The Impact of Artificial Intelligence on Agriculture

and Food Services with a Focus on Labor Markets

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Introduction

According to McKinsey, nearly 40% of current US jobs are in professional categories that could shrink between 2019 and 2030 (McKinsey, 2019). Although the shrinkage can be attributed to many factors, the most impactful is technological advancement and consequential displacement of manual labor jobs. Roles in healthcare, STEM sectors, and business services are increasing while the opposite is true of occupations in transportation/operations, customer service, office support, and food service. The latter is particularly interesting, as it has one of the highest rates of forecasted displacement, and it presents one of the largest contributors to the United States economy.

In 2021, nearly 18% of the nation's economy and 29% of all American jobs were linked to agriculture (Bode, 2022). From farming to processing and retail food services, many U.S. workers are linked to the agriculture/food services labor market. Technological advancements and machine learning in particular are disrupting these sectors. In fact, McKinsey believes technology could handle the activities that account for more than 35 % of all hours worked in food service occupations, or the equivalent of 5.4 million full-time workers by 2030 (McKinsey, 2019) See Exhibit 1. This is second to only office-support workers which represent around 8.1 million jobs that can be done by technology (McKinsey, 2019). Still, food service has one of the highest rates of workers without college degrees (more than 90% of workers), making it harder for them to transition into higher-skilled jobs (which are the ones that will be at high demand in the future). Equally concerning is the high number of minority groups associated with these low-skilled

occupations.

Indeed, the development of the job landscape in the United States will affect certain groups of people more than others. Factors such as skill level, level urbanization of resident city, age, gender, and ethnic group can tilt the scale of odds for job displacement due to technological disruption. Because of this, it is critical to understand which demographics are at higher risk of displacement and which mechanisms can help mitigate the effects. The following case study considers how technological innovation - specifically artificial intelligence and machine learning - will disrupt the food service industry in all faces - from agricultural production to restaurant services. This is followed by a discussion of how their labor markets will be affected, in particular trying to find patterns to highlight which groups of people are most threatened. Finally, policy responses are proposed that attempt to alleviate some of the challenges expected for these groups of people.

Background

Technology is disrupting most - if not all - industries and sectors in the global economy. However, some fields will be impacted more than others. From production to consumption, agriculture and food services will change dramatically as a result of automation and artificial intelligence. It is not a new phenomenon: technological advancement has been disrupting agriculture since the replacement of draft animals with the steam engine during the Industrial Revolution. As such, changes in labor market dynamics as a result of innovation are not unprecedented. Still, every new technology brings its own set of opportunities and challenges and affects different peoples uniquely.

In the 21st century, artificial intelligence and machine learning systems represent the next stage of technologies that will revolutionize the way humans do things, including work. As many

readers may already know, artificial intelligence gives computers and machine learning systems the ability to simulate human intelligence in a way that powers understanding and analysis of historical data - just as human learning does with past experiences. Different technologies powered by AI, hence, can understand, track, analyze, and even discover data points and recognize patterns in order to make optimized decisions. Machine learning utilizes AI to learn from complex algorithms and make predictions based on historical patterns.

In the following section, I analyze the most prominent artificial technologies impacting three parts of the agriculture supply chain to understand the implications of this on worker displacement. The three sections are farming and agriculture, food processing and preparation, and retail food services.

Step 1: Farming

The United States farming industry has been fundamental to the country's workforce since its founding. With more than 2.1 million farms spanning America's farmland, millions of production workers, food scientists, truck-drivers, and engineers work within the industry (Bode, 2022). Thus, it is unsurprising that artificial intelligence is being utilized to optimize these sectors, as they represent such an important part of the economy. Not only is it a huge part of the American economy, but there is also mass global demand for increased food surplus due to a rising world population which is expected to reach 9.7 billion by 2050 (Revanth, 2019). Artificial intelligence is being used to power solutions that will optimize processes to increase production and reduce inefficiencies, hopefully combatting some of the challenges associated with rising demand.

