



The Effect of Automation on Employment and Wage Stagnation

Over the past 20 years, technology has progressed substantially, leading to improvements in computational power, “social” interaction, availability of information, and countless other areas. In particular, artificial intelligence and machine learning have taken off over the past few years, becoming more advanced and sophisticated. Not only have these technological advances been (sometimes seriously) compared to Terminator, but many are also scared that this new technology could seriously affect unemployment. Article headlines such as “One-third of US workers could be jobless by 2030 due to automation”, “Will robots and AI take your job?”, and “Automation could kill 73 million U.S. jobs by 2030” all stand to scare consumers and average citizens[1,2,3]. Are these fears valid? Will automation actually leave millions of citizens without jobs? Will entire countries break down due to an overwhelming number of impoverished citizens? These are all possibilities, but are rather unlikely. Automation will certainly eliminate jobs in some sectors, but just because some jobs disappear does not mean others aren’t created.

The first people who come to mind when people think of automation killing jobs are low-skill workers. No one is imagining a surgeon’s job being automated out of existence, but rather a factory worker or minimum wage employee at a grocery store. Business and Economics writer for Axios, Christopher Matthews, suggests that this is the case. When companies face demands for higher wages from their lowest level employees, they will always have automation as an alternative [4]. Consider the most common minimum-wage job known to man: working at a fast food restaurant. McDonalds has to pay all of its employees at least minimum wage, including all of the cooks, drive through attendants, cashiers, and managers. With some states increasing the minimum wage to \$15 per hour or more, all of these employees start to cost significantly more than they used to [5]. This leaves a corporation like McDonalds with a few options. They can increase prices on their food to make up for the changed wages, they can make less profit (unlikely in capitalistic, corporate America), or they can automate these jobs away. McDonalds has plans to eliminate all cashiers by 2020 by replacing them with ordering kiosks

[6]. Furthermore, they intend on using voice recognition software coupled with artificial intelligence to have orders taken at the drive through by a machine instead of a dedicated employee [7]. This case study exemplifies the ease with which a company can automate and the extent to which they are willing to. McDonalds will not stop employing people in minimum-wage positions; employees must cook and gather the meals, and then deliver them to the customers. However, this is a stark decrease in the number of overall employees needed to run a fast food restaurant on any given day.

Obviously, fast food is not the only industry which is looking to automate. Manufacturing is possibly the most natural industry to apply automation in. In a podcast from McKinsey, a renowned consulting company, Anu Madgavkar and Sree Ramaswamy discussed the effects of automation on the manufacturing industry and economy as a whole. They discussed how wage stagnation is a pressing issue in the current economy, and manufacturing has been no exception [8]. Manufacturing employees have relatively less bargaining power thanks to automation, because employees fear that their jobs will be taken away and replaced. Thus, these employees are unable to effectively unionize against their employer and demand increased wages.

Additionally, there has been a significant decrease in labor share for manufacturing employees, especially those at the lowest level in the industry [8]. Labor share is the percentage of GDP which is going to laborers.

Manufacturing has accounted for 65% of the decrease in labor share over the past 10 years, while only accounting for approximately 10% of the overall workforce. It stands to reason then that the manufacturing laborers are experiencing the worst of the wage stagnation and may actually be experiencing wage cuts. Sree Ramaswamy went on to explain that this is partially due to laborers in the

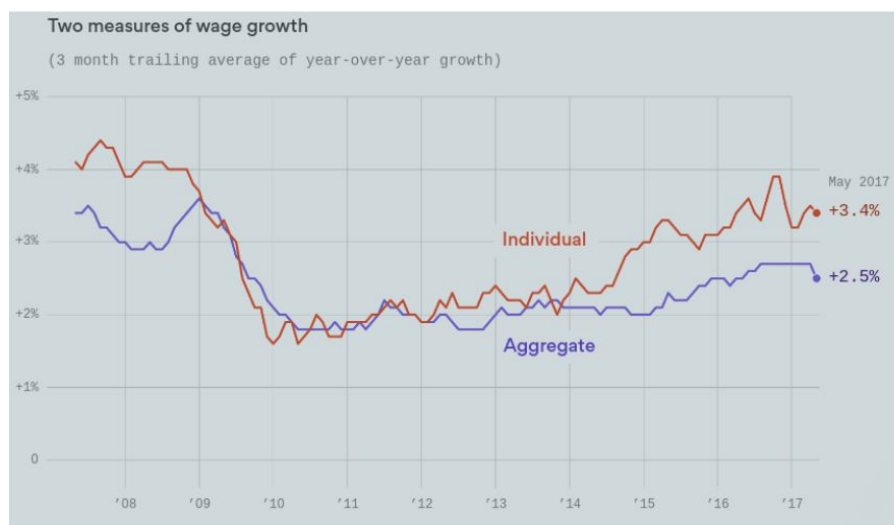


Figure 1: Individual vs. Aggregate wage growth [4]

