Rural Migration News

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Ag Automation

Human history is the story of productivity improvements in agriculture that allow fewer farmers to feed more people, setting the stage for the emergence of cities and ruling elites. In modern times, labor-saving mechanization in agriculture is a response to economic and risk factors. Farmers mechanize when the cost of hand labor exceeds the cost of machine services, and when there is a risk that farm workers may not be available. Rising nonfarm wages draw workers out of agriculture, while biological and engineering innovations make it possible to replace workers with machines.

US agriculture has experienced several waves of mechanization. Tractors replaced horses in the 1920s, cotton harvesters replaced sharecropper families and Mexican Braceros who hand-picked cotton in the 1940s and 1950s, and machines replaced workers in sugar beet fields in the 1950s. Precision planting reduced the need to thin plants, herbicides reduced the need for hand weeding, and bulk bins holding 800 to 1,000 pounds of apples and oranges and moved by forklifts eliminated jobs lifting and stacking smaller lugs, baskets, and other containers.

Most remaining hand harvested commodities are fresh fruits, vegetables and nursery plants and flowers. Farms producing fruits and nuts, vegetables and melons, and horticultural specialties (FVH) are a sixth of US farm employers, but FVH farms accounted for half of farm labor expenditures in 2017. Within this FVH sector, a handful of commodities account for most hand work, including apples, oranges, strawberries, lettuce, and tomatoes.

Mechanizing the remaining tasks done by hand workers in fresh fruits and vegetables is hard because the work is outdoors in unpredictable settings. By contrast, jobs in packinghouses are easier to mechanize because tasks are more predictable and in controlled environments. McKinsey predicted that almost 60 percent of US farm jobs could be mechanized, compared with 75 percent of US accommodation and food service jobs.

Once Over and Fresh-Processing

Once-over harvests and crops destined for processing are easiest to mechanize. Harvesting all of a commodity during one pass through the field allows the machine to destroy the plant, which is why most root vegetables such as potatoes are harvested by machines that dig the crop from the soil, remove the dirt, and convey the harvested crop to a truck or wagon.

Harvesting fruit from perennial trees and vines poses more challenges. Catch-and-shake harvesters are non-selective in the sense that they remove all of the fruit and nuts in one pass through an orchard. Catch-and-shake machines aim to minimize damage to trees by using a rubber-coated head to grasp the trunk or limb and deliver a jolt that dislodges the fruits or nuts. Grapes and blueberries can be harvested with rotating fingers that dislodge the fruit onto conveyor belts for transport to bins or gondolas traveling on or alongside the machine.

Crops that do not ripen uniformly must be picked several times. Humans can distinguish mature and immature fruits and vegetables much more efficiently than machines, which must locate an apple, determine its maturity, and harvest it without damage to the picked apple and nearby immature apples. The loss of immature crops with once-over harvesting, and the need to discard bruised and unusable machine-picked fruit, lowers marketable yields and grower revenues. For example, the pack out rate for hand-picked peaches is typically 85 percent or more, while pack out rates for machine-picked peaches are in the 60 to 70 percent range.

It is easier to mechanize commodities destined for processing than those sold fresh to consumers. Processors are less concerned about blemishes and other damage that may occur in machine picking, which explains why most vegetables that are canned or frozen, such as beans, corn, and peas, are harvested by machine. However, farmers may not know at the time of harvest whether their commodity will be sold in the higher-price fresh or the lower-price processing market. For this reason, blueberry farmers who hope to sell to the fresh market may hand-pick their crop and only later learn that it was sold to processors.

Change Crops or Adapt Machines

When considering how to mechanize the harvest of major hand-harvested commodities such as apples, oranges, strawberries, lettuce, and tomatoes, a major question is whether it is easier to change the plant or to develop machines that work efficiently in current cropping systems. The first pick normally yields two-thirds to three-fourths of the total crop, so developing uniformly ripening crops would make it easier to mechanize harvesting.

