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Agricultural Mechanization

American society has a tendency to romanticize farming. Perhaps this is due to the still-young nation's memory of the time when farming was the primary way of life. Farmers fought for independence; farmers became presidents; farmers expanded west toward the Pacific, conquering and domesticating the land as they went. Farming conjures the image of a man and his family pitting themselves against the land, growing what they need in order to survive and selling any leftovers for what tiny profit they can make. Though this kind of farmer still exists, American agriculture has largely transformed into an industry dominated by corporations that control large areas of farmland for mass production. These corporate farms require a substantial amount of labor to tend, harvest, and test the crops. The traditional method the corporations employed to accomplish this was to hire laborers on a seasonal basis during the harvest periods. However, in recent years, the agricultural industry has developed a new method of completing these tasks that has the potential to once again change farming across the nation: the use of computer-controlled machinery.

With the advent of cheaper, more powerful computers, researchers have begun experimenting with ways to incorporate automated machines into the farming environment. Though primarily assigned the task of harvesting crops, these machines have also assumed roles in planting, weeding, data gathering, and quality control. As is often the case with computers, the primary motivation for their use is to lower labor costs and increase efficiency. Though admirable goals, it is unwise to assume that these two reasons are enough to embrace this technology without hesitation. Several negative consequences could result from the widespread use of automated machines: unemployment for laborers and independent farmers, a decrease in the quality of food, and a further reduction in the diversity and number of farms in the nation.

The question surrounding the use of automated machines is primarily an ethical one. Taken from a purely capitalist viewpoint, several studies have shown most machines to be far more efficient than human laborers, working faster for less money and under less supervision. However, it is important to consider other issues such as those listed above before a rational decision can be made regarding the desirability of automation in the realm of agriculture. It is most practical to adopt a utilitarian point of view when considering these issues, the basic definition of which proposes that the optimal solution is that which produces the greatest amount of good for the greatest number of people. An optimal solution in this scenario becomes apparent only after weighing both the positive and negative consequences of using this machinery.

The benefits derived from the use of automated farm machinery vary greatly depending on the machine’s use. Farmers currently use machines for applications in areas as diverse as digging, weeding, testing crops for defects, planting, data gathering, and, of course, harvesting. Before going into detailed examples of these machines and their benefits, however, it is necessary to understand the argument that serves as a foundation for the ethical defense of farm automation. The primary goal of the use of automated machinery is to decrease the farmer’s costs. This would seem to have the effect of increasing profits for the farmer at the cost of several jobs previously given to hired laborers. Taken at face value, this outcome fails to meet the utilitarian criterion of the greatest good for the greatest number of people, and thus would be an unethical course to take. However, proponents of automation point to the primary economic model used for farming, perfect competition. The basic premise of perfect competition is that having a large number of firms in a business causes each to produce at a level of maximum efficiency and zero net profit in order to prevent competitors from stealing customers through lower prices. According to this model, the farmers who utilize machinery first do increase profits in the short-term, however, soon other farmers see this method of increasing profits and follow suit. Once a large number of farmers have access to the same technology, price battles occur that drive the cost of the crop down to the minimum, which is lower than before the adoption of these machines. In this long-term view, the farmers make exactly the same profit as before – theoretically, zero – but the overall cost of food is substantially lower (Ahearn 1). This clearly constitutes an ethical action according to this model, because though a small number of jobs may be lost, the cost of food nationwide drops, allowing a large number of poor families access to more food. This is the cornerstone of the ethical defense of farm automation.

Armed with an understanding of how lowering costs can represent an ethical farming practice, it is now helpful to examine some examples of this technology. One way the agricultural industry makes use of automated machines is to standardize aspects of crop harvesting. For instance, peat harvesting requires the farmers to periodically mill (turn over) the crop so that all parts are equally exposed to the air and dry evenly. One difficulty inherent in this task is the imprecision of human millers who turn over various depths of crop. This causes variation of dryness among the crop, requiring multiple harvesting runs to collect the entire range of dry peat, or, if it is all harvested simultaneously, a lower quality or even unusable crop that is wasted (Von Ow 1). When using a machine to mill automatically, however, the depth variance achieved is less than one-quarter of the human variance, eliminating the costs of multiple harvestings and increasing production of high-quality peat (Condon 127).

A second example of machine use in agriculture is the identification of defective crops. In most cases, this does not have a significant impact on cost, since a low number of crops are defective and the consumer can simply throw out and replace them when discovered. Defects in some crops, such as apples, are not so simple to correct. Apples harvesters have to combat watercore, an infection that causes tissue breakdown and a buildup of fluid within the apple. In mild cases, the apples are still completely usable and even slightly sweeter than normal. However, moderate to severe cases of watercore can ruin not only the infected apple, but also the entire batch in which the infected apple is stored (Shahin 265). Researchers have found that x-ray imaging can distinguish a watercore apple from a healthy one; however, this identification is tricky and imperfect. Human recognition of watercore apples from x-ray images is greater than 90% when still, but when shown at even half the speed of the processing line, the rate of success falls to 20% (Shahin 265). To mitigate this problem, researchers have developed automated machinery to scan the images for watercore. The success rate of these machines can reach 88%, leading to a decrease in the costs of replacing defective batches of apples, and in turn a lowering of costs for the consumer (Shahin 265).

