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Technology's impact on farming and the rural Midwest

by David B. Oppedahl, senior business economist

On November 27, 2018, the Federal Reserve Bank of Chicago held a conference to explore the opportunities and challenges presented by new technologies to farms and rural areas in the Midwest and other parts of the U.S. Experts from academia, industry, and policy institutions gathered to discuss how technological advances have reshaped the rural economy and how they may affect its future.

The goals of the conference included understanding technological change and its impact on farming and rural communities; examining policies that affect the availability (and adoption) of technological innovations in the countryside; analyzing the primary influences of new technologies on the rural Midwest, especially on its employers, health care systems, and educational institutions; and considering potential ways to fund rural broadband and agricultural innovations, particularly given lower farm profits in recent years.

To kick off the event, David B. Oppedahl (Federal Reserve Bank of Chicago) described some of the long-term increases in farm productivity—which have been largely driven by technological innovations. For instance, he highlighted the fact that corn and soybean yields (bushels per acre) in the five states of the Seventh Federal Reserve District had more than doubled over the past 55 years.[1] While productivity improvements have lowered operating costs for farmers over this span, they have also contributed to lowering real prices for their goods (as supplies have increased), he explained. In the cases of corn and soybeans, their real prices have been trending lower over the past five decades, noted Oppedahl. Fortunately, multiple technology firms are looking to help farmers achieve even further cost-saving efficiencies in agricultural production in order to remain profitable. Not only have traditional agriculture-related firms invested in new technologies, but other companies, including start-ups, have entered the market to fund advances in farming methods (including the use of robotics, satellite imagery, and artificial intelligence tools). New forms of technology may help turn around the downward trend in net farm income that's been going on since 2013, said Oppedahl.

Most materials presented at the 2018 Agriculture Conference are available online, https://www.chicagofed.org/events/2018/ag-conference.

The role of agricultural technology in the future of Midwest farms

Karen I. Plaut (Purdue University) began her keynote address by underscoring the ways in which innovations in agricultural technology have driven rapid advances in crop field work. For instance, farmers are now using drones and robots not only to scout for pests, diseases, and nutritional

deficiencies, but also to aid in harvesting and maintaining fields. Spectral imaging from overhead is becoming more widely used to identify problems in fields, allowing farmers to manage crops, soil, nutrients, and water more effectively. While such technologies are being increasingly adopted by farmers, broadband internet access remains unavailable to many of them, as well as other people in rural areas. According to recent research at Purdue, there would be gains to the Indiana economy estimated at four dollars for every dollar invested in expanding broadband internet access to the state's rural communities.[2] Plaut said she envisioned a world where broadband internet would be available for all. With ubiquitous broadband internet access, real-time automated decision-making could become the norm, autonomous vehicles could more easily assist on every farm, sensors and robots could connect every distribution point worldwide, and all transactions could be electronic. It was Plaut's contention that digital technology for agriculture could help solve labor shortages, increase global productivity, disseminate expertise, enhance education, provide opportunities for entrepreneurs, and promote trade.

Keith Fuglie (U.S. Department of Agriculture) focused on productivity enhancements as a driver of agriculture's growth. He shared that over the period 1950–2015, total U.S. output of crop and livestock commodities rose nearly threefold, although the quantity of inputs for agriculture remained fairly flat over that time frame (the mix of land, labor, capital, and intermediate inputs did change, however). Fuglie illustrated this evolution in farm productivity with the example of corn yields increasing following the adoption of successive waves of farming innovations—such as hybrid seeds, herbicide applications, nitrogen fertilization, genetically modified seeds, and tractor guidance systems. Such innovations have enabled farmers to realize economies of scale, said Fuglie, leading to both increased consolidation of farm operations and greater specialization among the survivors; for instance, relative to the mid-1990s, fewer farms now produce crops and livestock together, and today crop output is more often from farms harvesting only one or two kinds of crops. While productivity gains in U.S. agriculture since the mid-twentieth century have been impressive, Fuglie warned that signs of slowing productivity growth have started to emerge. In his view, these recent signs reflect lower spending levels on farm research and development (R&D) in the past ten to 20 years (the time it takes to transfer knowledge from the laboratory to the farm, he explained). Fuglie said that according to his research, public investment in agricultural R&D has provided high returns—at least ten dollars in benefits for the economy per one dollar spent on R&D.[3] Fuglie argued that public sector investment in farm R&D is the main policy driver influencing agricultural productivity. Hence, the 20% decline in public funding of agricultural R&D since a 2001 peak implies that the prospects for improving U.S. agricultural productivity growth are dimming, he indicated. While private sector investment in agricultural R&D has recently risen above the government funding level, there could still be a lack of vital longer-term research, which has typically been funded by the public sector. Moreover, the outlook on continued funding for farm R&D from private sources is uncertain, he said.

> Over the past five decades, great strides in agricultural productivity have been made, in large part because of technological advancements.