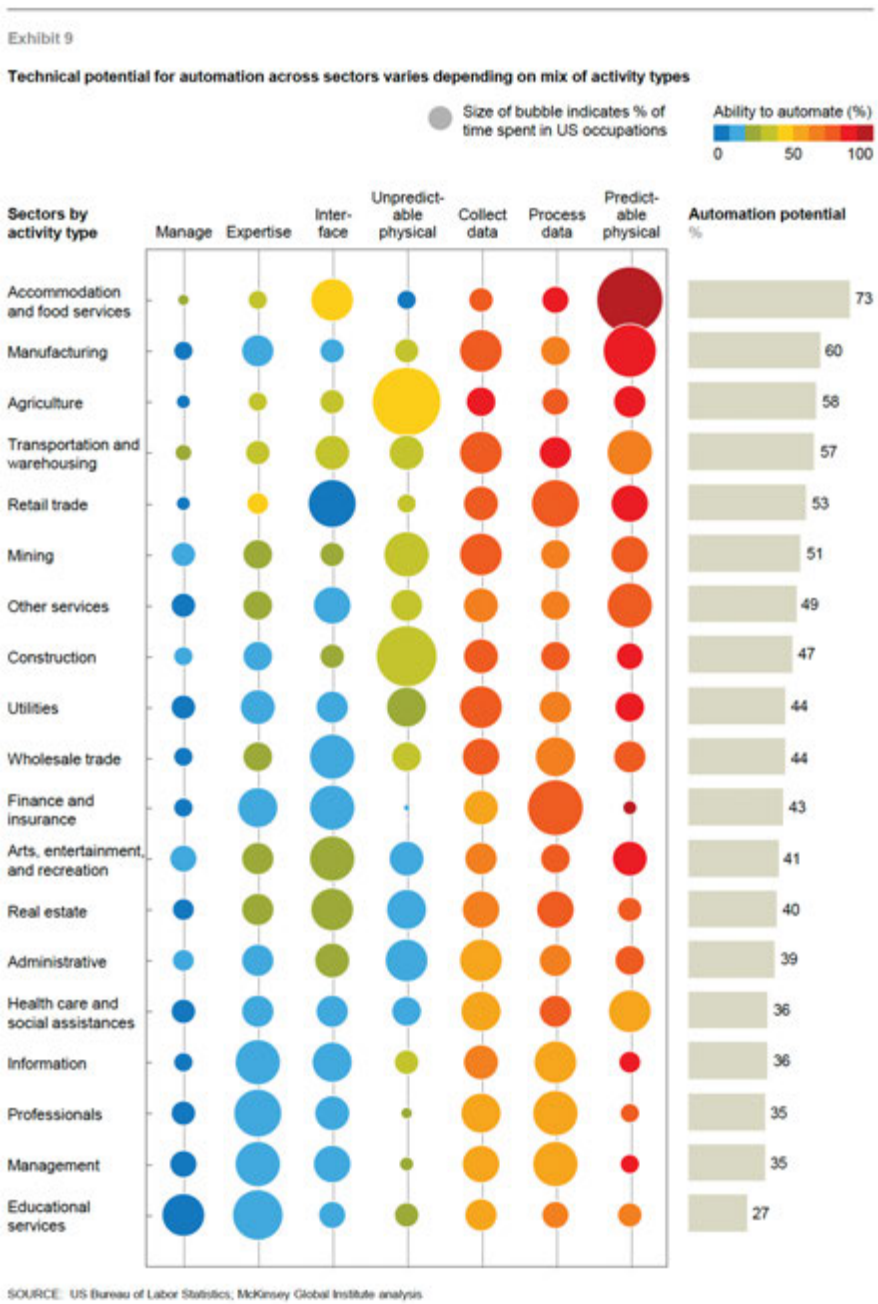
Processing oranges and some varieties of tomato are picked only once, but harvest mechanization has been slowed by disease that weakens trees and the availability of workers in the case of oranges, and by damage to mature green tomatoes in California.

A UK review of the potential for further automation identified three clusters of technologies to save labor. First-wave automation involves using technologies and machines that are readily available to replace hand workers, second-wave automation uses technologies that provide more information on crops to farmers and make workers more productive, and third-wave automation replaces workers.

First-wave automation may require more investment, as in greenhouses or packinghouse machinery, or in technologies to collect and analyze data on crops. Packinghouses adopt labor-saving technologies even though most operate only seasonally, which can lengthen the time required to repay the investment. Once-over harvesters are available for some crops.

