The Changing Nature of Scarcity

Automation and the U.S. Labor Force

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Automation is fundamentally changing the dynamics of the labor market and the U.S. economy.

1. **The proliferation of automation will only accelerate as it is driven by powerful forces**
    - Moore's law applies to many electronics beyond transistors per chip
    - Artificial Intelligence is improving the capabilities of robots & software at an incredible rate
    - Modularity of both hardware & software is bringing automation to the masses
    - Technologies such as Blockchain threaten to take down barriers for automation in various industries
    - Dramatic reductions in automation costs – both hardware & software – as well as significant increases in capabilities also is spurring adoption

2. **The economic effects of automation is widespread**
    - The proliferation of automation has resulted in increased productivity overall
    - This increased productivity has translated into the need for less workers
    - Research indicates that 47% of U.S. employment is easily automatable
    - Workers increasingly are struggling to find a job due to their job no longer being performed by humans.
    - A key contributing factor is the misalignment of education with the skills needed in an automated workforce

Automation is fundamentally changing the dynamics of the labor market and the U.S. economy.

3. **While automation can lead to higher standards of living, how the benefits it creates are distributed will be important to how the public responds to its proliferation.**
   - Automation inherently is deflationary
   - Deflation caused by inflation overall is beneficial to the economy
   - However, how the benefits of automation is distributed will be key to how the public responds to it
   - In addition, automation is driving the growth of the sharing economy, the on-demand economy & the shortened work week

4. **Business models & investment strategies will need to be adapted to respond to the widespread disruption caused by automation.**
   - Human resources that facilitate modularity: B2B system that intelligently manages workers around shortened work weeks
   - Sharing/On-Demand Facilitation: I2B2C consumer facing facilitation of Individual's Service to Customer
   - Connectivity: B2B connectivity facilitation of real world devices
   - Education Support/Skill Training: B2B automation consulting & education facilitation at corporate and government levels

Thesis

Broadly stated, the proliferation of automation will lead to a new labor market equilibrium with less jobs and participation in the labor force.

- The short term dislocations in labor skills and jobs will be bridged by higher standards of living and a more self-sustaining society

- However, the resulting permanent reduction in labor force participation goes against the historic trend of an equal amount of better jobs being created.

- As such, the Federal Reserve, U.S. government and corporations all have important roles to play to ensure that the disruption brought about by automation results in a better standard of living for all

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Automation Technology: History and Types

Hardware

Hardware automation has its roots in the first industrial revolution but saw large moves to full automation starting in the 1960s with the Milwaukee-Matic II, a Computer Numeric Control (CNC).[1] The CNC machining tool could switch its cutting tool, reducing the need for human labor to perform dangerous and time intensive tasks.[1] Over time, new, safer, and better jobs were introduced as the need for human hands decreased in factories.

Software

Software automation began in the 1970s with the computer and communications revolution. Many office and administrative support jobs became automated, along with other routine based work.[2] While low-skilled jobs were being automated, the demand for high-skill jobs that required a college degree outpaced the 100% growth in college graduates from 1960 to 1980.[3] Software was easy to understand, like word processors that used the same keyboard as typewrites, and once implemented improved productivity. This period had high unemployment and sparked the debate of technological unemployment that continues today.

The Machine's Job and the Human Skill Gap

Initially, as automation came into the workforce, there were clear boundaries as to what the machine could do, and what the human needed to do.

Limiting factors for hardware automation:[3]

1. **Dexterity**
2. **Mobility**
3. **Need for and unchanging environment and task**

These barriers left humans to fill the gaps in less structured manufacturing work.

Limiting factors for software automation:[3]

1. **Computing power**
2. **Strictly defined rule based work**
3. **Need to understand natural language**

Human labor filled in where software or algorithms were not a substitute

These limiting factors have been important in the past but the roadblocks are being cleared.

Automation Technology: Advancements Over Time

The Last Roadblocks

Machine learning first came around in the 1980s, but it had two major hindrances: ***computational power*** and ***lack of data***.[3]

Moore's law is a statement made by Gordon Moore who realized that every 18 months the amount of components double on an integrated circuit.[4] This means the computing power doubled over that time period.