Representing one view from the private sector, Jerry Flint (Corteva Agriscience) emphasized that agriculture offers opportunities for investment based on long-term trends. The demand for food is expanding as the world's population continues to rise, he said, and a growing global middle class will eat more meat, driving demand for animal feeds. Flint shared that world production of key crops, such as corn, soybeans, and wheat, has been able to keep up with demand only because of boosts in crop yields from new technology adoption; increases in planted acreage alone would not have been sufficient. Recently, the global supplies of grains and oilseeds have even outstripped demand—yields for these were above average for six consecutive years, resulting in their prices being substantially lower, Flint noted. Continued innovation, he argued, remains critical to meeting the food needs of the future. Corteva's technology-based solutions are used in the seed (breeding

and biotechnology), on the seed (treatments to help plants get a head start), on the plant (crop protection), and on the farm (digital platforms and agronomy). According to Flint, seed is a key delivery mechanism to improve farm productivity. Also, farm business software and data analytics can help farms of all sizes become more efficient, profitable, and sustainable, he said. As U.S. growers adopt new technologies and gain a competitive edge, Flint contended, the opportunities for midwestern farm exports will expand given that the long-term outlook for agriculture is positive.

Agricultural technology investment and rural economic development

John Mann (Michigan State University) focused on the role investment plays in generating innovations in agriculture and rural development. The share of venture capital (VC) devoted to agricultural technology rose from 2002 to 2018, but remained small (under 1%), according to Mann. Mann indicated that VC funding for agricultural technologies had become more global in scope and that the Midwest has lagged other regions in its share of agricultural VC. The North Central Regional Center for Rural Development has a goal to promote innovation diffusion for rural development by linking agricultural experiment stations, university faculty, and small rural or agricultural firms (across state lines and even outside the North Central region).[4] Mann shared that new technologies developed within North Central universities have been slow to transfer out of the academic setting, partly because most faculty are not great judges of which technologies best fit the market. Also, rural innovators have typically been less likely to get formal protections for their intellectual property than other innovators. Developing connections between entrepreneurs, universities, and federal programs[5] can leverage resources to support rural start-ups, get academics engaged with rural firms, build bridges between innovators, and create new marketing channels. All of these functions can help promote rural economic development, helping stem outmigration from rural areas, stated Mann.

Douglas J. Reinemann (University of Wisconsin–Madison) discussed the difficult economics of the dairy industry and the decline in the number of dairy farms. Simply put, low worldwide milk prices due in part to huge gains in productivity have made it difficult for dairy farms to turn a profit, so many have shut down their operations, he noted. Reinemann went on to trace the evolution of dairy farming technology (and the resulting productivity growth) from hand milking (1880–1920) through robotic systems. As dairy technologies evolved, each system in turn allowed for more dairy cows per farm as milking speeds improved. Reinemann explained that state-of-the-art rotary milking parlors now make it possible for dairy farms to have thousands of cows with a fair number of employees. But demand for low-skill dairy laborers may be waning, Reinemann contended. Milking efficiency depends on how quickly cows walk onto the moving parlor, so robotic milking systems can often provide advantages over other systems relying more on human labor. Indeed, robotic systems can better regulate the cows' movements than humans can. These systems can also more accurately tailor each cow's diet so that the milk produced is of a high quality on a more consistent basis. With the adoption of robotic milking systems picking up quickly—even when milk prices have been quite low—a tipping point could be coming soon, Reinemann suggested. Should that occur, various types of robotic systems will be a major part of the dairy industry in the future, despite the high initial investment to install them. The increase in automation implies that the mix of labor and capital for most dairy operations will shift in the coming years, he said. Additionally, because the individual management of cows will entail the analysis of a lot of data, there will be rising demand for workers with technical skills—in contrast with falling demand for low-skill dairy workers. So, while the transition to greater automation will not be painless for the dairy industry, ultimately it may cause only a modest decrease in rural employment, said Reinemann.

Broadband internet access, farming, and rural economic development

Brian E. Whitacre (Oklahoma State University) described the status of broadband[6] internet access in the rural Midwest, placing it in the context of the urban–rural digital divide. Broadband internet service is provided by fixed (e.g., cable, fiber optic, or satellite) and mobile (cellular) technologies.