It is certainly not the first time that technology shifts the labor landscape within the agriculture industry. As of 2022, much of the low-skilled work in farming has already been automated and some shifts in labor markets have solidified. For instance, agricultural precision

technology, introduced in the 1990s, offered farmers the ability to simultaneously decrease wasted resources and labor costs. Examples of these technologies include GPS auto-steer and guidance in tractors and liquid fertilizer appliers (Schmitz and Moss, 2015). Mechanical harvesting technologies, which help pick and plow crops, have been rapidly adopted since the late 20th century. Although much displacement has occurred as a result of these, there are still new technologies emerging that will rapidly replace workers. Specifically, customized agricultural robots are emerging for specific crops. For instance, a machine is being developed by engineers in California that can thin a field of lettuce in 20 times less the amount of time it takes the human workers (Schmitz and Moss, 2015). Thus, farming workers are not exempt from this new wave of change.

There are certain technologies that optimize the work of human labor without completely displacing it. For instance, with the help of machine learning models, data points on temperature, soil, water usage, and weather conditions are leveraged to obtain insights on the right timing for chemical dispersion. “Intelligent spraying” occurs when AI sensors can detect weeds and decide which herbicide to use to target and eliminate the weeds. The “AI sprayers” help improve accuracy which has led to cost savings from reduced waste: “These robots are able to eliminate 80% of the volume of the chemicals normally sprayed on the crops and bring down the expenditure of herbicide by 90% (Wipro, 2019).” The robots help predict when is the best time to sow the seeds (scatter them where they have a chance to germinate) in order to arrive at maximum yield. The tool provides an exact date, as well as soil health and fertilizer recommendations. Similarly, farmers are using predictive analytics to understand what their crop yield will be in order to forecast pricing dynamics. For many farmers, price fluctuations are a big worry due to unstable production patterns. With the help of data analytics, companies can detect pest infestations earlier,

estimate output and yield, and guide farmers on weather conditions. This group of tools that is used to gather data and make predictions are not displacing many workers as they were nonexistent before machine learning and are extensions of predictive work originally done on an informal basis.

On the other hand, there are certain technologies that have been taking over manual labor in farming in the last few years. Agriculture robots, for instance, perform bulk harvesting in the U.S. with more accuracy and speed. However, as of 2018, only 3% of growers are using harvesting robots on farms (Cosgrov, 2019). The robots are mostly used for field and row crops such as potatoes and corn, but still lack efficiency on gathering softer crops such as fruits and vegetables. As adoption becomes more mainstream and the robot models become more efficient, workers will be displaced at an alarming rate. Signs of this are starting to show: In 2020, agriculture-tech startups in California received $5.6 billion in venture capital funding, composing 20% of the world's total funding in ag-tech (Sainato, 2022). With California composing an estimated 25% of the United States' food, the increased funding is certainly a sign of a coming change (Sainato, 2022).

See Exhibit 2.

Step 2: Processing and Preparation

After harvesting, crops are sent to cooling, cleaning, sorting and packaging as part of the processing step in food preparation. Artificial intelligence is actively disrupting this part of the food supply chain, optimizing processes such as sorting and packaging. EXHIBIT

The most common application of artificial intelligence is in sorting, which includes grading and inspecting crops to identify deficiencies. Previously a rigorous human labor activity, sorting left room for a lot of human error, leading to increased waste, infection hazards, and profit loss.

Sorting is now partly run by machines using AI technologies, specifically machine vision. With cameras and algorithms, machine vision can perform accurate inspection to detect product defects or contaminants. Crops are often homogenous, making them an easy target for robotic grippers to pick out. Good sorting is also an indispensable part of quality protection - an essential factor in this industry. Artificial intelligence has improved past scanning only for physical defects and can be used to detect sensory cues such as smell and taste. This recent innovation is crucial in replacing human handlers with machines as it was previously a human capability inimitable through technology. Essentially, it removes the need for food handlers to conduct sensory analyses, while at the same time improving cost efficiency and reducing error probability. Finally, many companies have integrated AI into their packaging operations. With AI vision, robots have gradually been replacing humans in the task of packaging, especially processed foods which are more uniform in shape and size.

