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BIG and Technological Unemployment: Chicken Little Versus the Economists

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Abstract

The paper rehearses arguments for and against the prediction of massive technological unemployment. The main argument in favor is that robots are entering a large number of industries, making more expensive human labor redundant. The main argument against the prediction is that for two hundred years we have seen a massive increase in productivity with no long term structural unemployment caused by automation. The paper attempts to move past this argumentative impasse by asking what humans contribute to the supply side of the economy. Historically, humans have contributed muscle and brains to production but we are now being outcompeted by machinery, in both areas, in many jobs. It is argued that this supports the conjecture that massive unemployment is a likely result. It is also argued that a basic income guarantee is a minimal remedial measure to mitigate the worst effects of technological unemployment.

1. Introductory

I consider myself a disciple of Chicken Little, for I too believe the sky is falling: the unemployment sky, that is. Chicken Little's conjecture is that prospective developments in computers and robotics will result in an age with greatly reduced demand for human labor compared with the present. However, I am not a

follower of King Ludd (leader of the Luddites). I believe the era of reduced need for human labor will be a wondrous thing for humanity. On the horizon is an age where we might work because we want to work, not because we must work; an age where human labor is like the labor we devoted to our hobbies, motivated by joy and self-actualization. It will be very unlike our current threat-economy where fear of starvation, homelessness and death is a stick to ensure compliance by the masses to the imperative to work.

The main obstacle I see is getting from here to there. The change will be gradual. At some point, the labor of some but not all will be entirely optional. Or to put the point negatively, the threat-economy faces a paradox: the threat-economy says everyone must work but the threat-economy will not generate enough jobs for everyone, so the work of some will become redundant. How are these people to manage in an economy metamorphosing from the old to the new? A basic income guarantee (BIG) is the most attractive policy to help transition from the old to the new. I advocate instituting a BIG today to help us transition to a future so bright we will need robotically produced shades.

As a disciple, it is incumbent upon me to deal with an embarrassing problem: the master has been wrong for a solid two hundred years running. After all, the prediction that technological developments will lead to massive unemployment has been made since at least the turn of the 19th century, and at least over the long term, the prediction has proven false. The question, "Isn't two hundred years of failure enough?" deserves an answer. The aim of this essay is to provide an answer. While I concede Chicken Little's case doesn't look promising, at least initially, I hope to show that if we dig a little deeper, we can see why there are good reasons for siding with Chicken Little despite two hundred years of failure.

2. Technological Unemployment

One way to see the threat to employment from robotics is to think about all the jobs presently done by humans that could soon be done by robots. To see this, let's fast forward ten or twenty years and imagine you need to do a little shopping. You go to your local Walmart and pick up a few groceries and other household items. On the way to your office you realize you forgot to buy an electric razor, so you order one through Amazon on your cellphone. Your trip to the office is to pick up a book you are supposed to review. When you get home, you are not surprised to see that the razor from Amazon actually beat you to your doorstep. As you sit down to dinner with your clean shaven face to read your new book, you marvel that in all likelihood, all the products you are using were untouched by human hands other than your own.

How is this possible? The answer, of course, is robotics. The book you are to review was run off and bound by the licensed printer at your university. Yes, you could have received an electronic version right to your tablet, but you are old fashioned: you still like the feel of a paper book in your hands. Hence you had to use one of the few printing and binding machines that you know of: the one at your university. The razor was made at an entirely robotic factory and shipped robotically to an Amazon distribution center. When your order was placed, it was robotically packaged and sent out in a small robotically driven helicopter, small enough to drop the package right at your doorstep.

Your trip to Walmart also did not require human touch (other than yours). Gone are the days of waiting in line to have your items scanned and bagged. As soon as you put an item in your shopping cart, the embedded RFID tag was read and the item automatically charged to your account. Gone too are the small army of human shelf stockers. This job is now done robotically. Robots are also in use at every step in the

distribution and production sequence. Robots packed and drove the food to your local Walmart. Robots also were used to grow the food on the farm. Then they were packed and shipped robotically as well.

I expect two quite different reactions to this little description of consumption in the year 2024 or 2034: some will think it is wildly implausible because it attributes too much to robotic developments; others will find it wildly implausible because it attributes too little to robotic development. The latter reaction is probably closer to the mark; but only the former is inconsistent with what is argued here, so we shall focus on it.

What may be unnerving for those who do not follow robotic development closely is not how much extrapolation from our current technology is required, but how little. Some of this is already a reality. Part of our little story involved print-on-demand technology. But print-on-demand robots are already available. By 2024, this will be considered ancient technology.

The idea that the electric razor might reach your hand untouched by any other human is only a small extrapolation from current technology. Recently, Philips Electronics opened a factory in the Dutch countryside that uses 128 robots and 1/10 the human labor as a counterpart factory in China (Markoff, 2012). The robots work with greater acuity and dexterity than is possible for an unaided human, e.g., one robot bends a connector wire in three places, and guided by video camera, slips the bent wire into holes too small for the human eye to see (Markoff, 2012). The robots are able to do such incredible feats at such a rapid rate that the robots themselves must be enclosed in glass cages: their rapid speed is a danger to the few humans working in the factory. Of course, the robots are capable of working 365 days a year, 24 hours a day. The new factory has made obsolete the hundreds of Chinese workers who assemble razors in China the old way, using human labor.

Not only is manufacturing being revolutionized by robotic workers, but the same is happening in the shipping and receiving industry. We are on the cusp of being able to get inventory from the factory to the warehouse robotically. In some advanced warehouses, Kiva robots are directed by a computer program to select inventory from the warehouse shelves and bring it to human workers who actually place the items into boxes for shipping. On the transportation end, Google has software for driverless cars: vehicles that can drive themselves on busy roads. Of course, legal restrictions still require a human driver capable of taking over the wheel, but the software is already so good that experimental vehicles have gone hundreds of thousands of miles without any human intervention. The safety record of this software already exceeds that of the average human driver. It is not hard to imagine that human driven vehicles may be illegal in twenty years, only because they are so dangerous in comparison to robotically driven vehicles Thus, it is only the barest extrapolation beyond today's technology to imagine robots packing orders at the factory, driverless trucks shuttling inventory between factory and warehouse, and robots packing and driving orders straight to the doors of customers. Amazon recently demonstrated a helicopter delivery drone that could potentially make 30 minute deliveries possible, with the prediction by its CEO, Jeff Bezos, that the technology could be deployed within five years (Lee, 2013).

An obvious analogy here is the great reduction in the workforce, as a percentage of the population, devoted to agriculture. In 1790, there were about 3.5 million farmers, 90% of the population, while farm workers now make up 1.6% of the population with 5 million workers (Growing a Nation, 2005). Poignantly, even this small residual workforce will be replaced in large measure by "farmbots." Small prototypes being tested in the field do such things as plant seeds, pull weeds and harvest in swarms. Although they are not ready for prime time at the present, it is already possible for robots to plant, maintain and harvest fruits in the laboratory. In all likelihood, in twenty years, robots will greatly

outnumber humans on farms in the U.S. Agriculture hasn't seen the last reduction in its workforce (Sager, 2013; Sofge, 2009).

