption and financial management with farms, ranches, and agribusinesses. However, there are far fewer farm management extension economists today than there was two or three decades ago. Productivity is not just important to farms and agribusinesses. Extension farm management economists will need to keep improving their productivity with regard to program delivery and impact to be effective.

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Author Information
Michael Langemeier (mlangeme@purdue.edu) is Professor, Department of Agricultural Economics, Purdue University, West Lafayette, IN.
Jordan Shockley (jordan.shockley@uky.edu) is Assistant Extension Professor, Department of Agricultural Economics, University of Kentucky, Lexington, KY.
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