Second- and third-wave automation include selective harvesters operated by people or autonomously. Adoption of selective harvesters has been slowed by the high cost of developing such machines for limited markets, since a harvester that picks apples may not be able to pick oranges efficiently.

Farm Jobs are Hard to Mechanize Because of the Unpredictable Environment



Developing labor-saving farm machinery is difficult. Researchers who develop prototypes must refine them to ensure that they work under field conditions and are competitive with hand harvesting costs. Taking an idea from the lab to a manufacturer is difficult, and many startups fail in this so-called valley of death, running out of money before their ideas are commercialized.

Challenges and Opportunities

Worries about the cost and availability of farm labor are spurring interest in farm automation. Key challenges include the farmer characteristics, uncertainty about markets, and difficulties integrating biology and engineering.

First, many farmers are older, own their land, and their children may not want to farm, making them reluctant to invest in new cropping systems and machines that may require decades to repay. Second, many farmers are unsure if they will have markets for their produce; the lack of contracts with buyers who promise to buy farm produce at an agreed price may make it harder to justify investments. Third, there are few businesses or institutions capable of integrating the biological aspects of cropping systems with the engineering challenges of developing machines.

References

UK DEFRA. 2022. Automation in horticulture review. https://www.gov.uk/government/publications/defra-led-review-of-automation-in-horticulture/automation-in-horticulture-review

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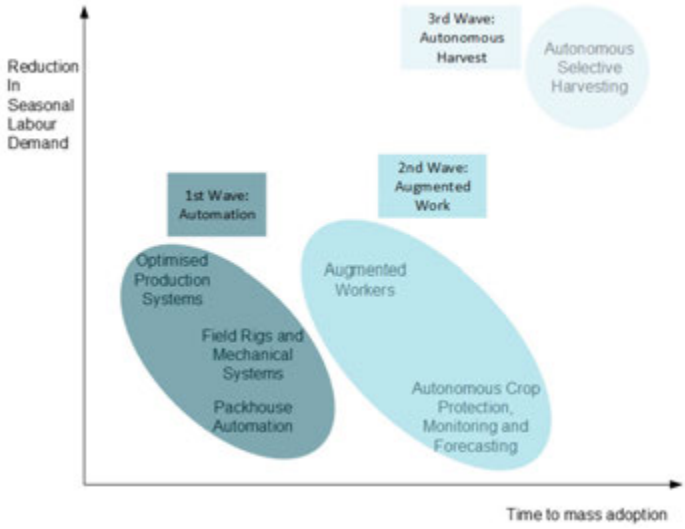
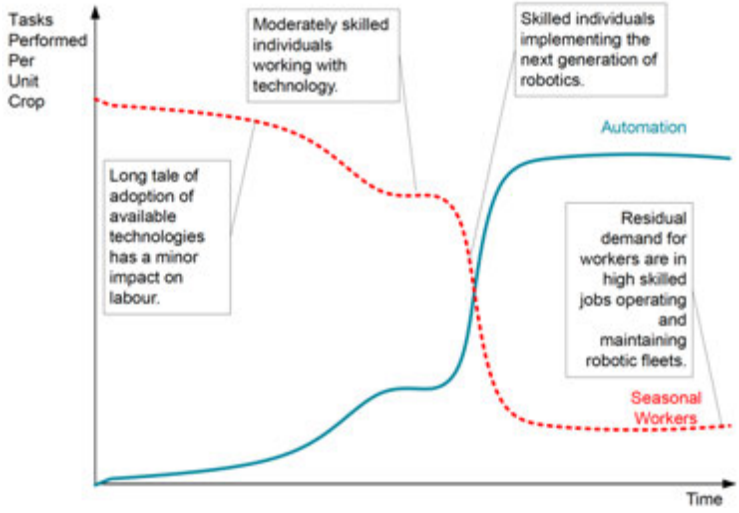
Three Waves of Horticultural Automation



As Machines do More Farm Tasks, the Demand for Seasonal Workers Falls



The Valley of Death in Turning Research Into Reality