Not only will we see a radical reduction in the need for human employment in manufacturing, distribution, transportation and agriculture, but in more "cerebral" professions as well. There are medical programs that outperform even experienced physicians in diagnosing disease (Khosla, 2102). Surgical robots are also being developed. In both cases, the physician and the surgeon are not completely replaced, but it is easy to anticipate the need for both on a per capita basis might drop dramatically. For example, up to 60% of visits to family physicians are for upper respiratory infections that can be easily diagnosed with a computer program (Gonzales, Malone, Maselli, & Sande, 2001). The point again is that the claim is not that either profession is going to be completely replaced by robotics in the next twenty years, it is, rather, that robotics will increase the efficiency of physicians and surgeons such that fewer will be necessary per capita. A title of a recent CNN article summarizes the trend: "Technology will replace 80% of what doctors do" (Khosla, 2102).

It seems that hardly a week goes by when there is not some headline about robotics taking jobs. Almost to the day when I had finished a draft of this paper, a *Wall Street Journal* headline appeared with this intriguing title, "Robots vs. Anesthesiologists: J&J New Sedation Machine Promises Cheaper Colonoscopies; Doctors Fight Back" (Rockoff, 2013). About a billion a year is spent on sedating patients for colonoscopies. The robotic anesthesiologist developed by Johnson & Johnson promises to take over much of the labor of anesthesiologists. Physicians actually performing the colonoscopy typically charge in the $200-$400 range for each procedure. Anesthesiologists charge an additional $600-$2,000 on top of that. The robotic anesthesiologist, now approved by the FDA, would work for a fraction of the cost: $150 or so, per operation.

Medicine is not the only high profile profession under siege: there are computer programs operating today that can perform legal research faster and more effectively than well-trained lawyers (Krugman, 2011). We need not imagine a future where robotic lawyers stand up in court to give an eloquent defense of the accused to see that the need for human labor in the legal profession will decrease.

The so-called "oldest profession" should also worry about the reduced need for human labor. Sexbots are available now with several different "personalities," capable of performing a number of different sexual acts. The reason they haven't penetrated, as it were, the market further, is due at least in part to their price: they typically retail in the neighborhood of $10,000. As the price drops, there is every reason to suppose sexbots and other robots will replace even more human labor (Levy, 2011).

Part of why the robot revolution is still invisible to many, despite much recent press, is that we are still suffering a hangover from earlier expectations. There was a lot of optimism in the 1960s that general purpose humanoid robots might be a reality in the 1980s. The promise, obviously, was not fulfilled. Instead, what we have are far more limited special-purpose robots. Presently, robots are designed for very specific tasks, e.g., most of the robots sold for floor cleaning are specialized in terms of whether they vacuum or wash the floor. The idea that we would have a general purpose house servant like "Rosie" from the Jetsons is a long way off. Still, once our expectations have been retrained, we can see why the robot revolution is inevitable: robots are getting incrementally cheaper and better every year.

Robotic vacuum cleaners like Roomba have vastly improved in the last decade. When they first reached the mass market, they were designed to clean a single room, prone to falling down stairs, getting stuck in corners, and they needed to be recharged by humans. Now, many can vacuum a whole house unaided by humans. When the batteries run low, the robots return to their "feeding stations" where they recharge.

They are by no means perfect but certainly much better at vacuuming than your average teenager. They also work cheaper and do not complain.

Another example of robotic progress is Baxter from Rethink Robotics. Baxter is an industrial robot designed by Rodney Brooks, inventor of the Roomba robot. Consider cost first: Unimate is usually credited with the installation of the first industrial robot in 1961 (Roy, 2014). The robotic arm worked at a General Motors factory with hot die cast metal sorting and stacking. Unimate sold the robot at a loss: it cost $65 million to make and Unimate sold it for a paltry $18 million. Baxter costs more than a 1,000 times less, retailing at $22,000. Even compared to many of its contemporary competitors, Baxter is a giant leap forward. Often the price of the robot is a fraction of the total cost of operation. For example, a typical industrial robot that costs $100,000 at present might use an additional $400,000 in labor fees to have programmers write and debug code to instruct the robot how to perform its task. Baxter, in contrast, can be trained by factory workers: it is simply a matter of guiding Baxter's arm to show it what needs to be done. Baxter learns by doing rather than having new code input. This makes the lifetime cost of Baxter an order of magnitude cheaper than many of its competitors ($22,000 versus $500,000). Robots like Baxter will revolutionize industrial production.

As mentioned above, the robot revolution is being spearheaded by specific-purpose built machines. And because of this, there are very few who are able to see the revolution in all its clarity because it requires knowledge of developments in a number of specialized domains. For example, when a reporter asked Rodney Brooks, inventor of both the aforementioned Roomba and Baxter robots, how long it might be before robots could replace McDonald's workers, his response was very telling: According to Kevin Kelley, Brooks claimed that "it might be 30 years before robots will cook for us" (Kelly, 2012). His reasoning for this prediction is also interesting: "In a fast food place you're not doing the same task very long. You're always changing things on the fly, so you need special solutions. We are not trying to sell a specific solution" (Kelly, 2012). I can't help but wonder whether Brooks has ever worked at a fast food restaurant. As a former McDonald's employee, I can attest to the repetitive nature of the work.[1] I would describe working there in exactly the opposite way: you do the same task for a very long time with little variation in the routine at each station. Interestingly, there is already a robotic hamburger maker available from Momentum Machines (Murray, 2013). It will cook up to 360 hamburgers an hour, plus cut fresh tomatoes, lettuce and pickles. Or consider Kura, a sushi restaurant chain in Japan that uses robotics to lower its labor costs (Chan, 2010). The fact that a world class roboticist like Rodney Brooks has underestimated the robotic revolution is revealing. The reality is that we are almost at a tipping point where robots are cheaper even in an industry known for its low cost labor.[2]

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[1] I don't want to brag, but I was once "crew member of the month" at my local McDonald's.

[2] The tendency to underestimate the robotic revolution is apparent even in Brynjolfsson and McAfee's wonderful book *Race Against the Machine* (Brynjolfsson & McAfee, 2011). They mention that humans still have a competitive advantage in fine motor skills so that gardeners and busboys have occupations that are safe, at least for now. However, the Kura chain demonstrates the dispensability of much of the labor of busboys, and robotic lawn motors are busy today replacing the labor of human gardeners. The most detailed and methodologically sound investigation of the issue I know of can be found in Frey and Osborne (2013). They identify 702 distinct occupations in the U.S. work force and have found that "about 47 percent of total US employment is at risk" (Frey & Osborne, 2013).

Indeed, what is disturbing is that even in China, with its notorious low wages and harsh working conditions, there is a move to robotics. The Chairman of Hon Hai (also known as Foxcon), manufacturers of Apple's IPhone and other electronic devices, announced a few years back that the company's goal is to have a million industrial robots in use by 2014 (Wagstaff, 2011). The plan has hit some snags but is still proceeding at an aggressive pace (Perez, 2012). Some analysts suggest the price of robots is still too high for it to make economic sense for Hon Hai, suggesting that the price per robot would have to fall to $25,000 from their current $50,000 to $200,000 level. Interestingly, this is the price of the aforementioned Baxter. So, again we are reaching a tipping point where even in a low wage country like China, it makes economic sense to replace human workers with robots. Indeed, as we noted, Philips Electronics has already found it more economical to set up a robotic factory in Europe than have electric razors made in China with cheap labor and then shipped to Europe.