Whitacre shared that the difference between rural and urban availability of fixed broadband (excluding satellite connections) had changed a lot over the years: In 2012, rural areas had 45% availability, while urban areas had 90%; but by 2016, rural regions had 69% availability, while cities had 98%. Satellite services can technically provide broadband internet access, explained Whitacre, but there are substantial drawbacks because of weather and line-of-sight restrictions. Also, both satellite and mobile services typically cost more and limit data usage compared with other options. Mobile broadband has made inroads into the rural Midwest, yet its availability in rural areas still lags behind its availability in urban ones. Precision agricultural technologies, including those that allow for remote equipment diagnostics and field monitoring, can be used adequately with internet service from cellular networks. Yet other applications—especially videoconferencing and telemedicine—require higher speeds than such networks can provide. Improvements in broadband internet availability have been spurred by significant private investment (aided by public investment and policies aimed at helping remote areas gain access). According to Whitacre, recent studies have shown the positive impacts of broadband expansion programs on rural economic development (as measured by employment, payroll, and the number of business establishments) and farm profitability—at least in rural counties next to metropolitan counties. Moreover, Whitacre stressed that other research has shown the expansion of mobile broadband into rural areas helps fill the gaps in fixed broadband coverage and has significant potential to stimulate economic development. Compared with other rural parts of the U.S., the Midwest's countryside seemed to have better connectivity, but Whitacre said he still saw room for improvement that would benefit agricultural producers and rural residents. Matt Johnson (Shawnee Communications) discussed some of the issues surrounding broadband internet access that linger in the rural Midwest. His company began a rollout of a fiber optic network serving only rural areas in 2005, which has helped bridge the urban–rural digital divide in Illinois. For example, a rural cooperative faced a disadvantage in pricing crops because of the latency and low speeds of data transmission, but fiber optic broadband gave it access to real-time pricing. Additional fiber optic connections will aid other aspects of farm operations, as well as rural business and community affairs, while facilitating wireless expansion (wires are needed for building out cellular networks), he indicated. Johnson supported federal funding for new telecom and internet infrastructure, programs for maintaining rural broadband networks, and the removal of barriers to broadband deployment (e.g., local right-of-way restrictions for laying down fiber optic infrastructure). He emphasized that increased rates of broadband adoption by rural consumers are vital and that achieving this goal may require customer education about the value of paying for broadband. Moreover, Johnson said he anticipates internet use in rural regions will require even greater broadband speeds in the future, so the pressure will be on to upgrade broadband networks in such areas.

How will new agricultural technologies be implemented and funded?

A panel led by Cortney Cowley (Federal Reserve Bank of Kansas City) discussed the challenges of funding the implementation of new technologies in areas with declining populations. The panelists were Edwin Elfmann (American Bankers Association), Tanner Ehmke (CoBank), and Douglas Wilson (U.S. Department of Agriculture). The profitability of technology (and loans issued to support its implementation) depends partly on population density. For instance, the Federal Communications Commission (FCC) found that fiber optic networks were cost effective only for counties with a population density of 100 residents per square mile or greater (the least populous counties have to rely more heavily on satellite connections). Although current governmental programs have helped close the urban–rural digital divide, the consensus among the panelists was that significant additional public sector funding will be essential to make broadband internet available nationwide. Toward this end, Ehmke said that the FCC could ensure rural broadband internet service providers are allowed to bid and win chunks of electromagnetic spectrum at the auctions it runs. Moreover, he said, better reporting and mapping of holes in broadband coverage would allow efforts to expand such coverage to be carried out more efficiently.

The panelists agreed that as farm technologies improve, there will be better data and much more of it—which will allow for more-detailed analysis of farm operations (yield verification, livestock counts, etc.). Such data will provide greater certainty not only for the farm operators, but also for the lenders that support them. In addition, with these new data, landowners will be able to figure out how to optimize their returns from renting out their farmland (likely in smaller increments than they presently do), while farmers will be able to better evaluate the profitability of renting. The panel concluded that the adoption of new technologies is critical for the improvement of economic opportunities, local services, health care, safety, and education (e.g., through distance learning) in rural areas. By making these aspects of rural life better, communities in the countryside can combat population decline and attract a quality workforce.

Conclusion

Over the past five decades, great strides in agricultural productivity have been made, in large part because of technological advancements. These productivity gains have helped create larger and more specialized farms while lowering the need for farm labor. Although agricultural jobs have dwindled and farm incomes have dropped (contributing to rural population declines), conference participants agreed that innovations in agricultural technologies and improved internet access in rural areas have the potential to bring new kinds of skilled employment with higher earnings to the Midwest.

[1] The Seventh Federal Reserve District comprises parts of five midwestern states—all of Iowa and most of Illinois, Indiana, Michigan, and Wisconsin.

[2] Alison Grant, Wallace E. Tyner, and Larry DeBoer, 2018, "Estimation of the net benefits of Indiana statewide adoption of rural broadband," *Research & Policy INsights*, Purdue University, Center for Regional Development, publication, No. 006, August, available online, https://www.pcrd.purdue.edu/files/media/006-RPINsights-Indiana-Broadband-Study.pdf.

[3] Keith O. Fuglie and Paul W. Heisey, 2007, "Economic returns to public agricultural research," *Economic Brief*, U.S. Department of Agriculture, Economic Research Service, No. 10, September, available online, https://www.ers.usda.gov/webdocs/publications/42826/11496_eb10_1_.pdf.

[4] The North Central region encompasses the states of Michigan, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, South Dakota, and North Dakota.

[5] As two prime examples, Mann cited the Small Business Innovation Research program of the Small Business Administration and the National Institute of Food and Agriculture of the U.S. Department of Agriculture.

[6] The Federal Communications Commission defined broadband from 2015 on as any internet technology that provides downloads of at least 25 megabytes per second (MBps) and uploads at a minimum of 3 MBps.

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