industry being replaced by machines, but it is also largely a result of the manufacturing industry shrinking in the United States [8]. Ultimately, it is much cheaper for companies to look to third world countries for their manufacturing needs instead of paying the high premiums required to do manufacturing in the United States. Furthermore, when automation innovations allow for companies to lay off employees, they have a strong tendency to lay off the older, more experienced ones who take home a fatter paycheck. This can be seen in figure 1 which compares how individual wages have risen compared to aggregate wages. The relatively lower increase in aggregate wages shows favoritism toward newer, less expensive employees.

Anu Madgavkar made a great point in saying that job replacement as a result of automation is not specific to just low-skilled workers in the manufacturing industry, but actually applies to all workers whose jobs are routine and predictable. This could include not only those doing predictable physical labor, such as those assembling cars in Detroit, but also many office employees who tend to do the same thing day in and day out [8]. A possibly good rule of thumb is if your job is extremely boring and monotonous, it is subject to automation. Ultimately, some jobs are just going to be easier to automate; some industries lend themselves well to being done mostly by machines instead of people. That doesn't mean that all jobs are going to be replaced, but it does mean the labor force will have to shift.

Realistically, this required shift means that employees and economists have to find a way to make this transition possible, or else the country could face serious unemployment issues. One possible solution is to focus less on moving workers from industry to industry, and more on educating employees to do different jobs within the same industry. For example, consider automation in the car manufacturing industry. Sure, many employees working on the manufacturing lines will lose those jobs; however, many employees will still be needed to monitor the machine progress, perform small tweaks to the machines, change the settings as needed, and handle routine maintenance. While companies could hire outside employees to do these tasks, they also have the option of educating current employees, who already have lots of domain specific knowledge, and giving them these job opportunities. Even then, there would not be as many jobs available as before (otherwise the automation would have been completely

pointless), but it would help reduce some percentage of unemployment as a result of automation in manufacturing.

Another potential issue to consider in the wake of automation is how this unemployment can affect different groups. A paper from the Brookings Institution considered how different ages, genders, and ethnicities might experience automation from an employment perspective. They found that men and younger employees are at a distinct disadvantage when it comes to automation; their tasks are more automatable. In the case of younger members of the workforce,

this is understandable. First jobs tend to be at places like fast food restaurants or doing rote manual labor. On the gender side of things, men are more likely to do tasks which are automatable because a lot of the fields which are unlikely to be automated are women dominated. Some of these fields include healthcare, teaching/education, and

personal services [9]. Despite this, the largest problem revealed in the study is the imbalance which will result when stratified by ethnicity. In figure 2, we see that Hispanic, Indian, and Black employees are most likely to have their jobs taken over. The United States already imposes a distinct disadvantage on these underrepresented groups by way of bad urban neighborhoods and systematic racism in society, especially on the part of politicians. Automation replacing jobs for these ethnicities more frequently than others would just compound their already existing disadvantage. The Brookings Institution paper also highlighted that those who have a college degree are not necessarily safe from automation, but are somewhat “shielded by their degree”, thus being less likely to be affected [9]. One of the more obvious, though certainly controversial, solutions is to double down on things like affirmative action. Helping these underrepresented