For example, in 1997, the U.S. Military's supercomputer ASCI Red was the worlds fastest computer and cost $55 million.[3] In 2006, the Playstation 3 (a video game console) had the same computation power and cost $500.[3] This increase in computational power per dollar has made machine learning feasible and practical.

Data is the fuel for machine learning, but until recently there was not enough to make machine learning effective.[6] The main way to gather real world data is through sensors: cameras, gauges, gyroscopes, accelerometers. In the past these sensors were prohibitively expensive, but as it will be shown, many electronics, including sensors, follow Moore's law. This means there has been a price reduction which has lead to a proliferation of sensors and data.

Source: 48

ASCI Red (above) filled an entire room and could do over a trillion of calculations a second. 9 years later, a game console matched it's performance[3].

Automation Technology: Advancements Over Time

Mind the (Shrinking) Gap

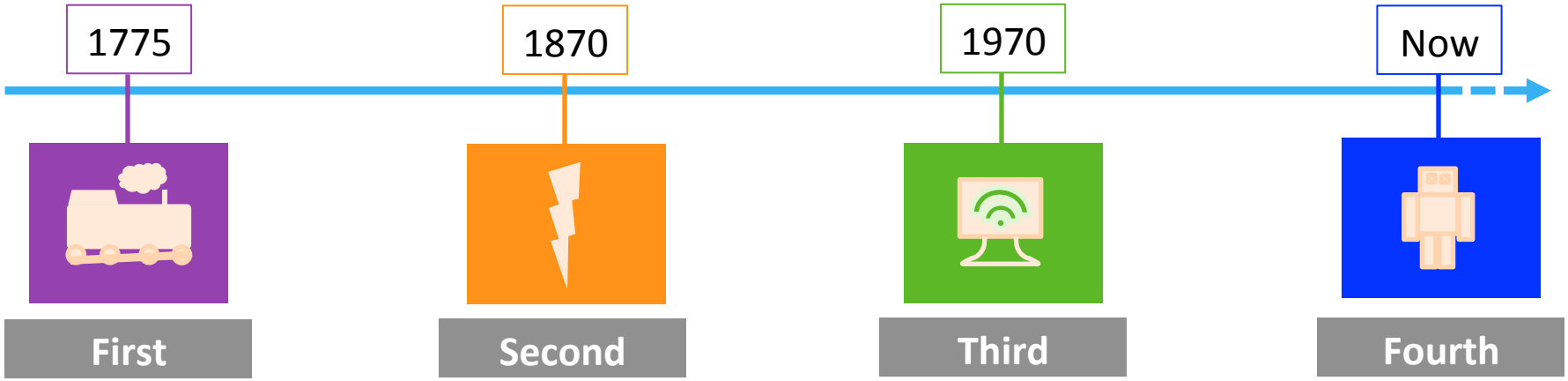
The world has seen radical developments in the past two and a half centuries, starting in 1775 with the steam engine to the computers of today. Each iteration has shrunk the gap between the capabilities of technology and of humans.

Hardware automation has been limited by dexterity, mobility, and a need for an unchanging environment and task. With the introduction of software and sensors, hardware has gained the potential to begin understanding its environment to complete a wider range of tasks previously relegated to humans.

Software has been the backbone to improvements of hardware, and software itself has increased its capabilities. For example, software using machine learning ushered in an even wider range of tasks, from automated data processing to stock market trading, and more.[7,8]

The gap between what machines can do and what humans can do is shrinking. How prevalent are machines today and will they proliferate further?