The logic behind this move is explained by Hon Hai Chairman Terry Gou: "Hon Hai has a workforce of over one million worldwide and as human beings are also animals, to manage one million animals gives me a headache". Terry Gou added that he wanted to learn from Chin Shih-chien, director of the Taipei Zoo, regarding how animals should be managed. Whether we find this offensive or not, it is hard to deny the logic of his thinking from a ruthless business perspective. Humans are expensive machines to run and maintain. The working conditions of Hon Hai regularly make the headlines because, as noted, they are the major manufacturer of Apple products. It is alleged that the working conditions at Hon Hai are terrible and that there have been a number of suicides as a result. Whether this is true or not, it is clear that negative publicity is not something Hon Hai desires. Even if humans could compete with robots in terms of work produced per hour, the extra "headaches" of managing "animals" is surely going to tip the scales in favor of robots. Focusing just on the economics of the issue, if the price of robot and human labor is even, then robots are leaving humans in the dust.

3. The Economists Versus Chicken Little

It can't be stressed enough that the argument is *not* that machines will completely replace all human labor. This may come to pass one day. (However, there are good moral reasons why it would be wrong for robots to replace humans in all occupations (Walker, 2006).) Long before this transpires, robots will partially replace humans in the workforce. This is the point I mentioned above where we are between two economies: between the threat-economy and the non-threat-economy. As long as the economy does not produce enough jobs for everyone to stave off the usual threats from the threat-economy—starvation, homelessness, death—Chicken Little is right. So, the argument is the relatively modest claim that robots will *reduce* the need for human labor below full employment.

It may help to put some numbers to these claims. The height of unemployment during the great recession of 2008-2009 was about 9.9% by 2010 (Bureau of Labor Statistics, 2010). If technological unemployment is occurring, within ten years the rate of unemployment will consistently be higher than this and it will continue to grow. In other words, the reason for the higher unemployment rate will be due not to the cyclical nature of markets or subprime mortgages, but because of huge increases in automation.

To this conjecture, it is often objected that economies have also found jobs for displaced workers in the past; for example, when backhoes automated the work previously performed by hundreds of workers on a single worksite with shovels, many laboring jobs were lost. But economic growth spurred new employment opportunities for the displaced laborers, including work in factories making backhoes, backhoe mechanics and backhoe salespersons.

Pressing the objection, it might be suggested that the analysis here is mere Luddism. The Luddites (1811-1817) reacted against the mechanized machinery of the industrial revolution. Skilled artisans in the textile industry were replaced by machinery and less skilled labor was required to operate the machinery. In response, the Luddites wrecked machinery, killed capitalists and battled with the British army.

In hindsight, it is easy to sympathize with their plight, if not their prescription. These artisans had much to fear. It is true that the economy as a whole benefited with the reduction of the price of textiles, but most of these workers did not reap a commensurate reward. Their jobs were permanently lost to automation and their particular skill set did not position them well to compete in a new economy. Imagine their plight as all the workers who put the requisite years in to learn their craft found out that their skill was no longer needed and that they would have no way to look after their families. At the micro level of the individual worker, this is very sad. At the macro level, we can see the benefit to the entire economy.

The same thing that happened to textile workers happened in many professions. The objection, then, can be summarized by saying that the history of the modern world is one of workers made redundant by machines. And each time workers are made redundant; disciples of Chicken Little have suggested that the employment sky is falling. Each time the prediction of massive unemployment as a permanent feature of the economy has proven false. Yes, there is pain as the economy readjusts, but eventually workers find new jobs; often in entirely new industries. This line of rebuttal to technological unemployment is nicely summarized by the economist Alex Taborrok:

> I am growing increasingly annoyed with people who argue that the dark side of productivity growth is unemployment. *The Economist*, which ought to know better, says we are overproductive. *CNN Money* discusses the problem of productivity, the President blames productivity growth for unemployment. Even someone as sophisticated as Brad DeLong writes "with productivity surging, it's hard to be pessimistic about GDP growth, but it's easy to be pessimistic about unemployment" which seems to suggest that if only productivity growth were lower, employment would be higher.
>
> And yet the "dark side" of productivity is merely another form of the Luddite fallacy – the idea that new technology destroys jobs. If the Luddite fallacy were true we would all be out of work because productivity has been increasing for two centuries. Sure, some say, that may be true in the long run but what about the short run? Even in the short run there is no necessary connection between productivity growth and job loss. In the computer industry, for example, productivity growth has led to falling prices and a bigger not smaller industry. If demand is inelastic then productivity growth can create short-term unemployment, especially at the level of the industry experiencing the growth – less likely but not impossible is that productivity growth leads to short-term economy-wide unemployment (Tabarrok, 2003).

I will refer to this objection as the 'economists' objection' simply for ease of reference. I do not mean to suggest that all economists endorse this idea, nor do I mean to suggest the idea is proposed only by economists. Indeed, the belief that the economy will always generate enough jobs seems to be well entrenched: every year I hear college freshpersons make it with the same unflinching faith as economists like Tabarrok.

Notice that the economists have the more extreme position. They are committed to the idea that the economy will generate full employment. Chicken Little wins if there is massive technological unemployment or even just a little unemployment. The reason for this division stems from the nature of

the threat-economy. It says everyone ought to work (or face starvation, homelessness and death). If robots take away enough employment to make full employment impossible, then the paradoxical result emerges that there is a demand for people to do the impossible. Therefore, as long as full employment is not possible, the threat-economy will have to be reconceived to remove the contradiction.

4. The Nature of the Debate Between Chicken Little and the Economists

Thus far I have merely rehearsed the outlines of a familiar debate. It is easy to get the impression that we are at an argumentative impasse. On the one hand, the case for Chicken Little is based on the observation that computers and robotics are making inroads into so many sectors of the economy: agriculture, mining, construction, manufacturing, retail, professional services, teaching, health care, and food services to name but a few. On the other hand, it is hard not to concede that the economists have a very powerful case. Their argument in a nutshell is:

> **Premise 1**: People wrongly claimed that automation will result in massive technological unemployment from 1811-2014.
>
> **Conclusion:** People who claim in 2014 that robots will result in massive technological unemployment are wrong.

The seeming impasse is exacerbated by the following problem: if we press economists to tell us where the new jobs will be created for workers in displaced industries to move to, they will (rightly) respond that it is generally impossible to foresee. The worker replaced by the automated threshing machine had no inclination that his grandson would work as an elevator operator. The elevator operator made redundant by automated elevators had no idea that his granddaughter would be a cellphone engineer. This makes the economists' position hard to criticize because they claim that some new but as yet unknown sectors of the economy will open up and employ workers made redundant by automation. It is, of course, hard to argue against the unknown.

Despite this seeming impasse, I believe the case can be pressed against the economists. The first thing we should notice is that the economists' argument is an inductive argument based on the general premise that the future will resemble the past. The general pattern of reasoning is straight-forward enough. A reason to believe that the temperature will dip below freezing next winter is that it has every other winter for as long as humans have recorded temperature in these parts. A reason to think the sun will rise tomorrow morning is that it has risen every morning since before humans populated this planet. Similarly, the economists' argument uses the same inductive pattern: every time automation displaced workers in the past, new jobs were found.