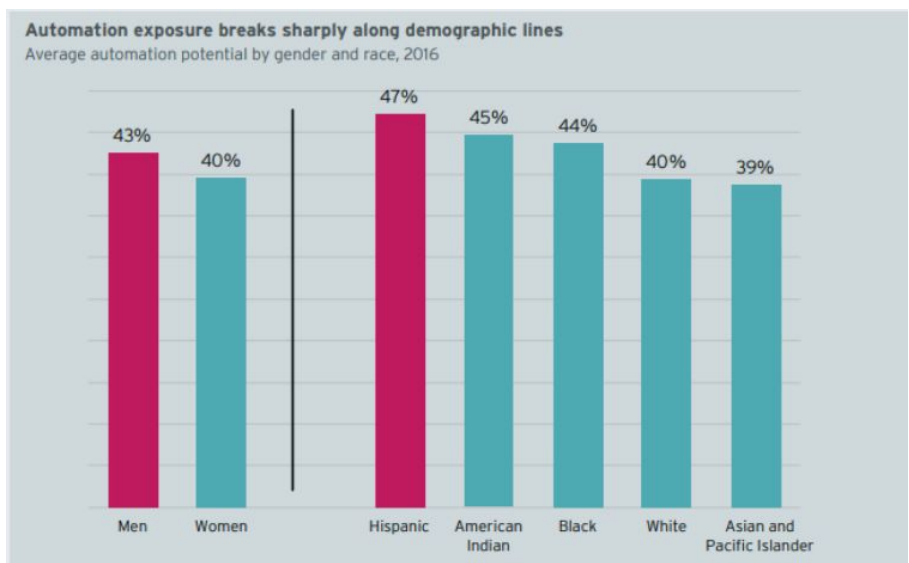


Figure 2: Share of automatable tasks by gender and ethnicity [9]

groups get a better education could be their best option to avoid being automated out of existence.

From a historical perspective, the current phenomena of unskilled workers being at risk of joblessness in the face of automation is an unprecedented one. A professor of economics at UC Davis put together a comprehensive set of wages in Britain which date back to the 1200s.

Davis took a look at the ratio of wages between “craftsmen” (skilled workers) and “laborers” (unskilled workers). He found that one of the major changes in this ratio came during the industrial revolution, when the ratio of skilled worker’s wages: unskilled worker’s wages dropped significantly. This can be seen in figure 3 and has a rather simple explanation. Inventions such as the power loom and spinning jenny actually replaced the skilled artisans who were creating fabrics and materials, instead of

replacing the very basic, unskilled laborers. Thus, these artisans were significantly less valuable than they were prior to the automation of their craft [10]. For the first time ever, technology has advanced to the point where widespread automation may be possible to replace unskilled labor.

An argument can be made that all skilled workers are not safe from automation. For example, consider an accountant. While an accountant has to go through four years of schooling and pass a certification exam, it is likely that a lot of their daily work can be streamlined or automated. That is not to say that accountants would not still be necessary, just that their work could be made much more efficient, and thus fewer would be required. Obviously, designing the software to automate an accountant’s job would have to be done with the help of an accountant. That is to say that even after the automation, accountants would be needed as consultants to help maintain and improve this automation product.



Alternatively, consider fields with more human interaction and personal skills required. For example, medical care requires adept interpersonal skills to not only help cure a person's ailment, but also make them feel cared for and safe. An even more specific example could be something like a therapist, which will almost never be replaceable by machine simply due to the nature of the job and the relationship required with the patient. Marketing also may be hard to replicate with non-human methods. Marketing focuses on getting inside the mind of a human and predicting what kinds of phrasing, imagery, and pricing will make a person want to purchase an item. This is an inherently human task, because an algorithm cannot possibly understand the nuances of the human experience as well as another human can.

An article in the Harvard Business Review references a study which found that higher-skilled workers are more likely to be laid off as a result of an automation event. They came to this conclusion by looking at companies with automation events, which are defined basically as a steep increase in spending on automation compared to previous years [11]. At these times, employees in the upper quartile of wages for their age were the most likely to get fired. In other words, of all the employees at the company, when looking at any particular age group, the ones who make the most money were the most likely to lose their job. On the surface, this just seems intuitive; fire the people making the most money so you can save the most. However, consider a manufacturing company with many roles: janitors, assembly line staff, middle managers, shift leaders, etc. The 45-year old employees making the most money are not going to be the janitors or assembly line staff; they will be middle managers and shift leaders. Thus, this study concludes that in general, the higher skilled, more "white collar" jobs are being automated away much more often than low-skill work.

That being said, the study also noted that the highly skilled workers who were laid off as a result of automation had a much easier time transitioning to new work. On average, the unskilled workers spent more time unemployed than the skilled workers did [11]. This can likely be attributed to how much easier it is to change industries with a higher level skill than it is as a general laborer. The article also considered if the sensationalism surrounding automation was worth worrying about as much as the media does. The study compared layoffs due to automation with mass layoffs, usually a result of plants closing, companies going bankrupt, etc. Automation

events do not even come close to having an impact comparable to mass layoffs. Approximately 0.7% of employees leave their jobs due to automation each year, while nearly 4.4% leave from a layoff event [11]. This statistic helps make the point that the state of the national and global economy have a much larger impact on unemployment than automation does presently.

