

# The Economic and Technical Feasibility of AI Substitution of Harvesting Jobs in the United States During COVID-19

~~~ Zemichael Gebeyehu, Svetlana Gulyaeva, Khadija Khan, Grant Kibel, Cameron~~~  
MacMahon, Norman Zvenyika, Mateo Sánchez

## 1. Executive Summary

This investigation looks into the economic and technical feasibility of replacing the agricultural job of a harvester in the US with an AI robot during the COVID-19 pandemic and provides policy recommendations based on these findings. Making use of AI to replace harvesting jobs is pragmatic, and in fact is demonstrated to be economically feasible through a large-scale examination of the agricultural industry as well as the occupation of a harvester during COVID-19. Next, an examination of the job of a harvester from a technical point of view is undertaken, and while many skills can be replicated, it is shown that the productivity of robots in a number of cases is limited on the shop-floor level by technological bottlenecks. This is done through an investigation of specific tasks a harvester must complete to carry out their job. This demonstrates a lack of technical feasibility of substitution that is shown to depend on what is being harvested. Furthermore, to confirm or deny conclusions made about feasibility, the responses from an interview with the CEO of HarvestCROO Robotics are dictated, and shown to support the conclusions. Lastly, future employability of harvesting workers can become problematic with a lack of legal protection policies for workers who are victims of AI displacement. With this in mind a number of policies may materialize, for example, incentivising the use of robots to complement labour rather than replace it.

## 2. Description of Issue

### *a. Background of the Issue*

During the last decades, the advancement of technology has been the pacemaker by which human beings and societies dictate their rhythm. It is also true that we contemporaneously relate technology to the development of software and hardware or even new machines based on machine learning. Nevertheless, what technology really means is any scientific knowledge by which human beings develop the tools to practically solve issues. In that sense, technology has always been a pacemaker for humanity, and what has become evident is that technology has drastically increased the rhythm over the last two centuries. Perhaps this accelerated pace threatens people's jobs. This uncertainty justifies several studies which analyzed the effect of new technologies within the labour sphere. Many studies, such as the one published on Oxford Review of Economic Policy (2020), are just beginning to consider the effects of the COVID-19

Pandemic in addition to the rapid development of technologies which are yet to determine the displacement effect to workers around the world (del Rio-Chanona et al. S94).

Taking into consideration the possible effect of AI and Automation in the labour sphere, the main concerns that arise are the advantages that the use of robots has over the traditional use of human labor. In the meantime, at least until robots are capable of interacting with humans in a social sense, the more clear advantages of their use are the reduction of expense (depending on the industry) in relation to wages, hours of productivity, and transportation (Barcia de Mattos). This conclusion is drawn by the work of the International Labour Organization about Robotics and Reshoring, Employment implications for developing countries (2020). In regards to the reduction of expenses by the effect of the employment of robots in regards to wages, the conclusion is clear, robots won't be subject to wages, motivating displacement if the task is subject to displacement. In the case of hours of productivity, the regulation to determine a maximum number of hours for the workday that employers are subject to might also be a motive to displace workers, once again if their tasks are subject to displacement. The concern due to transportation is correlated to the effects of offshoring and reshoring and is therefore a secondary effect of the previous two concerns. In that case, the concrete effects will depend on the needs and alternatives of each industry. Thus, the risk is implicit for workers being subject to displacement.

In regards to the second objective of this investigation, the effects of the COVID-19 pandemic, the proportions of these effects on the labor sphere are yet to be determined, and they most likely will be clear once the pandemic is solved. This is due to the fact that each country has its own plan to address the pandemic and the recollection of data, specifically within the labour sphere. However, this is a second priority for the governments at this time. The first priority being the containment of the pandemic and ensuring access to medical relief for those affected by the virus. Due to this, jobs have been left aside as a secondary concern. In that sense, most of the governmental policies during the harshest months of the pandemic have been based in isolation or social distancing. This has Drastically affected the access of workers to their working stations, and has even prevented them from carrying out their work activities. According to the Oxford Review of Economic Policy, "public health measures and changes in preferences caused by avoidance of infection" (del Rio-Chanona et al. S95), have become the primordial reasons for the effects towards the labor sphere. Within this study, the economic crisis caused by the pandemic has both supply-side and demand-side effects which secondarily affect workers and workplaces. In regards to the supply-side, most industries, companies, or independent workers are incapable of carrying out their labour activities due to the restrictions imposed by the government mainly on the "non-essential industries and workers". This "essentiality" measure has been popularized in the face of isolation, where most of the work has been done from home. A considerable percentage of workers are on total stop, since their labour activities were unable to adapt to remote alternatives. On the demand-side, people are not consuming goods or services which might increase their risk of contracting the virus. Because of

these two sides, most industries' operations have been drastically reduced and in consequence their working forces.