Industrial Revolutions Timeline



- Machine Power
- Railroads
- Mechanical Production

- Electricity
- Plumbing
- Mass Production

- Internet
- Electronics
- Automated Production

- Big Data
- Robotics
- Artificial Intelligence

Contents

- **Automation driving forces include:**
  - **Moore's Law:** Not only limited Microprocessor Chips but also applies to all electronics including sensors
  - **Machine Learning:** Artificial Intelligence is improving the capabilities of robots and software at an incredible rate
  - **Modularity:** Getting this technology in front of more people is what will drive innovation
  - **Enabling Technologies:** Technologies threaten to take down barriers for automation in various industries
  - **Reduction in Cost:** There has been dramatic reductions in automation costs as well as significant increases in capabilities

- **Current Trends: Robots and Software**
  - Depending on the type of robot, we are seeing year-on-year increases of supply between 30% and 600%
  - Service robots dominate recent trends

Automation Going Forward: Driving Forces

5 Driving Forces

1. *Moore's law*
2. *Machine learning*
3. *Modularity*
4. *Enabling Technologies*
5. *Reduction in Cost*

Continuing to Shrink the Gap

Moore's Law

It applies to more than just transistors per chip, it stays true across many electronics.

Machine Learning

Artificial Intelligence is improving the capabilities of robots and software at an incredible rate.

Modularity

Getting this technology in front of more people is what will drive innovation.

Enabling Technologies

Technologies like Blockchain, which has been theorized as an early general purpose technology, threaten to take down barriers for automation in various industries.

Reduction in Cost

There has been dramatic reductions in cost as well as significant increases in capabilities.

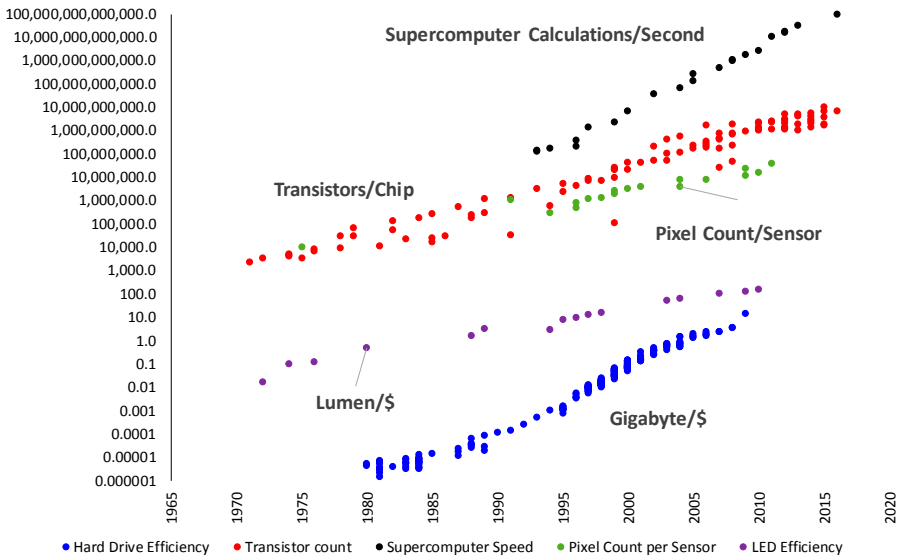
Automation Going Forward: Moore's Law

Moore's Law in Action

Moore's law states that every 18 months the amount of components double on an integrated circuit.[4] **Moore's Law also applies to sensors.** As one example, the resolution of an aerial image sensor increased 27x from 2009 to 2014.[16] Sensors becoming cheaper and higher quality helps the advancement of robotics. Sensors allow for better capabilities, like understanding the environment. This increases robots' task flexibility and mobility substantially.

Cheap sensors are only part of the solution, but the utilization of them is equally important. Those sensors generate large amounts of data, which need to be stored, processed, and acted upon. Without hard drive efficiency and computer speed improving logarithmically, much of machine learning would not be possible. One example of the culmination of these improvements is Rethink Robotics' Baxter.

Moore's Law Across Electronics[3]



Moore's law applies to many electronics beyond transistors per chip – it extends to devices such as hard drives & sensors as well.