Step 3: Food Service and Restaurant Operations

Once the food is packaged, it goes through wholesale and retail channels. Some of the aforementioned technologies are prevalent in wholesale companies, as well as some artificial intelligence tools used in logistics analytics and operations management. However, the most recent developments (as of 2022) have taken place in the retail companies that sell food directly to consumers. In this sector, technology is replacing service agents and optimizing workforce numbers. Automated machines can do previously-human tasks including taking customized orders, cleaning floors, and delivering items. Most of the big players are using artificial intelligence to improve customer experience, fast-track operations, and expedite services. A survey conducted by Lightspeed and Forbes in 2022 highlighted that of 2,000 restaurant operators surveyed in 2021, about 50% of hospitality operators in the U.S. utilized or planned to utilize some form of

automation technology (Srivastava, 2022). Starbucks is using artificial intelligence to help with labor scheduling while Taco Bell and McDonalds are using it to suggest certain items to customers (Maze, 2019). In fact, McDonalds' digital drive through menu boards display items based on time of day, weather conditions, and store busyness. Even more advanced examples include burger-flipping robots such as the one at a CaliBurger franchise in Pasadena or the delivery drones used by Domino's.

In other parts of the world, AI is even being used for facial recognition systems in order to understand customers and better predict people's choices. In a KFC restaurant in Beijing, for example, facial-recognition technology powered by artificial intelligence recommends menu items mashed on a customer's estimated age and mood (Hawkins, 2017). Although accuracy and adoption prospects remain unknown, this type of development is bound to reach U.S. grounds soon, and will displace millions of workers in the restaurant and fast-food service industry.

Effects on Labor Market

There are varied consequences that stem from the introduction of all these technologies. As AI-systems gain traction in agriculture and food service, the persons who completed the tasks pre-mechanization are likely to be displaced or forced into new roles. This shift will affect not just the people themselves, but entire communities and demographics.

In the agricultural sector, labor can be classified into two categories: hired and owner-operator. There supply and demand factors that affect these two types of laborers are different. Hired labor is affected by policies such as minimum wage rates and immigration policies, while owner-operator models are influenced predominantly by policies related to agricultural programs and tax or credit incentives (Bode, 2022). Technology improvements also affect these two units differently. Machine learning systems used for harvesting, sorting, and processing procedures

substitute the work of hired labor, while AI-embedded programming systems used for logistics, operations management, and consumer customization in food services affect more owner-operator models. From this, one can understand that as with all labor markets, there are losers and winners that result from the widespread adoption of new technologies. In fact, owner-operators benefit from new technologies as they seem to absorb most of the pros (cost efficiencies, speed and accuracy improvement, labor cost reduction) and much less of the cons (work substitution and displacement). This phenomenon can also be thought of in terms of high-skilled versus low-skilled jobs, with high-skilled labor benefitting substantially from automation and low-skilled labor suffering from the same. This discrepancy plays a crucial role in the shifting labor dynamics within agriculture and food services, as it pushes a further widening of existing gaps in socio-economic status.

Key Demographics

Food preparation is characterized by higher than average female workforce, with predominantly African American and Hispanic workers. On average, their education falls between high school degrees or less than high school; Around 90% don't have a college degree. (McKinsey, 2019). In terms of salaries, they tend to be skewed towards low-to-middle skilled jobs, which are in growth decline compared to higher-skilled jobs (and hence wages)" (McKinsey, 2019). With a displacement rate of 28% accounting for 1.4 million jobs at risk within food preparation, it is evident that some groups of people will be affected more than others.

Hispanic Workers

One of the key groups affected by automation and AI-technologies in the food industries will be Hispanic workers. Hispanic workers are overrepresented in food service and agriculture roles. With regards to farming, in the United States as of 2020, family-owners and members

account for an estimated two-thirds of the workers on U.S. farms. That leaves around one-third of work for hired workers, of which more than half (51%) are Hispanic (USDA, 2020).

See Exhibit 3.

Hispanics are also the highest racial group employed in food services – a sector estimated to lose 5.4 million jobs out of the 14.1 million jobs to automation by 2030 (McKinsey, 2019). Food services is one of the top 3 categories expected to have significant displacement, next to office support and customer service. Roles such as food preparation, delivery and service are the most prone to substitution.