*b. The Question*

*Has Covid-19 affected the use of AI robots in the process of harvesting in the agriculture industry in the United States, and if so, to what extent has it affected the economic and technical feasibility of possible substitution of labor in this job?*

Harvesting is one of the least digitized branches of agriculture. Most of the fruit crop harvesting is done by hand, involving seasonal workers who are likely to be unauthorized immigrants engaging in hard physical/manual labor (Calvin & Martin, 41 ). The seasonal worker position primarily involves harvesting fruit crops safely and efficiently, ensuring productivity, and achieving goals that focus on thoroughness, speed, and quality. Covid-19 and the restrictive measures towards curbing the spread of the virus had an obvious impact on the agricultural workforce, especially on the pool of seasonal workers who are typically employed in fruit crop harvesting. This has led to a labor shortage and has jeopardized food security (Bochitis *et al.*1). The possibility investigated here is that of turning to robotic agriculture as a solution to speed up harvesting (Di Vaio *et al.* 4). In the US, which is partly dependent on agriculture for food, employment, income and social stability, agriculture harvesting robots have become an absolute must. With increasing urbanization and labor shortages, the use of agriculture harvesting robots in agriculture has the possibility to increase productivity, reduce waste, and increase agricultural sustainability. (Tang et al. 2).

*c. A Speculative Economic vs. Technical Review*

A brief review of the feasibility of AI complementing or substituting labor as it pertains directly to the job of a harvester in the COVID-19 crisis will now be conducted. To do this, four data points will be examined. The RLI, the “essentiality,” a measure of probability-of-substitution by AI, and the risk of exposure to disease and infection. Before this analysis is undertaken and these numbers are explained, it will be important to turn attention to the overall trends in this industry that have taken place over the course of many years (and what is expected in the future by pre-COVID-19 future projections for the industry) so as to distinguish them from any findings/ changes in the COVID-19 era agricultural sector. Referring to the Occupational Information Network (O\*NET), harvesting is included in the category of “Farmworkers and Labourers, Crop, Nursery, and Greenhouse”. The harvesting occupation specifically is designated as having an “average” employment growth according to the U.S. Bureau of Labour Statistics. Moreover, the 2019-2029 employment prediction of the United States Bureau of Labour Statistics for a harvesting role is only 3.8 percent increase for the coming decade (Employment). Comparing this data with the percent employment change between 2011 and 2019, which is approximately a 39 percent increase, indicates that the available additional jobs in the harvesting sector has significantly decreased compared to the last decade, leading to a sharp decrease of labour force in this sector. With this background in mind,

a look will now be taken at the effects of AI and automation in substituting harvesters to meet the demand for agricultural products. To begin the investigation, the four numbers that put the work of a harvester into the context of COVID-19 will now be undertaken.

First the RLI. The RLI or the Remote Labor Index is a measure of the activities in an occupation that can be performed at home, with 1 being all activities remote-friendly and zero being no activities performable remotely (del Rio-Chanona et al. 70). The RLI for the agricultural industry as a whole has the lowest average value of all industries.

The Occupation specific RLI chart from the same source demonstrates a significantly low number as well for farming. Since the RLI is not given for specific occupations within agriculture, the job of a harvester is assumed to have a very low RLI (below .5), since the main object of a harvester's work resides in a field which is not at home. In the spirit of the paper on supply and demand shocks (del Rio-Chanona et al. 74), to measure the "essentiality" of the job of a harvesting worker, the fraction of six digit NAICS codes relating to harvesting/ farming that are categorized as essential (Bennet) are examined. If this fraction is greater than one half, the occupation of a harvester/ farmer in the large shall be considered essential in further analysis. This fraction is 19/30, categorizing harvesting/ farming as essential. Last examined is the risk of infection for harvesters. ONET gives a work context variable named "exposed to disease or infection" which is a measure from 1- 100 of how often a worker in an occupation is exposed to disease or infection in the workplace ("45-2092.00 - Farmworkers and Laborers, Crop, Nursery, and Greenhouse"). 1 denotes very little exposure and 100 denotes very frequent exposure. This number for the occupation of harvester is 1. These three numbers have served to categorize the occupation of a harvester in the context of COVID-19, namely, that the work a harvester accomplishes cannot be feasibly done online, the work a harvester does can be reasonably categorized as essential, and harvesters are relatively safe from COVID-19 in the workplace.