In addition to economic benefits gained from the use of automated machinery, there are also methods of using these machines that lower the environmental cost of agriculture. For example, the traditional method of controlling weeds on a farm is through use of herbicides that are harmful to the environment. Farmers apply these herbicides evenly throughout fields, even though weeds themselves do not grow evenly, because the cost of weed location and localized spraying is too high. If farmers used just the amount of herbicide needed in the weed areas, herbicide use would be reduced by an estimated 40% (Manh 139). This overuse of herbicide can cause a significant amount of groundwater contamination (Abu-Hamdeh 178).

By using automated machines, researchers have found several methods to decrease the use of herbicide in weeding. One approach is to equip the machine with infrared cameras that can detect the differences between weeds and plants in most cases, and only spray the areas that require treatment. This approach can lead to as much as a 70% reduction in herbicide use, which would clearly have a beneficial environmental impact (Manh 140). Another technique could eliminate the need for herbicides completely. Research in peas and lettuce has indicated that applying a plastic mulch banding and then using machines to locate and remove weeds not only requires no herbicide, but also more than doubles plant productivity. In fact, one study indicates that using the mulch banding and mechanical weeding on peas and lettuce given only 25% of their irrigation requirements would still produce more crop than using chemical treatments at 100% irrigation (Abu-Hamdeh 181). Such application of machinery in weeding can produce not only environmental benefits, but also ways to deal with adverse conditions that would greatly benefit farmers and consumers in the unfortunate event of a drought.

Although there are many benefits of automated technology in agriculture, it is necessary to recognize the more subtle but equally important negative impacts of these machines. The primary concern is, of course, the loss of laborer jobs. Machines can typically each do the work of several laborers, increasing efficiency so that those laborers are redundant. Moreover, increases in agricultural efficiency have been responsible for the drastic reduction of agricultural laborers employed nationwide in the last 50 years (Ahearn 1). By 2000, despite a substantial increase of crops grown and harvested, the total number of hours worked by agricultural laborers nationwide had decreased to about 25% of the total hours in 1950, the product of a continual increase in efficiency (Ahearn 9). This is not to say that automated machinery has been around for 50 years, but only to show that historically, increased agricultural efficiency has invariably resulted in fewer laborer jobs nationwide.

The increasing use of automated machinery threatens to continue this trend of increasing efficiency and decreasing laborer jobs. In effect, this process transfers these jobs to the researchers and engineers who develop the machines. Though this may be a more productive use of money in a purely economic sense, ethical practice demands a consideration of who has greater need of these jobs. Engineers and researchers are trained, highly educated professionals; agricultural laborers tend to have low education levels and may be unable to secure a job outside of agriculture. In fact, the majority of agricultural laborers nationwide have to travel at least 75 miles from home to get to their jobs. Few would probably choose to do this when given a viable alternative (Mehta 20).

As a small aside, we feel obliged to mention the complication that slightly more than half of the agricultural laborers in the United States are unauthorized to live or work here (Mehta 22). This fact leads some to claim that those who have no legal right to be in the United States forfeit any such ethical consideration. The scope of this topic is far too broad to cover here, save to mention that the most general definition of utilitarianism makes no mention of whether people deserve good or not, but simply that the greatest good be served for the greatest number of people. Without passing judgment on the current political situation, we will continue to employ this broad definition.

A second negative impact of automated agricultural machinery is far more dangerous and far-reaching than the loss of laborer jobs. Though the computers built into these machines are becoming cheaper and more available, much of the hardware is still quite expensive. Automated pistachio harvesting systems, for example, operate on large tractor-like vehicles built specifically for the task. Many other machines need special vision hardware, such as the infrared weed detector or x-ray apple viewer discussed above. With each machine developed for farming tasks, fewer farms are able to afford the technology needed to continue competing in the market. This trend has accelerated the growth of large farms as well as the loss of small farms. Recent data has shown that 48% of all farm sales come from 1.3% of the total number of farms in the United States (Hoppe 9). This portion of sales is increasing, in part because the total number of farms nationwide is dropping annually. The National Agricultural Statistics Service, a branch of the U.S. Department of Agriculture, estimates that from 2005 until the beginning of 2007, a period of slightly more than a year, the total number of farms in the nation dropped by almost 9000, while the number of farms with sales over $500,000 increased by about

2000 (“Change” 1, “Farms” 1). While this only amounts to a slightly more than 1% drop in small farms, this trend, continued over several decades, could have severe implications. With more of the nation’s crops originating from fewer farms, several undesirable situations are becoming more likely.