A crucial difference between inductive arguments and deductive arguments is that it is possible to accept the premises of an inductive argument but deny the conclusion, whereas with a deductive argument, this is not possible. Consider this deductive argument:

> **Premise 1**: People wrongly claimed that automation would result in massive technological unemployment from 1811-2014.

> **Premise 2**: If people wrongly claimed that automation would result in massive technological unemployment from 1811-2014, then people who claim in 2014 that robots will result in massive technological unemployment are wrong.
>
> **Conclusion:** People who claim in 2014 that robots will result in massive technological unemployment are wrong.

If we accept premises 1 and 2, then we are logically forced to accept the conclusion. With inductive arguments, it is possible to accept the premises but deny the conclusion. Generally, however, we need special reasons to deny the conclusion because denial of the conclusion of an otherwise good inductive argument requires denying the idea that the future will resemble the past. Suppose with the assistance of a time machine, you are transported to Pompeii, August 23rd, AD 79. Someone tells you that fresh bread will be available in the market the following day based on the fact that fresh bread has been available in the market every day for over fifty years. This is a very good inductive argument; but still you have reason to deny the conclusion, that bread will be available tomorrow, even while accepting that it has been available for the previous fifty years. Your knowledge that Vesuvius will blow the next day gives you reason to think that the future will not be like the past for the poor city of Pompeii.

I propose to take a similar line with the economists' argument. Although I think there are reasons to deny the premise, we will assume for the sake of the argument that the premise, that automation has not caused unemployment, is correct.[3] I will argue that there are reasons to think that the future will not resemble the past with respect to employment. Accordingly, we have reason to deny the conclusion of the economists' argument.

5. The Good of Humans in an Economy

To see why the future will not resemble the past, economically speaking, it will help to step back for a moment and ask what role humans play in the economy. On the demand side, things are relatively straightforward: humans are the primary consumers of the economic goods produced in economies. On the supply side, our primary benefit is in the form of labor. What we offer to the economy in terms of labor is helpfully illustrated by comparison with horses:

> There was a type of employee at the beginning of the Industrial Revolution whose job and livelihood largely vanished in the early twentieth century. This was the horse. The

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3 One worry here is how unemployment is measured. If workers give up looking for work, they do not count as unemployed by official government accounting. To make the unemployment rate drop, then, the nefarious government leaders need not necessarily create jobs, but simply a climate of despair. Some evidence for this increased level of despair is another measure of employment: labor participation rates. The percentage of the population classified as "workers' has trended down since the turn of the century.

Also, as Karl Widerquist has pointed out to me, stagnant wages are another indication of the effect of increased productivity. Both lines of evidence require far more discussion than I can provide here. Still, there is reason to believe that official unemployment rate figures are hardly decisive evidence that gains in productivity have not negatively affected the labor market.

> population of the working horses actually peaked in England long after the Industrial Revolution, in 1901, when 3.25 million were at work. Though they had been replaced by rail for long-distance haulage and by steam engines for driving machinery, they still plowed fields, hauled wagons and carriages short distances, pulled boats on the canals, toiled in the pits, and carried armies into battle. But the arrival of the internal combustion engine in the late nineteenth century rapidly displaced these workers, so that by 1924 there were fewer than two million. There was always a wage at which horses could have remained employed. But that wage was so low it did not pay for their feed (Clark, 2008).[4]

It is interesting to ask why new career opportunities did not open up for horses after the invention of the combustion engine. After all, if we are to believe that new job opportunities will open up for humans in the robotic revolution, then surely capitalism should have found jobs for horses after the internal combustion engine revolution. The unbridled optimism of the economists seems to suggest full employment for horses too. So, why did so many end up at the knackers? Why shouldn't we predict the same thing for human workers?

The answer is perhaps obvious: horses have one main thing to offer the labor market, namely, their physical labor. As the quote from Clarke indicates, it is not that physical labor is not valued in the modern economy; it is simply that the internal combustion engine (or electrical engine) can provide the same physical labor much more cheaply.

Horses also have some residual value in terms of what we might call "nostalgia". You can rent a horse and go for a ride. Or you can take a ride on a horse-drawn sleigh or go on a carriage ride through a park. No one pretends that these are the most efficient means to get around. Some people just like being around horses, or enjoy fantasizing about a bygone era when horses used to be the primary mode of transportation.

So, horses have two things to offer to the economy: muscle and nostalgia. By and large, their muscle power is not cost-effective in a modern economy.[5] And the demand for horse nostalgia is not enough to keep horses employed at the same rate they were in the early part of the twentieth century.

Humans have three things to offer the economy: brains, muscles and nostalgia. History shows the inception of two great transformations in the economy. The first, approximately 1800-1950, is where human muscle power was replaced by machine power. Thus, starting in the eighteenth century, there was a rapid rise in development of machinery to replace human physical labor. First steam, and later, combustion and electrical engines replaced human and animal labor. Take a simple example: A backhoe can dig a hole for the foundation of a building in a day; a small army of humans with shovels might take a month to do the same thing. In terms of energy output, we can see why this is so: an average human might generate 1/10 of a horsepower over an extended period of time, whereas a typical backhoe might be rated around 100 hp. A backhoe operator, then, has at his disposal the equivalent muscle power of 1,000 average human beings.

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[4] This passage is quoted in Brynjolfsson and McAfee (2011).

[5] There are still a few specialized uses for horses, such as use by police in parks and crowd control situations.

Perhaps nowhere is the replacement of human physical labor with machine power more obvious than in agricultural production. As noted above, at the turn of the eighteenth century in the U.S., about 90% of the population was involved in agricultural production. A mere hundred years later, this fell to 40% of the population. One such manual labor-saving device was the introduction of threshing machinery in the late seventeenth and early eighteenth century. Threshers separate wheat and other grain kernels from the rest of the plant. Prior to the introduction of the threshing machine, this was done through the use of a flail. A typical flail is two sticks of wood joined by a piece of chain. A flail, then, looks much like a nunchaku weapon, often seen in Kung Fu movies, although the sticks tended to be longer on a flail. Workers would beat wheat and other grain crops in order to separate the "wheat from the chaff." This was extremely physically demanding and labor intensive. With the introduction of the threshing machine, about 25% of the farming work force was made redundant. Again, at the individual level, we should feel sorry for those farm workers who were laid off and unable to find different work due to the invention of the threshing machine. But at the social level, we can see how automated farm machinery ultimately improved the lives of many: no longer must 90% of the population work on farms with long hours, low pay and dangerous working conditions.

The Second Great Transformation, 1950-2050, is where computers and robots replace human minds in the economy. Humans can still compete in the area of the mind, but as we have seen, this advantage is dwindling. Robots that work in factories, advanced computers that drive cars in busy traffic or make accurate medical diagnosis, or do effective law research, all are making inroads into areas where humans once had a unique advantage. There are two reasons for thinking that robots will continue to chip away at our last great advantage in the labor pool. First, the cost of hardware for robotic intelligence drops every year. This seems to be a consequence of "Moore's Law" which states that the number of transistors on integrated circuits doubles every two years. In plain English, computer hardware gets more powerful and cheaper every year. Secondly, gains in software can be distributed virtually for free. A comparison with humans may serve to highlight the difference. Teenagers are no better at vacuuming today than they were ten years ago. It costs about the same to raise them, and each child has to be taught the art of vacuuming. Compare that with robotic vacuums. If the computing power necessary to run the robot's brain cost $100 ten years ago, it now costs just over $3. Programs for robotic cleaners have also improved in the intervening period: robotic vacuum cleaners are less likely to fall down stairs, or get stuck trying to vacuum up a sock. Each time programmers make an improvement, it can be disseminated to current and future robots through a simple download. In short, although we still have one great advantage in the labor pool, our minds, our minds are not getting significantly better or cheaper, whereas robots are improving on both scores.