It can be easy to see that automation has the potential to kill lots of jobs. As mentioned previously, manufacturing jobs are extremely vulnerable, and many higher-skilled jobs don't have a free pass either. Are there just going to be fewer jobs in the economy as a result of this? Will the middle class actually get thinner and thinner until it completely disappears? In an article titled *The Impact of automation on Employment: Just the Usual Structural Change*, Ben Vermeulen et. al attempted to answer these questions.

The opening sentence of the paper states we are on the brink of the 4th industrial revolution globally [12]. As mentioned earlier, Vermeulen is not the first person to draw this comparison, but it is worth taking a more careful look at. Historically, the industrial revolutions came about when big inventions allowed for much more efficient production. This could be seen in the eighteenth century when the steam powered engine was first introduced. Textile production exploded via new steam-powered inventions which could automate the skilled artisans who preceded them. Again in the early 20th century with the invention of cars, gasoline engines, and the use of Henry Ford's assembly line, production shot up [13]. When learning about these revolutions in high school history classes, unemployment is never mentioned. So how are these revolutions significantly different than the present automation revolution? In a lot of ways, they are not that different. The important consideration that many miss while considering future unemployment is the complementary relationship between human labor and automation. When production increased in the eighteenth century, the factories didn't just maintain the same amount of production and fire tons of employees. Instead, they hired even more employees than before and tried to make as many textiles and other products as possible, given their newly found efficiency. Corporations are greedy. No one is ever satisfied with their current profits; all companies are interested in earning more. If automation presents an opportunity to do so, employers will not replace all of their employees with machines, but instead will find new complementary roles for them to keep production as high as possible. In

other words, automation doesn't seek to eliminate jobs, but instead to increase output.

Companies are rarely investing in automation simply to fire employees.

Vermeulen's findings support those in the Harvard Business Review article suggesting that skilled workers are actually the ones who are more likely to be fired in an automation event. He suggests the most at risk are really medium skill employees - not the top level technical and managerial roles, but not the low skill laborers either. He hypothesizes that automation won't result in low level employees losing their jobs necessarily, but rather it will create a "hollowing out" of the middle class as a result of increased competition among employees [12]. Many of these middle skill workers will have to start competing for lower level jobs in order to keep food on the table, resulting in a greater supply of employees for companies to choose from. With an increased supply and stable (or even lessened) demand, the wage of employees will go down, or at the very least will not increase. It is at this point that we have wage stagnation.

The paper's findings are not all negative; the economy and unemployment rate are by no means doomed. The study considered three main economic possibilities following automation: there could be the "end of work", permanently higher levels of unemployment, or a "rebound" as seen in figure 4. The results of the study found that firms that automate tend to follow fundamental economic principles in doing so, and thus the most likely scenario is the "rebound" [12]. As touched upon earlier, automation will drive a firm's cost down; that is why they've introduced automation in the first place. With these decreased costs, the firms can then afford to lower the prices of their

products, because their margins are now wider and they want to be competitive with other companies.

Hinging on the most basic economic principle, when prices go down, demand

goes up. When demand for a given product increases, companies tend to hire more employees to keep up with the increasing demand. Effectively, the findings made by Vermeulen et. al

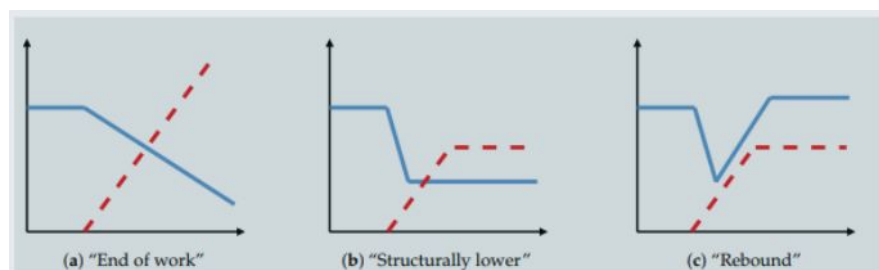


Figure 4: Three possible outcomes [12]

corroborate the intuition previously mentioned in reference to the industrial revolutions. In this extreme case where automation is perhaps making a more significant leap than previous revolutions, employment in these firms may fall. Even then, the effects will not be as widespread as the media would like people to believe because the effects of efficiency and demand will require the companies to hire some percentage of those “automated” employees back.