Automation Going Forward: Machine Learning

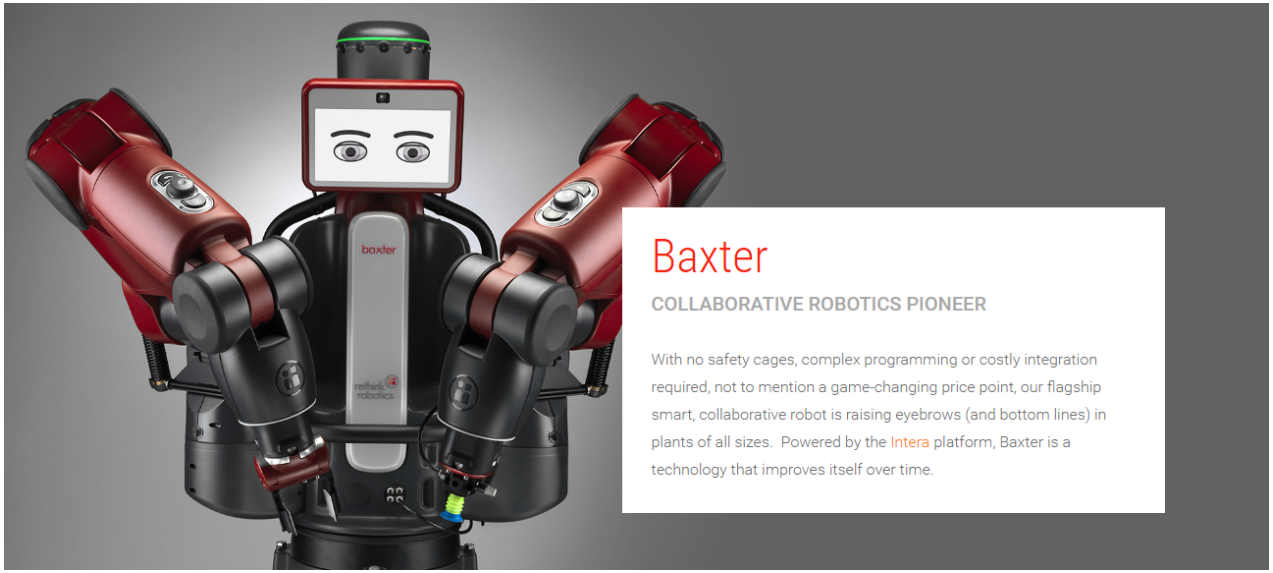
Baxter, the Contemporary Pinnacle of Automation

Baxter is a general purpose robot that works in factories. It is equipped with multiple cameras, accelerometers, and various other sensors. **Instead of having to program Baxter, it is trained like a human worker**; all that is required is to guide its hands once, and Baxter repeats the action. It is different than other manufacturing machines because it can be presented with objects in strange orientations and still perform its task. Baxter can see and feel its environment through sensors which allow its to perform different tasks simultaneously, surpassing human skills. Baxter's one drawback is that it is slower than humans at tasks, but has the ability to work 24 hours a day.[17]

Big Data

There is a saying in the machine learning community: **"Algorithms are the rocket, data are the fuel**." Machine learning did not take off in the 1980s because computers did not have the capability (nor the actual data) to handle the data necessary to make it worthwhile. Today, both of those have been remedied.[5] Moore's law solved computation bottlenecks, while cheaper sensors have provided necessary data.[3] Businesses generate incredible amounts of data every day and machine learning offers ways to use that data to their advantage to improve efficiencies and quality.

Baxter uses machine learning to be trained like a normal person and to understand his environment through sensors.