We can see then why the past is not a particularly good predictor of the future in the case of employment. With the First Great Transformation humans were squeezed out of brawn type jobs but new sectors opened up in brain type jobs. In other words, machines are encroaching in the last area that we have a competitive edge. So, unlike the displacement of labor during the First Great Transformation, there is no untapped category for surplus human labor to migrate to.

A couple of caveats are in order. First, the distinction between brawn and brain occupations is best thought of as lying along a continuum with few (if any) pure forms of either. My job as a philosophy professor is one of the clearer examples of a brain type job but even my job requires human muscles. I must, for example, pass out and collect student papers, carry books to class and so on. The brawn involved in my job is fairly minimal: it is not enough to keep me physically fit by any stretch of the imagination. Some of the purer forms of brawn jobs include rowing a galley or threshing grain. Neither of these is a pure form of brawn as at least some mental activity is necessary for each: following orders when to row, for example. The claim about two great transformations, then, may be nuanced by claiming

that the First Great Transformation saw a mechanization of jobs that tended to be on the brawn end of the spectrum and now we are seeing mechanization of jobs more towards the brain end of the spectrum.

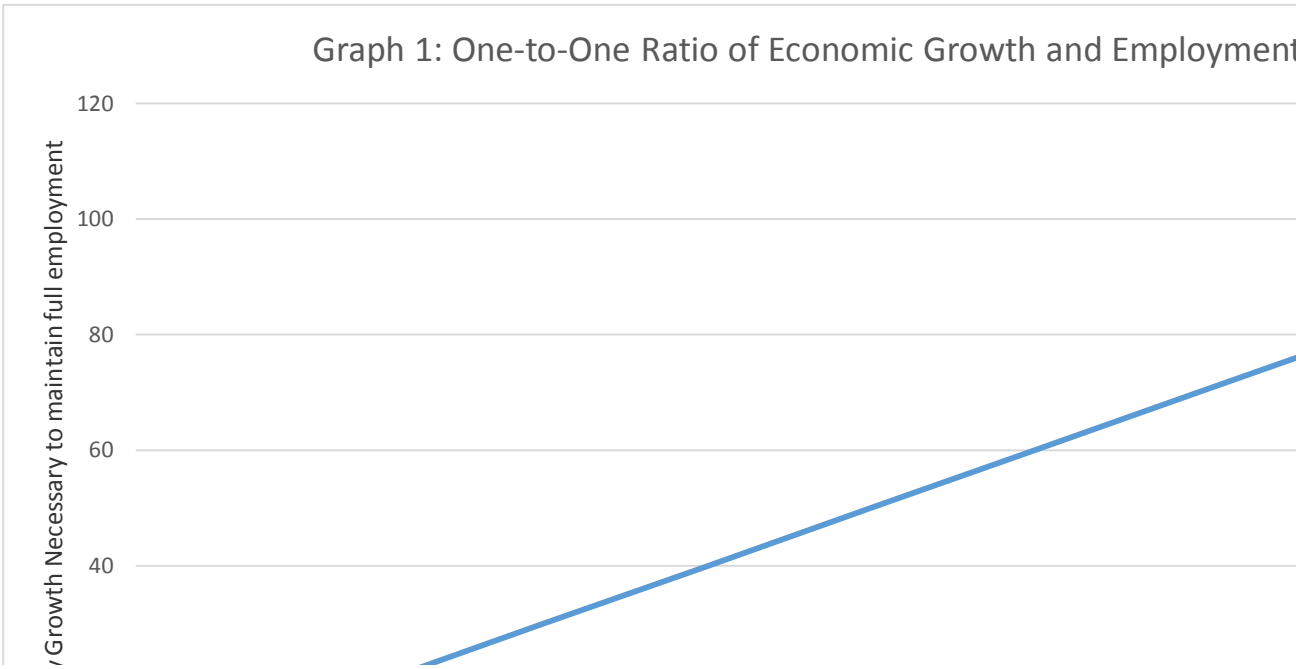
The second caveat is that humans will still be employed in nostalgic functions. For example, one can take a ride in an elevator in the Young-Quinlan Department Store operated by a human "elevator operator". Of course, at one time, elevators were not automated but run by specially trained elevator operators. The few that are still in operation appeal to nostalgia; it is certainly not cheaper to run an elevator with humans as opposed to computers. As with horses, we should expect the demand for human labor based on nostalgia will be pretty weak.

To summarize: the economists' argument says that new areas of the economy will develop to generate full employment. When Chicken Little asks about these job creating sectors, the economists say that it is hard to predict where the growth will come from. If it were easy to predict where growth is going to come from, investment would be straightforward, but it is not. The response to this is, even supposing new sectors of the economy open up, their demand for human labor is likely to be very weak since these new sectors too will be faced with the question of whether to employ robots or humans. The cost advantage will lie with robots for the most part, and so there will be weak demand for human mental labor in the future just as the demand for human muscle dropped precipitously in the past.

6. What If Chicken Little is Wrong?

Despite the strong case for looming technological unemployment, it is worth considering the possibility that Chicken Little is wrong. Chicken Little's dire prediction is based on two claims: (1) that a large number of jobs presently done by humans will be performed by computers and robots in the future, and (2), new sectors of the economy will not generate sufficient jobs for humans (because machines will supply most of the necessary labor in new sectors of the economy as well). Interestingly, there is near universal agreement among experts about (1). The residual disagreement between Chicken Little and the economists is about (2).