Given this relative decrease in employment still, will the economy fall into the “structurally lower” category? Vermeulen’s study seems to suggest otherwise. To get the full picture, one must look outside of the automated industry in particular. Obviously, the next logical step is to consider all of the jobs which will involve creating, installing, maintaining, and updating the automation software and hardware [12]. These employees will likely range from former “unskilled” employees to employees who have studied and specialize in the industry.

Beyond these obvious new jobs, there are also industries upstream in the process which will experience economic and employment growth [12]. Consider the industry which focuses on manufacturing and supplying electronic equipment such as logic boards and processors. These industries will experience substantial growth from the companies using their hardware to automate processes. One could argue that this example is particularly bad because the electronics manufacturing industry is one which lends itself extremely well to automation. While that is true, it does not negate the increase in production at that industrial level.

Beyond just these two obvious examples, there are other sectors where employment will rise as a result of an automation event. Vermeulen calls these sectors “complementary sectors”. These sectors facilitate the efficient implementation of the automation technology, exploit new business opportunities as a result of the automation technology, etc [12]. Falling under the efficient implementation section, we have professions focusing on education and training. When there are new tasks to be completed, one of the most important jobs to follow is the position which trains all of the new hires. Additionally, consulting can also be thrown into this “complementary” category. Often consulting can refer to many different things, but perhaps a consulting firm could specialize in the automation technology and training employees to do it such that an individual company wouldn’t have to hire someone to do these things full time.

Even still, there are more jobs left to be created than just what has been mentioned. Vermeulen refers to this as local demand spillover [12]. Effectively what he means is that as these new jobs are created, which tend to require a higher skill level than the ones they're replacing, people are going to be paid more. Higher skill jobs tend to garner higher wages. As a result, there will be more disposable income per capita (see figure 5). Higher disposable income logically results in people spending more money on things such as leisure, consumer goods, travel, etc. Thus, these "quaternary" sectors will see an increase in employment because the demand for their services will shoot up.

	1996	2006	2016	2026
Disposable personal income	5829.9	10,036.9	13,968.6	21,178.2
Disposable personal income, chained 2009 dollars	7476.1	10,595.5	12,608.7	15,440.4
Per capita disposable income	21,607.6	33,598.2	43,182.6	60,506.5
Per capita disposable income, chained 2009 dollars	27,708.6	35,467.9	39,160.4	44,112.9

Figure 5: Disposable income trends [12]

Vermeulen also lumps in an increase in healthcare jobs with these other sectors mentioned above [12]. This seems a bit out of place, because people generally do not actively choose to spend more money on health care when they are making more money. Elective procedures such as cosmetic enhancements or lasik are obvious counter examples, but these procedures are outweighed tremendously by urgent and necessary procedures. That being said, the number of healthcare jobs is predicted to grow by a significant margin in the next 10 years [12]. So why is that? Simply put, the population is getting old. The baby boomer generation was huge and is steadily getting older. As citizens get older, their medical requirements tend to sharply increase. Just based on American population trends alone, we can expect to continually see an increase in medical field jobs for the foreseeable future. Medicine is an inherently human job which cannot be automated easily without losing effectiveness. Technology can absolutely increase the efficiency of each employee in the medical field, but there is almost no chance of actually hurting employment number in the field via automation.

Vermeulen's study of data from the Bureau of Labor Statistics (BLS) concludes that automation is not going to drastically hurt employment. With all of the spillover effects from an automation event, the employment rate will be unlikely to dramatically change as a result of some jobs being automated [12]. Additionally, the extent to which the media portrays automation

is inaccurate. The vast majority of people have very little to worry about regarding automation for the foreseeable future. Most people will not have their jobs automated away within the next year or even ten years. Figure 6 shows what percentages of jobs have a normalized occupation automatability score of a particular value. The blue line represents that about 50% of jobs can expect 35% of their responsibilities to be automatable within the next 10 years. The red and green lines have similar meanings, showing that just