Since it is reasonable for harvesters to be safe while at work during COVID-19, a review of economic feasibility of AI substitution must be a comparison of the cost of AI workers vs. human laborers during COVID-19. Such a cost analysis is enormously complex, since many harvesters in the US are undocumented. Because of this, many costs must be considered such as those posed by periodic contracts. Such an in depth analysis has been deemed out of the scope of this project. To simplify this cost comparison and reach a conclusion on economic feasibility, a brief look will be taken at what actions industries are actually engaging in during COVID-19. This will be used to gauge what is seemingly more cost-efficient. It is reasonable to conclude that some of the percentage decline of harvesting workers in the past decade has been attributed to the rise of harvesting robots in the agricultural sector. These robots have continued to meet some of the demand from the agri-food sector in the United States during the time of COVID-19. According to a market research report by Technavio, the global crop harvesting robots market is expected to grow at Compound Annual Growth Rate (CAGR) of 27 percent, with the North American region accounting for 39 percent of this growth (Crop Harvesting). This signals that the utilization of automated harvesting robots increased during the pandemic regardless of the fact that workers could still work without much risk of infection, indicating that robots are a

more cost-effective option (some reasons for this behaviour are detailed in the section *A Real World Perspective*). Since an increase in robotic substitution has been directly observed during COVID-19, it is reasonable to assume that robotic substitution is economically feasible. However, even though the development of crop harvesting robots has the potential to increase the productivity of many farms, it has unwavering consequences pertaining to the labour force and unemployment rate in the harvesting sector (entailing economic feasibility for the individual companies, *not* the industry as a whole). **The main consequence is a major problem with the inadequacy of worker-protection laws and policies that specifically target harvesting workers, which by far account for the larger portion of the agricultural occupations in the United States.** This will be investigated in the portion on policy recommendations.

Regarding the above analysis, one must recall that economic feasibility does not entail technical/ robotic feasibility. Indeed, according to the 2013 Frey and Osborne study, the major occupation of Agriculture, Fishing, and Forestry is indicated as one of the occupations with high probability of computerization (37). Over the last couple of years, advancement in AI and machine learning has led to the developments of crop harvesting robots that are capable of harvesting delicate crops and fruits such as strawberries with high precision and quality (Lewis). Despite these ideal results, in order to examine the total feasibility of robotic replacement one must also take a shop floor approach to make sure robots can do the job of a harvester if invested in. According to O\*NET the main abilities of a harvester are multilimb coordination, static strength, manual dexterity, trunk strength, arm-hand steadiness, information ordering, finger dexterity, stamina and near vision. (“45-2092.00 - Farmworkers and Laborers, Crop, Nursery, and Greenhouse”).

To pick up a harvest in automatic mode, several complex technological problems need to be solved. These problems include accurate and correct positioning at the collection point, synchronization of actions with other collectors, analysis and selection of the correct algorithms for use with different cultures, recognition of ripe fruits, disposal of damaged or non-germinated elements, accurate grip and cutting of ready-to-harvest crops without damage, checking the correctness of current actions and minimizing damage at the collection site, etc. In addition, it is necessary to perform all of these tasks at high speeds in constantly changing environmental conditions. One of the main factors limiting the development of harvesting robots is the determination of accurate 3D visual perception and stability in difficult conditions. This can make carrying out the ONET harvester ability of near vision difficult. Fruit recognition and localization in certain circumstances such as occlusion and illumination can cause errors due to the complexity of the environment. As an example, iceberg lettuce must be harvested by hand with a hand knife, and presents two major challenges to automation. One, it is difficult to visually determine the location of the vegetable. Any AI harvester must be resistant to changes in individual lettuce leaves, and their appearance is highly dependent on weather conditions, maturity, and surrounding vegetation. Two, in an area with uneven soil the lettuce stalk must be carefully trimmed at a specific height in accordance with commercial standards. And three, lettuce stalks can be easily damaged by rough handling. A salad picking solution must include a

high-precision, high-force cutting mechanism to ensure gentle handling of vegetables (Birrell et al. 229).