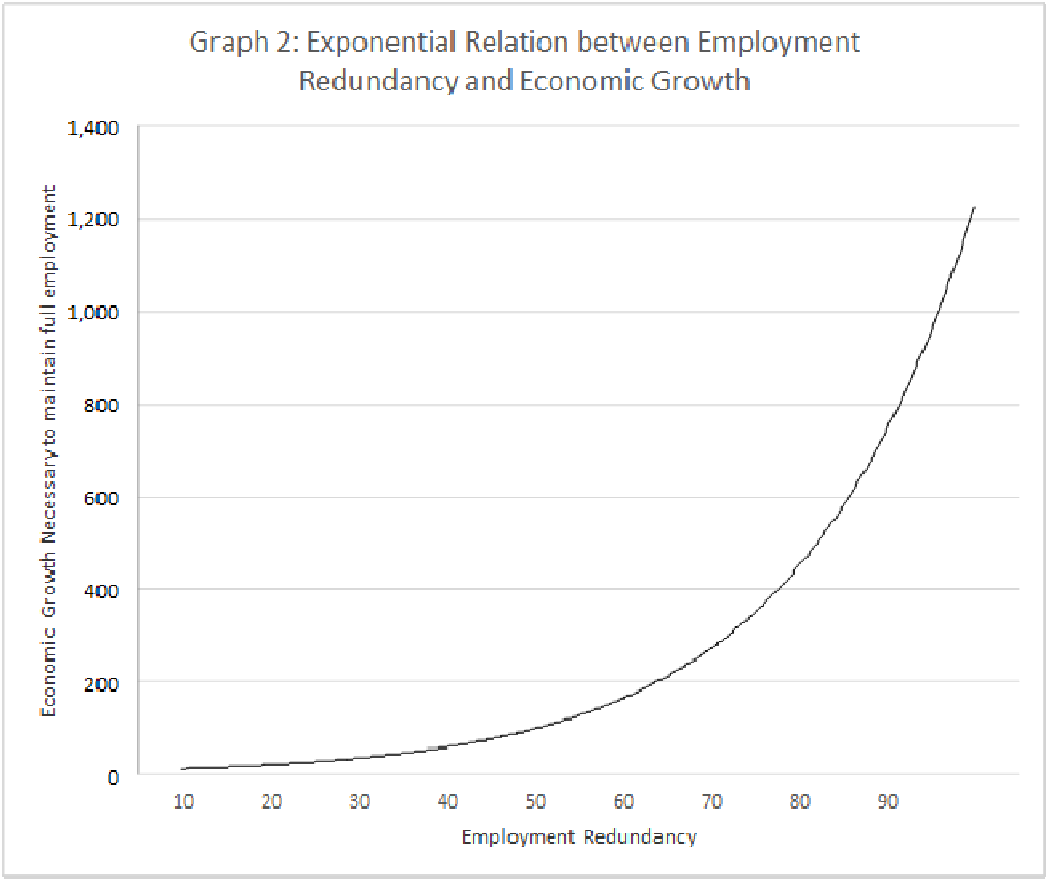
It is worth seeing what the economy will look like if (2) is false and (1) is true. The answer is that there will have to be massive growth in the economy. Specifically, growth in economic output will have to be greater than worker redundancy. For example, it might seem reasonable to expect that if 10% of the workforce is made redundant by robotics, then the economy would have to grow by 10% to absorb these workers to maintain full employment. Such a one-to-one relationship is illustrated in the One-to-One graph below.



However, the one-to-one relationship is not plausible. Here's why: Suppose an economy comprises exactly 100 firms with 10 workers per firm who each produce 1 widget per year. 'Widget' is to be understood as the product of the company, it could be goods or services.. This means that the economy produces 1,000 widgets per year. Imagine robotics and advanced computers replace only 10% of the work force. It is easy to suppose that the one-to-one relationship must be correct: the economy must grow by 10% in order to absorb these workers in order to maintain full employment. However, this is not the case; the economy would have to grow by more than 10% to absorb the workers. If each firm now only employs nine workers, the number of unemployed will be 100 workers. If the economy grows by 10%, this would translate into 10 new firms. In other words, 110 firms each producing 10 widgets equals 1,100 widgets per year. But 10 new firms would only employ 90 people, because the average number of workers employed has dropped to nine. So, the economy would have to grow by more than 11% to get back to full employment. The difference gets more dramatic as the redundancy percentage is increased. For example, if robots replace three out of 10 jobs at each firm, then the economy will have to grow by 43% to get back to full employment. For now there will be 300 people to find jobs for. Since firms now only employ an average of seven people, 43 new firms will have to be created to maintain full employment. If robots are able to replace five out of every 10 jobs at present, as suggested by Frey and Osborne's detailed study, (Frey & Osborne, 2013), then 500 people will be unemployed in our toy economic model. 100 new firms would have to spring up, that is, finding work for 50% of the workforce translates into a 100% increase in economic output.

Firms	Employees per firm	Total Employees	Total Widgets	Percentage of economy in 2014
100	10	1,000	1.000	100%
111	9	1,000	1,110	111%
125	8	1,000	1,250	125%
142	7	1,000	1,425	142%
166	6	1,000	1,660	166%
200	5	1,000	2,000	200%
250	4	1,000	2,500	250%
333	3	1,000	3,333	333%
500	2	1,000	5,000	500%
1,000	1	1,000	10,000	1000%

The point, in other words, is that new industries themselves will likely use advanced robotics and computers and so economic output will have to increase faster than the percentage of unemployed to keep the economy at full employment. Graph 2 shows the relationship necessary for economic growth and full employment.



We are now in a position to see why BIG is a smart bet, given uncertainty. Either the future economy with massive implementation of robotic workers will not generate full employment for humans or it will. If the former, then there is a clear need for BIG. In this case, we imagine that workers are simply outcompeted by robots in many areas of the economy. Addressing the needs of displaced workers is morally and prudentially important. Morally, of course, we ought to care about the plight of our fellow humans. Even for those motivated solely by prudential concerns, BIG would be an efficient way to stop social unrest caused by massive unemployment. Those still employed, in other words, should find BIG an attractive means to avoid the threat of having their heads put on the ends of pikes by angry mobs upset by perceived unfairness of the robotic revolution.

On the other hand, if the economy is able to generate full employment, then the economy will have to grow faster than the redundancy rate to keep full employment. This means that the economists who predict full employment must also predict a fast growing economy as a logical consequence. That is, optimism about full employment logically requires optimism about a massively expanded economy. In this case, paying for BIG will be comparatively easy, as it will be a small percentage of total economic output. As I will show in the following section, a reasonable BIG for U.S. citizens works out to 12/5% of the economy at present. Using this as our baseline we can see, that, if 20% of the jobs at present performed by human workers are performed by robots while full employment is maintained, then paying for BIG as a percentage of the economy should fall to 10% from 12.5% of total Gross Domestic Product. If half the jobs are taken over by robotics in an economy with full employment, then the total cost of BIG is about 6% of this economic future. So, what makes BIG a rational bet is that either it will be urgently needed or easy to pay for (and perhaps both).

7. A Simple Way to Pay for BIG: a 14% VAT

The call for a BIG is often met with the criticism that it is utopian. In one sense, the criticism is about its political feasibility: is it possible to get enough BIG votes in Congress? In another sense, the utopian objection is that the U.S. could not afford BIG. I will attempt to address the latter objection in this section. I have no expertise concerning the former[6], but I hope, perhaps naively, that Congress might be persuaded by good reasons. This paper is an effort to make the case to voters and representatives for BIG.

Many, perhaps most, authors writing on BIG do not suggest an amount for BIG. No doubt there is much wisdom in not attaching a dollar figure, but nevertheless, I am going to stick my neck out and say that it should be at least $10,000 USD per year in the U.S.[7] This meagre amount is below or at the official poverty line for most places in the U.S. In a land of plenty it is far from generous, yet, for many, it would be enough to stave off the worst forms of monetary deprivation.

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[6] Calls for progressive social change are invariably termed 'utopian' right up until the moment of legislative change; at which point, the changes are seen as inevitable. The pattern repeats with the emancipation of slaves in the U.S., the suffrage of women, and the legalization of same-sex marriage. Hence, I have little faith in the objection to BIG that it is politically utopian. The crystal ball to the future seems no clearer now than it did in the past.

[7] I will confine myself to the U.S. case here. Clearly, much more would need to be said once the discussion takes on a global perspective. So, what I offer here is merely a piece of a much larger puzzle.