Source: 17

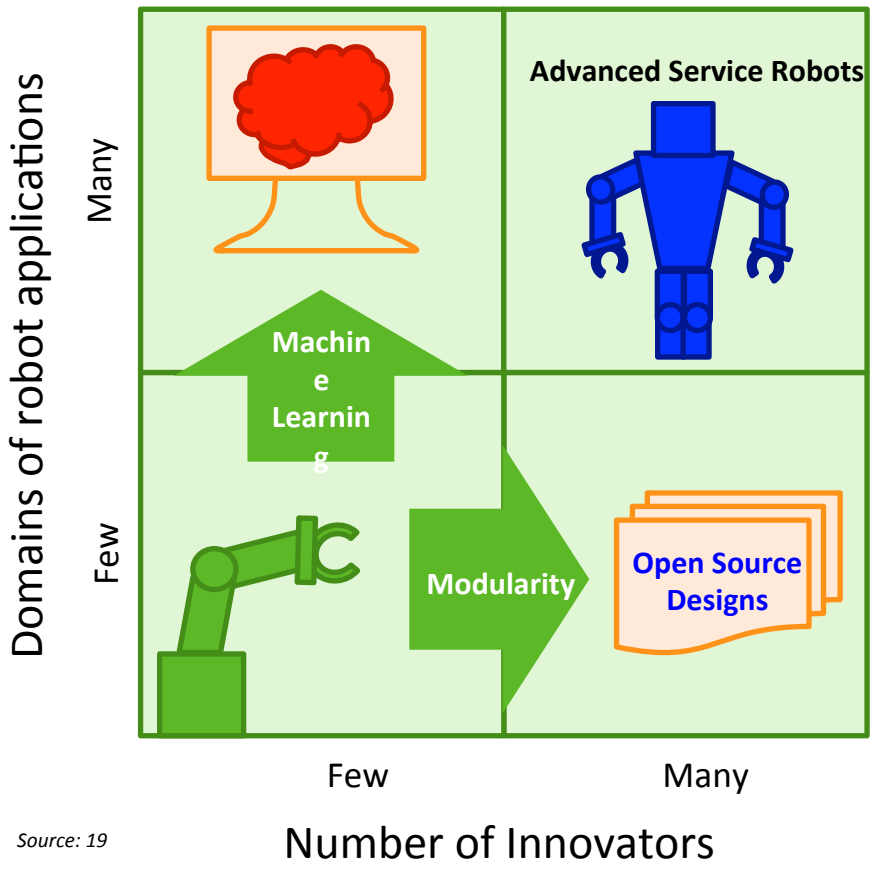
Automation Going Forward: Modularity

Building the Robot for All

Modularity is bringing automation to the masses.[3] It allows for more people to work closely with automation. Small and medium sized businesses can find ways to implement automation thanks to modularity of robots and software. Modularity increases affordability, customization, and comes in the form of open source software or build-your-own robot.[19] Economist Paul Romer writes, "The country that takes the lead in the twenty-first century will be the one that implements an innovation that more effectively supports the production of new ideas in the private sector."[20] Modularity is needed to facilitate more innovation.

Tomorrow's Robot

Modularity of robotics alone will not be enough to put automation in the hands of the masses. **There needs to be modularity of software**, like open-source machine learning platforms that assist in advancing the abilities of the robots. Service robots can be used in so many different ways that the issue is the number of people involved in innovation.[3] Open source projects like "Poppy," a 3D printed robot, designed and distributed for free, facilitate innovation.[21] One day, Poppy could come close to the abilities of Baxter. This kind of modularity will help drive automation proliferation, decrease costs, and improve performance.



Source: 19

Modularity and machine learning will make it cheap enough to replace low cost jobs, that previously were not cost effective.

Automation Going Forward: Enabling Technologies

Reducing the Fear of Implementation

Many users of automation fear the computer's decision-making ability. Even if the computer is right 99% of the time, and humans are right 60% of the time, humans still fret over the 1% computer error. Any technology that gives the user confidence in the automation will allow for faster integration. For example, many Tesla owners are nervous to use the "Autopilot" function at first, but once they use it and see its capabilities they begin to trust it.

What is Blockchain?

One such enabling technology is Blockchain. **Blockchain is a system of decentralization for a database.** Unlike another system of nodes that share information called the Internet, one can trust everything on the Blockchain. The trust comes from using computers as nodes that are constantly validating the system. If one node tries to alter the information of the database it sends out a signal to the system. Other nodes (often called "miners") work to verify the origin node has the funds or other requirements necessary, then writes the transaction into the database on a new "block," which is an aggregate of the recent transactions. Then all nodes work to verify the system and sort out any discrepancies in the Blockchain. This creates a verifiable chain of information that anyone can see.

Blockchain and Automation

Blockchain's proliferation will allow for automation processes in many areas that before were impossible. Currently, many people think of Blockchain technology just as the backbone of the popular cryptocurrency, Bitcoin. This is ill-rooted, as it has wide spread applications that could revolutionize how our world verifies information as well as in "smart" contracts, deeds, personal identification, voting, etc.