Additional data regarding regions and states emphasizes the upcoming challenge for Hispanic workers. McKinsey estimates that out of the potential displacement, 65% will occur in just 5 states: California, Texas, Florida, New York, and Illinois. Three of these – Texas, Illinois and California – are dominated by the agriculture sector and rank among the leading 10 states with farms in the United States (Statista, 2022). Unsurprisingly, California and Texas have the highest Hispanic populations in the United States with a combined total of over 26 million Hispanic workers. Add another ~2 million if you were to include Illinois (United States Census Bureau, 2022). Thus, automation in agriculture and food services will directly impact Hispanic workers and the effects will be concentrated among communities in these states. The fact that Hispanic workers have the highest rate of potential displacement among all minority groups, a staggering 25.5 %, just highlights how worrisome this can become for the population and the need for policy responses (Mckinsey, 2019).

Skewed Towards the Uneducated

McKinsey's report denotes how there is an above-average percentage of food preparation workers that have at a maximum high school education, with very few of them obtaining bachelor's

degrees. They also highlight how individuals with a high school degree or less are four times as likely to be in a highly automatable role than individuals with a bachelor's degree. In food service, people with no postsecondary education make up 93% of potential losses.

Overall, minority races, specifically Hispanic and African-American, have the lowest college graduation rates in the United States, with the males showing the lowest (McKinsey, 2019). See Exhibit 4.

Education attainment is particularly important for job transitions. Not only is the median wage for holders of bachelor's degrees much higher than those with only high school diplomas, but the opportunities for career advancement and economic mobility are also substantially better. With supply of non-educated minority groups rising and demand for the low-skilled workforce declining, the offset could push wage declines for less educated workers in agriculture and food service roles. Although full education degrees might not be efficient for these groups of peoples, specific-skill programs or subject classes might be extremely beneficial when job transition is necessary.

Indeed, the technologies that will replace basic-skill often conversational-tasks, are experiencing the most widespread adoption. These AI-systems, such as McDonald's self-selecting kiosks and Amazon's no-checkout stores, are making their way into America's big players. Furthermore, they will soon begin to have artificial intelligence features such as custom recommendations that will further dilute the value of human intelligence. If workers cannot prove they add value apart from the tasks the machines will now be able to do, they are likely to face difficulty in retaining their jobs. Because of this, without education, it is extremely more difficult to transition into new jobs, especially those that present opportunities for upward mobility. On the bright side, McKinsey points out that there is some growth in occupational categories that do not

require postsecondary education such as builders, mechanical installation and repair, and cosmetic services. However, the difficulty of a transition from occupations in food services to these more mechanical, somewhat knowledge-based occupations must not be discounted.

Impact of Covid-19 Pandemic on Food Service Labor

The aforementioned developments are not occurring in a vacuum – just as every other trend in the world, the progress of artificial intelligence technologies was interrupted by the 2019 covid pandemic. The pandemic led to an economic shutdown, driven by the lockdown of day-to-day operations. The restaurant industry was not different – in fact, it was one of the most affected by lack of consumer spending. After many layoffs and furloughs, restaurants began to see revamped demand, but they found themselves short-staffed. Although most state restrictions have been removed, restaurants are still facing labor shortages, with the industry still down 750,000 jobs, around 6.1% of its workforce (Krietzberg and Lucas, 2022). Because of this recent labor shortage, the displacement of food service workers by machines has slowed down and the rate of displacement has certainly dropped. Even though it might take longer, the direction the industry is heading is still clear.

Considerations and Policy Responses

The disruption caused to the labor market by technological advancement should be cushioned with state and federal policies. Just as the government provides incentives for technological innovation, they should also be prepared to address the inequities that will stem from such.

The most powerful policy tool at the disposal of the U.S. government is to utilize education as a means for social progress. As was mentioned before, many of the people at risk of displacement in agriculture and food service do not have a bachelor's degree. This lack of

education not only limits the possibility of advancement from manual labor roles to higher-skilled occupations, but it also burdens job transitions. Targeted education programs for workers in the above industries can truly be helpful for increasing job security. Although bachelor's degree programs might be too costly or time inefficient, basic skills (language, math, etc.) might be extremely helpful in advancing the career of workers who don't have high school diplomas. In the least, it prepares them for roles in other sectors which might need more interaction skills. For instance, McKinsey predicts strong job growth in healthcare, STEM occupations, creative industries, and business services.

Most of these occupations require some type of customer service or language skills. Hispanics, in particular, who might have more trouble with the English language, can be assisted by language training programs.