Finding a solution to improve the crop tracking accuracy is an issue to be solved. Technological bottlenecks like these make it very difficult to implement robots in agriculture at present from a technical standpoint. Therefore, from a shop-floor perspective, it is reasonable to state that robotic substitution of labor will only be technically feasible for a few specific types of harvester, depending on the crop. This also provides a valid explanation as to why it was observed in the speculative economic review that not all industries engaged in robotic substitution to cut costs during COVID-19.

#### *d. A Real World Perspective*

As a way to gauge the accuracy of conclusions made about the feasibility of automation, an interview was conducted with the CEO of HarvestCroo, Dr. Joseph Mcgee (Mcgee). On the issue of COVID-19 and agriculture, the result was slightly different than was expected. Even though the ONET “risk of infection” was low for harvesters (“45-2092.00 - Farmworkers and Laborers, Crop, Nursery, and Greenhouse”), Dr. Mcgee stated that since much of agriculture is based on cross-country travel, many workers could not get to their workstations without risk of infection, leading to a great decrease in the number of harvesters willing to work or show up at the jobsite (explaining why industries engaged in buying robots above). Additionally, H-2A visa application rejections have accelerated the demand for harvesting robots during COVID-19 period to meet productivity and labour demands in the harvesting sector. Similarly, with COVID-19 accelerating this trend, an aging population is already leading to a “chronic shortage of labour” in young persons with the ability to be farm workers (Mcgee). Furthermore, Dr. Mcgee mentioned multiple reasons why robots are more capable of maximizing revenue than human laborers, including the fact that they can measure the weight of the crops and pack/ store them according to specifications that are usually overmet, leading to loss of revenue. He stated that these three factors are leading to a direct increase in demand for agricultural automation. He elaborated on this fact by stating that “70% of the US strawberry business has invested in HarvestCroo,” and is currently waiting for the rollout of the final product. So why is this solution not being immediately implemented? The fact that the final product has not been perfected yet is, as Dr. Mcgee stated, a function of technical bottlenecks that would take “hours to present” including visual sensors as mentioned above. However, he expects that these can be dealt with in a few months to a year ahead. In summary, Dr. Mcgee believes that although technological bottlenecks stand in the way of complete automation in the short run, the aging population and accelerated effect of COVID-19 on the current carrying-out of agricultural business will motivate exciting new innovations that have the potential to completely substitute agricultural labor including harvesters. This leads to some questions policy-makers need to consider regarding the rights of these workers, this will be investigated in the next section.

### **3. Policy Options to Address the Issue**

- For the US government: Similar to other occupations in the United States, there should be worker-protection laws and regulations to ensure the involvement of workers in the harvesting sector through;
  - Subsidizing research and development of harvesting technologies that could possibly yield robotic augmentation of human labor in the harvesting process.
  - Corporate tax breaks for companies that reskill displaced harvesters regardless of immigration status.
  - Establishing a joint program with other governments which supply seasonal workers to the U.S. to reskill harvesting workers with short term training to enable them to operate augmented/semi-automated harvesting equipment.
  - Taxation of full automation harvesting systems to support joint government reskilling programs and facilitate H-2A visa programs in the future.
  - Incentivising startup companies that work on augmentation technologies to complement laborers or offering harvesting robot maintenance jobs to migrant workers by giving them tax breaks
  - For employers: investing more into infrastructure of communities that rely on agricultural employment. There should be more investment into furthering the education of workers so they can continue to be competitive with robots. This will allow them to compliment robots as opposed to being replaced by them.
  - Offering grants to higher education institutions specifically for research groups that are working on augmentation technologies.
- To conclude, a recommendation: For employers: investing more into infrastructure of communities that rely on agricultural employment. There should be more investment into furthering the education of workers so they can continue to be competitive with robots. This will allow them to compliment robots as opposed to being replaced by them.

### **4. Conclusion and Recommendations**

To that end, this study has demonstrated that the implementation of AI/automation to replace a harvester is economically feasible during the COVID-19 pandemic. Furthermore, it has been demonstrated that mechanical bottlenecks may get in the way of such implementation, relegating technical feasibility to a subset of harvesting jobs determined by the crop. In light of these conclusions, five policy recommendations have been given. The authors recommend that, with the conclusions of the above paragraphs in mind, these recommendations be considered, so as to prevent a response to the COVID-19 pandemic that could hurt harvesters.

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