For example in a smart contract, the Blockchain can facilitate automatic transfer of funds based on certain criteria met.[22] This eliminates the need for a lawyer or escrow agent to step into the middle. A non-obvious use-case is for drug manufacturing. Manufacturers could etch QR codes that allows customers to check with the Blockchain to confirm the pill is not counterfeit. This helps improve consumer confidence in online-pharmacies and improves pricing transparency.

Automation Going Forward: Reduction in Costs

Reducing Costs to Automate

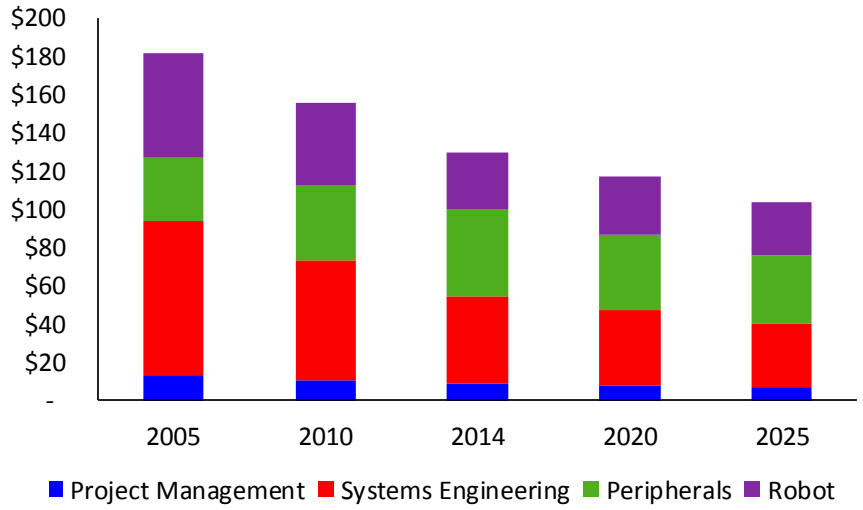
Over the past two decades, the price of robotics has decreased while the quality has increased significantly. [23] In addition, robot performance is increasing at 5% per year based on the data from the International Federation of Robotics.[8] These factors have resulted in significant increases in the amount of robots in the world and in turn, increasing efficiency and decreasing costs worldwide.

Integration and Proliferation

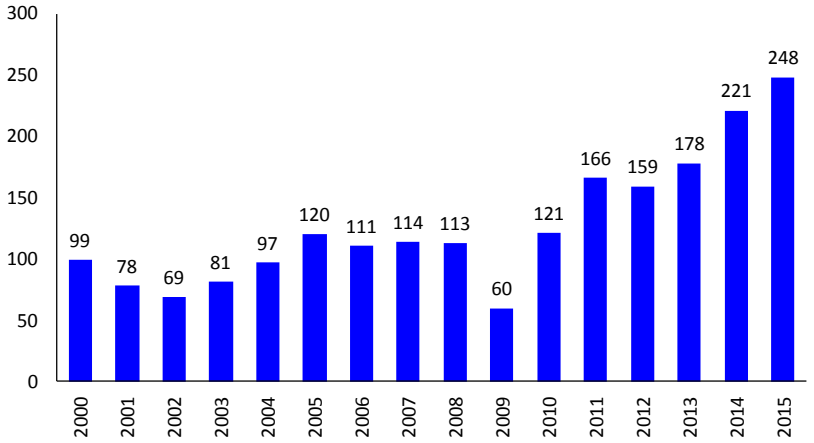
Since 2010, the annual supply of industrial robots has doubled. The international market for robotic systems is now valued at $32 billion.[9] Currently, the U.S. has the fourth largest amount of industrial robots behind China, and is the largest in the western world.[9]

Each one of these robots represents a machine that has overcome the machine-human skill gap. In general, these robots are either augmenting or replacing human labor, and as will be shown, increasing productivity. With this proliferation of robotics, the right implementation can lead to many improved efficiencies & cost savings.

Total Industrial Robot System Cost (Thousands)[24]



Worldwide Annual Supply of Industrial Robots (Thousands) [9]



Automation Going Forward: Current Trends in Robotics

Multi-Industry Proliferation

Robotics are entering not just into traditional manufacturing, but also a multitude of other industries. Automotive manufacturing robotics are the most prevalent, with one of every two industrial robots going to an automotive plant.