Education can also carve a path for underrepresented sectors of society (including women and ethnic minorities) to receive training in AI technologies. Federal programs might be too broad for this type of action, but states with large populations of minorities can start to train their younger citizens for successful integration into the digital economy. On a similar note, state and local governments can help inform those at risk of job opportunities in other labor markets that are growing more. Although some occupations will shrink, others will certainly grow, creating more and often better work-opportunities. Information programs directed at workers in farming, food processing, or food services can prepare them for the future. In a similar fashion, programs that inform workers on retirement plans, the importance of savings, and other budgeting resources can help the workforce be prepared for the time in between job transitions. Lastly, alternative income and taxation models can help alleviate the concentrated impact of technologies on the working class (as opposed to the owners). Although tax cuts/incentives are products of political endeavors

and to suggest a specific path would be presumptuous, there are certainly fiscal and welfare policies that can be designed to help workers who are replaced by machine systems while they find themselves temporarily unemployed.

Indeed, because automation and AI-adoption is still in an early phase, it is difficult to predict which initiatives will be better at mitigating workforce risk. Similarly, it is uncertain just how much the role of the pandemic affected the supply of labor for these jobs and if this shortage is temporary or permanent. The next few years will be critical in understanding the proper policy steps to battle worker displacement.

Closing

The supply chain behind food production is fragmented amongst many players. From those involved in farming and harvesting to waitresses at restaurants, it is a system filled with many different actors and processes. Artificial intelligence will distort the system and its many puzzle pieces, just as it will many others. The benefits of this optimization will be profound (efficiency, increased yield, lower costs) and much good will come from it (battling the global food crisis). From harvesting robots to defect-detection machines, AI will help gear the next generation of optimization tools in food production. A consequence of this will be worker displacement. For better or for worse, the labor market will suffer the effects of human labor replacement, and the scale is definitely skewed. A concentration of Hispanic, uneducated persons work in the aforementioned occupations. Because of this, these demographics, also highly concentrated in states such as California and Texas, will be hurt more by automation than others.

Professor Hartsough, Chair of the University of California (UC), Davis Agricultural and Biological Engineering Department, highlights how reductions in harvesting costs by nearly one half resulted in large increases in employment in other field work, transportation and processing

jobs (Bode, 2022). Professor Hartsough's example provides an illustration of how technological disruption both disturbs the cohesion of a labor market, but also provides new waves of opportunities of employment. Hence, it is important to understand not just the challenges that will arise, but also the possibilities of adjustment and improvement. Although government intervention in market dynamics is tricky, preparing citizens for the workplace landscape of the future is also part of their responsibilities. To what extent should the government intervene? What type of educational policies will be effective in targeting the populations that will be most affected? How can we prepare low-educated citizens for future job positions? These are the questions we must ask in order to understand the proper steps that should be taken to lessen the future pain of unemployment.

Concluding Remarks

Demand for food is expected to increase between 59% to 98% in 2050 (MaxinAI, 2022). As such, the importance of minimizing food waste, improving efficiency and optimization yields should not be underestimated. AI-embedded technologies and machine learning systems can help solve many of the problems such as high food waste and the labor shortage we see in 2022. Thus, they are critical to the development of industries and will be a vital part of battling the global challenge of food necessity.

The trade-off between technological advancement and humanity suffering as a result is immeasurable. However, innovation is a key component of what makes society push forward into the future; While it cannot and should not be halted, the spillover effects and negative externalities require attention. The government, at all levels, should attempt to lessen the burden of work displacement by policies focused on education. Education can help by increasing the skill-level of workers to widen their potential occupations, as well as growing the motivation and opportunities