Some may say this is not enough, but the BIG is proposed as a *floor* rather than a ceiling. I'm all ears to proposals that call for a higher amount. Notice, however, that such proposals are entirely consistent with the claim that BIG should be *at least* $10,000.

To show that BIG is economically feasible, let us first work on calculating its cost. As a first cut, there are 194 million adults 18-64 years of age in the U.S. A BIG of $10,000 equals $1,940 billion or $1.9 trillion for this group (Sheahen, 2012, 87). This represents only a portion of the over 300 million people living in the U.S. The 36 million seniors in the U.S. already have access to something like BIG: Social Security (Sheahen, 2012, 87). In the future, it might make sense to roll Social Security in with BIG, but for the present, we will assume that seniors will either collect their current Social Security or a BIG equivalent, whichever is greater. An additional 40 billion would be required to top up the lowest Social Security recipients to bring them up to the proposed $10,000 BIG (Sheahen, 2012). We will add this to our proposed budget, so we need to find an additional 40 billion to get to the total necessary to finance BIG to $1,980 billion.[8]

So, we are looking to finance approximately an expenditure of two trillion dollars. A huge number for sure, but in terms of the size of the total U.S. economy, over 16 trillion (World Bank, 2014), BIG would represent only 12.5% of the U.S. economic pie.

Allan Sheahen has looked at how the U.S. federal budget might be amended to pay for a $10,000 BIG (Sheahen, 2012). I am sympathetic with Sheahen's approach but I want to explore an alternate means to finance BIG through a 'value added tax' (VAT). Europeans and many others are familiar with VAT, but for those who are not, VAT is basically a sales tax that would be added to all final goods and services sold in an economy.

A VAT of 14% would generate sufficient monies to pay for a $10,000 BIG.[9] The VAT would apply to absolutely all final goods and services. So, there would be a 14% tax on food, haircuts, books, medical services and so on. However, consider those trying to live on $10,000 a year when the new VAT is introduced. Suddenly, their income would not go nearly as far. Imagine they spend $200 a month on food. After the 14% VAT is introduced, the same groceries would cost $228 a month. Their share of rent would increase from $300 to $342 a month. To have the same purchasing power as before the new tax, those living on $10,000 a year would need another $1,400 to pay for the VAT. So this is what I propose: increasing BIG to $11,400. As should be clear, this won't make those living on BIG as the sole source of income any better off, for although they have 14% more money, everything will cost 14% more because of the VAT.

Of course this raises a worry: who wants to pay an additional 14% tax on top of existing taxes? Many might say: "Yes, I would like to help the poor but a 14% tax on everything is a huge burden." In response, I say most of us should welcome VAT to pay for BIG for purely self-interested reasons. Suppose you have an above average salary of $50,000 per annum. A new tax of 14% would mean $6,100 in additional taxes. Yes, that is a lot out of $50,000, but remember too that you receive $11,400 in yearly BIG

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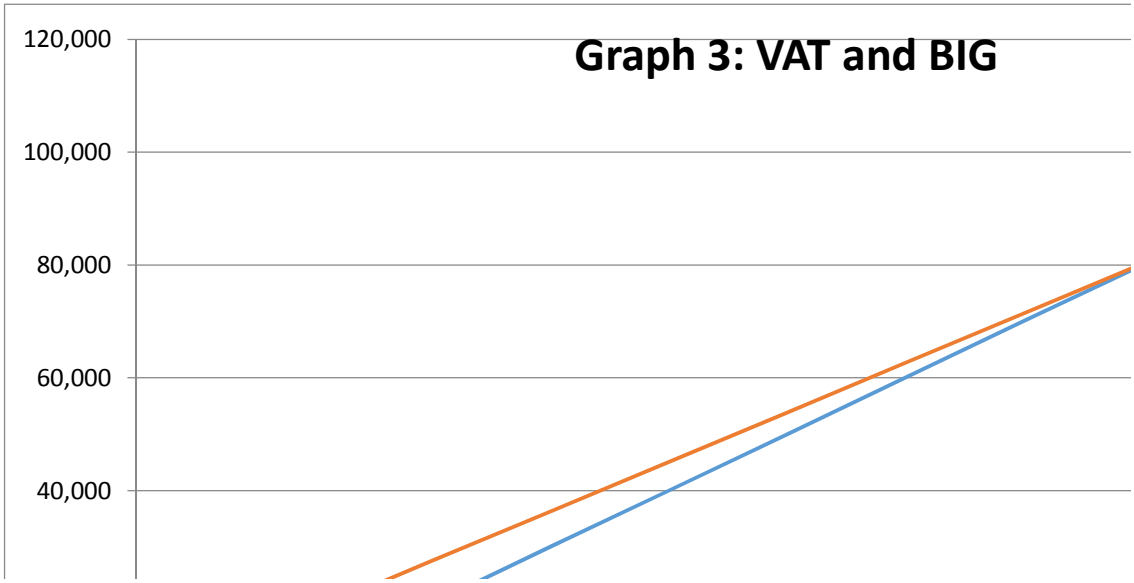
[8] For the sake of brevity I am excluding children, prisoners and non U.S. citizens from the analysis.

[9] Indeed, 13% would be sufficient at present. 14% would generate a small surplus that could be set aside to help weather the next recession.

payments. So, under the proposal, your new total income is $61,400 (your $50,000 salary plus $11,400 BIG payment). If you spend your entire income, your contribution to VAT would be $7,540, meaning that you would actually earn $53,859 or nearly $4,000 more on the proposal. The following graph illustrates the relationship between income, VAT and BIG.



It may help to walk through some of the information. The yellow line represents the proposed BIG payment. It is constant for everyone: BIG is exactly the same for everyone from a homeless veteran to Bill Gates. The purple line represents VAT, which everyone pays. The smallest contribution to VAT is $1,400, which a person living on just BIG would pay. Unlike the current income tax system, the proposed VAT is a "flat tax" meaning that the same percentage is paid no matter what a person's income. Someone making $10,000 a year pays 14%, as does a person making $100,000 a year, or even $100 million per year. The blue line represents a person's income in the present system. The red line represents the change in income (after paying VAT). In other words, the red line represents present income plus the BIG payment of $11,400 minus a 14% VAT. As can be seen, the red line crosses over the blue line at about the $81,000 income range.

The vast majority would do better under this proposal even though it includes a large new tax: anyone making between $0 and $80,000 a year would be monetarily better off. About 90% of the population has a net personal income that falls below the cross-over point (U.S. Department of Commerce, 2014). So, the vast majority of the population would be better off financially under the 14% VAT and BIG proposal.

Even for the higher income earners, the tax is hardly draconian. The top income tax rate for high income earners at present is 39.6%. So, the maximum a higher income earner would pay under this proposal is 53.6% (39.6% income tax plus 14% VAT). While this may seem like a lot, remember too, this is a maximum. The difference between the theoretical maximum and the actual tax paid (the effective tax rate) is enormous. The top 20% in terms of income pay only 20.1% income tax on average, and the top 1% pay a mere 20.6% (New York Times, 2012). In effect then, the difference between the maximum and the actual income tax rate is about half. So, the present proposal for the top 1% would increase the effective tax rate to nearly 35%. Or to put it another way, if all the loopholes were closed and the richest taxpayers actually paid 39.6%, then they would be much worse off.