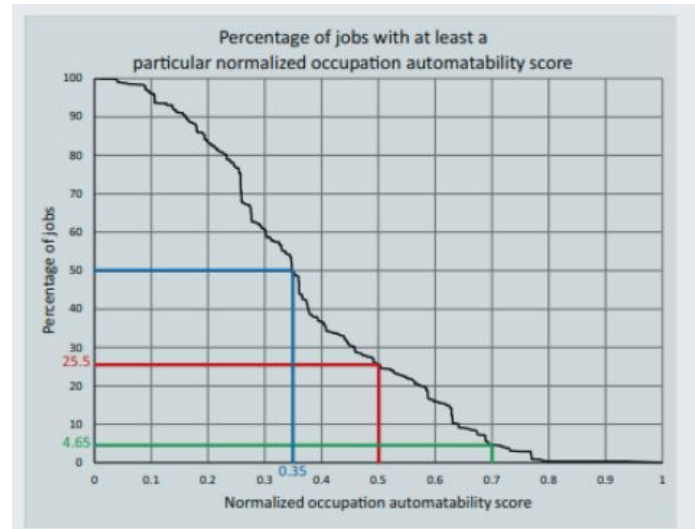


Figure 6: Automatability score [12]

4.65% of jobs will be 70% automatable within the next 10 years. The media makes large outcries about how many jobs will be gone soon due to automation, but that just is not true. These statistics can sound scary still, but when analyzed correctly, it becomes clear that a job which is 35% automated still requires a lot of manual work. Furthermore, that automation percentage is a projection for the next ten years. Even more, just because it will be possible to automate something ten years from now does not mean it will actually be done due to factors such as cost and reliability.

So then, is there even a problem as a result of automation? Will automation do any meaningful or even noticeable amount of damage to the economy? Well, in the short term, yes there will be damage. Vermeulen's research laid out all of the job replacement which will come as a result of automation. Generally, some people will lose their jobs, but plenty of others will be created and everything will be okay. The inherent problem with this outcome is not the number of available jobs, but rather the workforce's ability to fill the available jobs. If low skilled workers are replaced by automation, and all of the newly created jobs are in education, technology, and healthcare then we have an obvious problem: there are jobs, but the unemployed do not fit the criteria for any of them.

Furthermore, the distribution of jobs created and destroyed will decimate the middle class. If automated jobs are replaced by technically intense, higher paying jobs and an influx of retail and entertainment jobs due to increased disposable income, then the middle class will vanish. People will either belong to the technically advanced jobs and belong to an upper class, or they will work in some sort of unskilled role which can not really be automated. Additionally, these employees of the lower skilled markets will not share the disposable income of the upper class. When people have more disposable income, they spent it more and prices on goods increase as a result of the increased demand. That means that these lower skilled workers will have an even lower standard of living than before automation, even if their wage did not change when switching industries.

So then, what on Earth do we do? One consideration people often fail to make is that we cannot possibly imagine the new inventions and industries which will pop up in the next 10 to 100 years. It is easy to think that everything has already been invented and we will just incrementally improve on the inventions and constructs we have in present society. Because we cannot personally imagine what the new fields and creations will be, we automatically dismiss them as irrelevant. However, if the entire future of the economy rested on one person's ability to predict the future of technological advancement, we would all be doomed. In other words, we do not have to individually know what new industries will appear in the future and we cannot possibly know how many people these industries could employ.

The ultimate key to solving the automation problem is not hoping and praying for new innovations to solve all the problems. In a TED talk, professor David Autor gave an excellent historical example of this separation of the middle class [14]. The agricultural revolution decimated the number of necessary farmers in the United States. In 1900, 40% of all US employment was on a farm, whereas today it is less than 2% [14]. How then, did the economy possibly recover from this drastic change? Something called the High School Movement was put into place in the United States, which required the entire youth population to remain in school until the age of 16 [14]. This way, all of the younger generation would have the ability to read, write, and would generally be more educated and prepared for industry instead of farming. This

was by no means a cheap venture for the government, but it saved the economy almost single handedly.

So then, a possible solution is almost too obvious. The United States government should subsidize education in a way being done all over the world already. Many European nations already have exceedingly low costs for university, and the United States should follow suit. No where else in the world do “state schools” cost more than \$30,000 per year. Many of the low skilled workers are in these positions because they simply cannot afford to go to college without going into crippling debt. With education and student debt reform, the United States could become a substantially more educated country. With more education, there would be more members of the workforce available to fill the higher skilled positions created by automation. Education is key to innovation and a successful national economy, and could prevent problems with future automation in the United States.

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