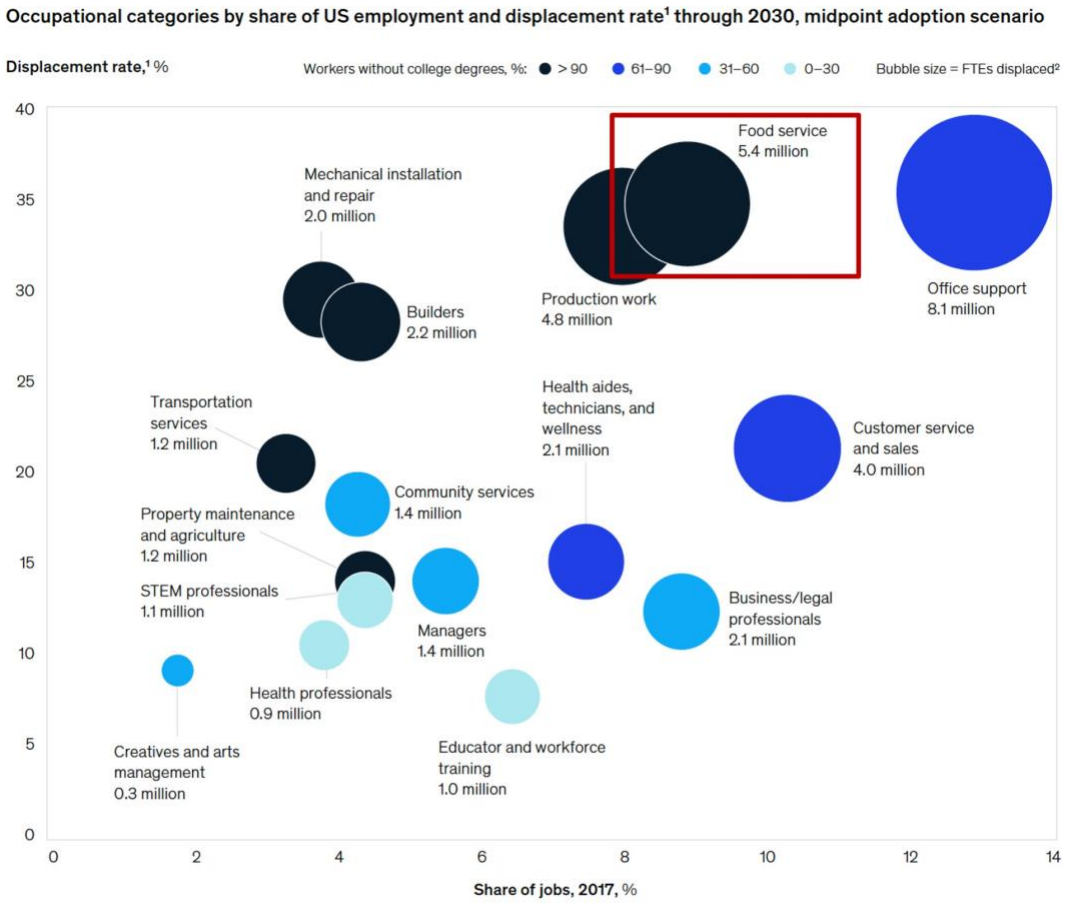
for upward mobility.

As a Hispanic, I fear for my fellow Hispanics who will be displaced and will have a harder time finding satisfactory employment. With inflation expected to continue rising in 2022 and 2023, and wages following, labor lay-offs are bound to continue. Once the AI-revolution evolves and disrupts both agriculture and food services, those who lack certain skills will be left behind. I find that it is still early enough to help educate young workers about the future of automation and which skills they need to overcome displacement. The future of artificial intelligence is promising, but it also raises many questions of fairness, equity, and economic disparity amongst people. The time to think about the future consequences is now, before it becomes too late.

Exhibits

Exhibit 1: Technology could handle the activities that account for ~35 % of all hours worked in food service occupations, or the equivalent of ~5.4 million full-time workers.

Source: McKinsey, 2019



[1] Based on the share of automatable activities for occupations within each category.
[2] Full-time equivalents displaced in midpoint automation scenario by 2030. In office support, for example, technology could handle the activities that account for more than 35 percent of all hours worked, or the equivalent of 8.1 million full-time workers.
Source: US Bureau of Labor Statistics; McKinsey Global Institute analysis

Exhibit 2: Artificial Intelligence in Agriculture.