Again, this only applies to the top income earners. Consider how well someone making $100,000 a year would fare under the proposal. Looking at Graph 3, we can see they make less, but the difference is almost imperceptible on the graph. The difference is actually $2,281 in additional taxes. This would only change the effective tax rate by 2.3% for those in this income bracket. The relevance of this is that about half of the 10% of the population negatively affected by the tax earn between $81,000 and $100,000. The additional tax this group would have to pay is very small: at most, 2.3% of their income.

It may help to note that historically, the highest rate for top earners was much higher. For most of the twentieth century the top rate was higher, reaching a peak in the Second World War at 91%. I am not trying to defend the suggestion at this point, only to put it in some context.

I have assumed that nothing would change in terms of other taxes, but we should briefly consider this simple assumption. With BIG, there would be a greatly reduced need for income tax to support welfare programs. Conservatively, federal welfare programs are estimated to cost $400 billion (Sheahen, 2012).These monies could be used to pay the additional cost of government services with a 14% VAT, reduce the deficit or offset future increases in income tax.[10]

8. Conclusion

A full consideration of BIG would require detailed consideration of other policy options, which are addressed by other authors in this journal. I will briefly, however, say something about welfare and a shorter work week as competitor policy options.

Many of the hodgepodge of welfare programs in the U.S. have an 'actively looking for work" requirement. The U.S., I suspect, is a world leader in blaming the victim when it comes to unemployment. When the number of unemployed greatly exceeds the number of jobs available, as clearly happened during the Great Recession, it makes no sense to say that everyone ought to get a job. There is a composition fallacy at work. It may be true that *each* runner might win the race but it does not follow that *every* runner can win the race. Similarly, even if *each* unemployed person could get a job, it does not follow that *every* unemployed person can get a job. The same reasoning applies to technological unemployment: if robots have cost advantages over human workers in many areas, then it is ludicrous to demand that everyone should get a job. Human workers simply cannot survive on pennies per hour—the cost to run many industrial robots (Robert Malone, 2006).

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[10] Not only is VAT a straightforward means to pay for BIG, instituting VAT would assist with another problem the U.S. faces: taxes and international trade. The sleep-inducing powers of the U.S. tax system are exceeded only by those of international tax codes and agreements, so I will be brief. Basically, income tax is a tax focused on producers, while VAT is a tax focused on consumers. European nations have VAT and income tax, but it will help to assume that all their taxes come through VAT. When exporting goods to Europe, U.S. companies must pay tax as a producer and when the goods arrive in Europe, consumers are charged VAT. When Europeans export goods to the U.S., they do not pay VAT, and Europeans do not pay American income tax. So, goods exported from the U.S. are taxed twice (once on American producers and once on European consumers) while European goods are not taxed at all. This is greatly simplified, but it is, in essence, the truth. If the U.S. introduced a VAT, it would put us on a fairer playing field with the rest of the world in terms of international trade. As it stands, U.S. companies are forced to compete with a heavy tax disadvantage.

We could, of course, consistently demand that everyone *try* to get a job, knowing full well that most will fail because of the price of robotic labor. But what would be the point of such an exercise? It would probably be a more useful and less soul-crushing exercise to demand that the unemployed dig holes on even days and fill them in on odd days. Yes, for most the task would be as big a waste of time as looking for a job in times of high unemployment, but at least it would be good exercise. Instead, people who give up looking for work during periods of high unemployment ought to be treated as selfless national heroes. If the economy is not producing enough jobs, then those who give up are making it possible for others to find work. Indeed, anyone who voluntarily withdraws from the labor market even during times of low unemployment ought to be celebrated as a hero of the nation too. Such a move puts pressure on the labor supply, which helps keep the cost of human labor higher than it would have been otherwise. The higher the cost of human labor, the sooner the robot revolution will be complete. The sooner the robotic revolution is complete, the sooner we reach a future so bright that we need shades.

So, if the robotic revolution leads to high unemployment, it would make sense to eliminate an "actively seeking work" requirement for welfare benefits. Furthermore, we would not want welfare recipients being actively discouraged from seeking work. To do this, there should be some means to allow such work to supplement welfare, rather than being forced to choose between, say, low paying temporary work and welfare. Such a choice would discourage people from reentering the work force should any jobs become available.

Once we see that there ought to be no work requirement and that work ought to be encouraged by allowing people to supplement, rather than replace their welfare payments when they have low wage jobs, then we can see that there are few differences between such a modified welfare system and BIG.

And to the extent that there are differences, the advantages are on the side of BIG. One advantage is efficiency. It currently takes a small army of government officials to run the nearly two hundred welfare programs in the U.S. BIG would eliminate most of these because of its uniform nature: everyone receives BIG. There is no need to hire sometimes officials to make sure that people are looking for work or not double-dipping by working and collecting welfare or working part-time and collecting too much welfare. A second advantage is that BIG is less stigmatizing. Since BIG is paid automatically, those laid off during the robotic revolution need not prostrate themselves before the welfare bureaucracy.

Shortening the work week through legislation is another policy possibility worthy of serious study. I'm not against it in principle. But the goal should to try to match supply and demand for those who would like to work, not to generate full employment. Suppose we found that the only way to guarantee full employment is to institute a 10 hour work week. However, a study shows that half the population would rather not work in paid employment but would be happier in non-formal work such as writing poetry, doing wood work, fixing up classic cars, etc. and living on a generous BIG, while the other half of the population would rather work 20 hours a week than 10 hours a week. Such a divergence in preferences is not hard to imagine. For example, some are very happy with freedom from formal work that retirement grants. Other retirees long to return to formal work, and many do so. So, shortening the work week may be a policy option worthy of consideration, but it should be applied in *conjunction* with BIG, not *instead* of BIG. The length of the work week should be roughly gauged to match supply and demand where demand is the preference for formal work. It definitely should not be set to maintain full employment.

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Technological unemployment is the loss of jobs caused by technological change. It is a key type of structural unemployment. Technological change typically includes the introduction of labour-saving "mechanical-muscle" machines or more efficient "mechanical-mind" processes (automation). Just as horses were gradually made obsolete by the automobile, humans' jobs have also been affected throughout modern history. Historical examples include artisan weavers reduced to poverty after the introduction of Technological Unemployment. Why machines will not replace humans in the labour market.Â Is this a lot or a little? Kapeliushnikov argues that a decline of this scale would be barely noticeable over a 20-year period: "In the U.S., the annual employee turnover, i.e. the sum total of all hiring and firing, exceeds 120 million. For new technology to affect the overall unemployment level, it would have to cause a one-off loss of at least 500,000 to one million jobs."Â According to Kapeliushnikov, while technological unemployment â€“ defined as loss of jobs caused by introduction of new technology â€“ is real and has long been part of today's marketplace, it is usually a short-term phenomenon, as markets need some time to adapt to innovation. In the study of Big Data, a recurring theme comes through. There is a great deal of data available and there is a need to understand this data. Machine analytics can help organizations understand these numbers, and computers are learning from these large datasets. Because of this machine learning, computer technology will have the ability to â€œthinkâ€, i.e. artificial intelligence. An assumptionâ€¦ CONTINUE READING. View on IEEE.