The first dangerous aspect of this concentration of crop is the fact that it introduces a single point of failure for the nation’s food supply. It is well-known among computer programmers that there is no such thing as a bug-free program. These harvesting machines may have a procedure that unintentionally damages the crop they are attempting to harvest, weed, or plant. For instance, blueberry harvesters may break or scar branches, which can be an entry point for disease (Bertelsen 10). Granted, it is unlikely this would affect food supply nationwide, but it is reasonable to assume several large farms in a region could all use the same machines. An error or careless programming in one kind of machine could greatly affect the amount of a crop available from the area. Even if the programs are successful enough to limit this possibility, machines fail. Elements such as dirt, rust, heat, and especially precipitation, could potentially damage an entire fleet of machinery if the damage occurs while together in storage. Moreover, if these failures occur during or just before harvesting season, the large farm owners would have no way to harvest all the crops before they rot, leading to a drastic reduction in the supply of those crops, and therefore a large increase in the price of food.

In addition to the dangers of machine failure, there is economic danger in crop concentration as well. As shown above, the proponents of farm automation argue that the greatest good for the greatest number of people comes about through the economic model of perfect competition, in which a large number of farms drives down prices. If current trends continue into the future, however, there will no longer be a large number of farms. Perfect competition hinges on the premise that companies can easily enter or exit the industry without substantial costs, which is no longer the case when automated machinery becomes a requirement. Small farms will no longer be able to compete, and large farms will dominate the industry. This economic structure begins to approach a monopoly, for although there will be some competition should the large farms raise their prices to pre-automation levels, they will have essentially free choice of price below that level. The large corporate farms will drive small farms out of business, and then pocket the profits after a minimal reduction in the price of food.

Agricultural automation clearly has both benefits and drawbacks. The advantages mentioned here included lower costs, greater detection of defective crop, and less herbicidal pollution. The disadvantages discussed were loss of jobs, single point of failure risks, and potential for monopoly structures in the farm industry. This point is where the failings of a utilitarian approach make themselves apparent. There is no effective way to assign values to these pros and cons, do some algebra, and find a solution. The process instead becomes a matter of intuition and educated guesses. However, when viewed this way, it appears that the benefits of lower food cost for all outweigh the drawbacks up to a certain point, the point when the consolidation of crop into a small number of farms becomes a serious threat, and then the scales begin to tip the other way. Up to that point, there is only a downside for a small number of people, but past it, the risk of hurting a large number of people becomes too significant. Although it would be difficult to define this turning point, it does indicate that the ideal solution must lie somewhere between the two extremes of complete automation and none at all.

Much of the research in automation supports this mix of human and mechanical labor. Recall the example regarding the use of automated machinery to reduce herbicides in peas and lettuce, which found a mixture of mulch banding and mechanical weeding to be the most profitable method. In addition to testing this method and an herbicidal method, the same researchers also attempted to use mechanical weeding without the mulch banding. The result of this experiment was an output more or less on the level of herbicidal techniques, yet still significantly less than half the production achieved by the mulch and mechanical combined practice (Abu-Hamdeh 184). This mulch banding, crucial to the efficiency of automated weeding, requires delicate placement by human laborers. Theoretically, engineers could design a machine to perform this task, but the use would be so narrow that it would be a waste of money to develop, test, and produce, especially when a human can easily learn such a procedure.

Another study found blueberries picked by machine to be of significantly lower quality than those picked by hand. The blueberry farmers quickly developed an ingenious solution to this problem: since the blueberry-harvesting period is three to five weeks and several sweeps over the fields occur during that time, the farmers sent the human laborers out only during the first few weeks, when blueberry quality is the highest. The farmers sold these high-quality berries for fresh consumption. After a few weeks, when blueberry quality typically drops noticeably, the mechanical harvesters made their passes through the fields. The farmers used these low-quality berries for freezing and processing, uses which have much less stringent quality requirements than fresh consumption (Bertelsen 9-10).

These are just two examples of how human laborers and machines can work in harmony to produce higher productivity than either could achieve independently. Other examples can be seen or developed in most crops grown throughout the nation. Although the laborer's contribution to each crop is smaller than before, he must have a wider variety of skills and in addition be trained in the use and supervision of these machines. These requirements in turn lead to greater job security, for a farmer will be loathe to replace a laborer who already knows how to interact with the machines used at that farm. In addition, the use of human laborers lowers the risk of pushing smaller farms out of business. Some will still be unable to compete by buying the new machinery, but many tasks will remain in the domain of the laborers, and the amount of machinery farmers must purchase will remain at a much more reasonable level. Finally, the use of human labor mitigates the danger of damage done by machine failure. If the machines fail, there will certainly be some negative impacts, but there will be laborers present who can, if needed, go out and harvest the old-fashioned way.

Automated agricultural machinery has been changing the face of farming across the nation. Is this a good change? If farmers and researchers can pursue technological innovations that will capitalize on the efficiency of machines while simultaneously utilizing the flexibility of human laborers, it most certainly can be.

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