Source: Wipro (Indian multinational consulting corporation that provides information technology and business process services)

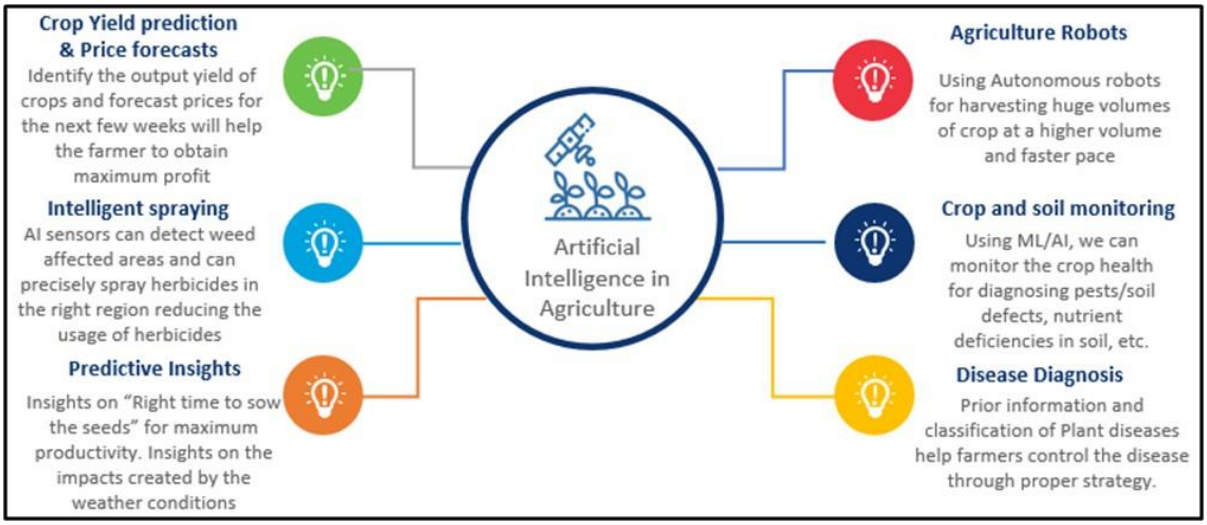


Exhibit 3: Ethnicity Composition of U.S. Farmworkers.

Source: USDA, Government Economic Research

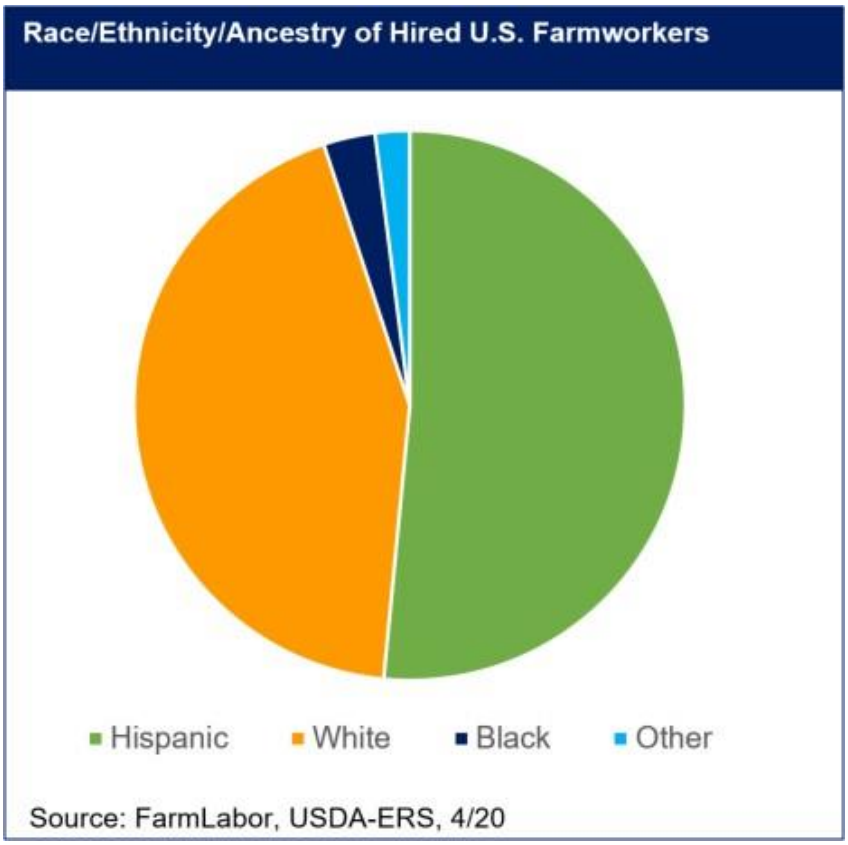


Exhibit 4: College attendance is rising but varies widely across race and gender. Hispanic and African-Americans remain largely below White counterparts.

Source: McKinsey, 2019

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