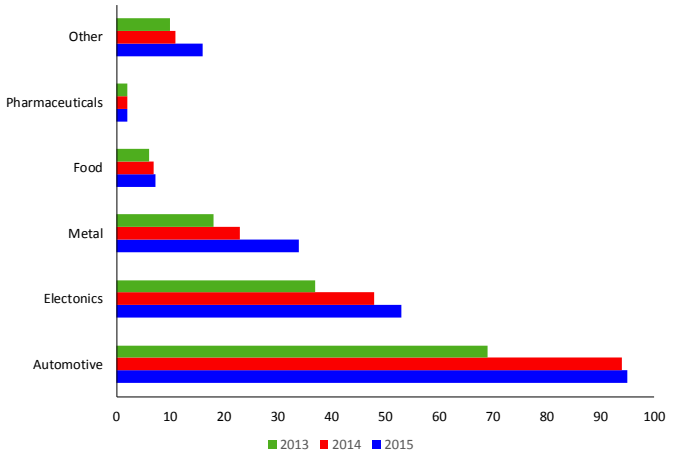
The growth rate for industrial robots across the world is about 5%, but the top countries are growing their robot fleets as much as 50% per year.[10] This is dependent on the major industries of the specific country, for now. There are driving forces that are enabling this proliferation outside of specific industries or countries in the near future.

Service Robots

Service robots are expected to experience a high growth rate as well. For example, in 2014 there were 4.7 million service robots sold for personal and domestic use, a 28% increase.[11] Advancements in personal robotics have made the proliferation in medical related robots like handicap assistance robots increase 542% in 2014.[11]

There is an estimated 152,400 new service robots expected to be installed by 2018. The market will be valued at around $20 billion. [11]

Annual Supply of Robots by Industry (Thousands)[12]



Sources: 50, 51, 52

Automation Going Forward: Current Trends in Software

Automation: Not Just Robots

Automation does not just mean robotics; it includes software that automates processes. There has been major pushes for automation in everything from stock market trading, to travel agencies, to marketing.

At its basic level, automation in the form of software started with the first hand cranked calculator. Over the next couple hundred years, software replaced various occupations such as typists jobs with the advent of word processing, point-of-sale cashiers with the advanced of advanced payment systems, and more.[3]

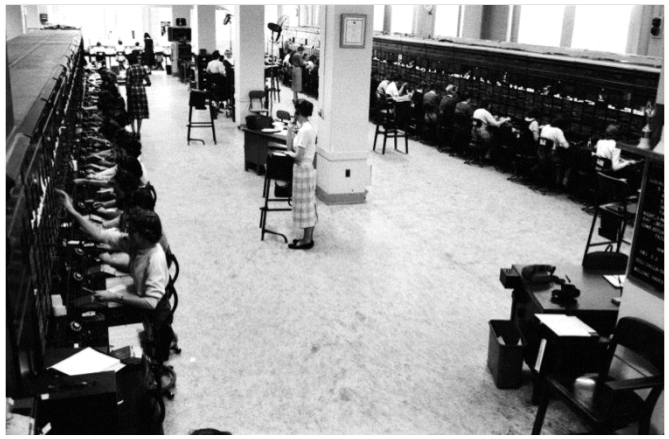
The Automated Back-Office

Today, many of the back-office activities of business are now being automated with software. Businesses look to save money and improve accuracy by automating highly commoditized activities, like record keeping, data entry, etc.[14]

Automation is seeping into many industries. mazon robots depend as much on their software as they do their hardware. In entertainment, Netflix uses massive amounts of data and machine learning to automatically make movie recommendations. It is also integrating into everyday life of the consumer in significant ways.

Everyday Automation

One ubiquitous example of automation is found in your pocket: your cellphone. Gone are the days of switchboard operators, whose jobs were taken over by software and computerization.[15] Automated routing of calls and radio technology lead to a device that more people have access to than clean water. The move to automated switching has allowed for increases in scale that would have been impossible in the days of human labor switchboard operators. [15]



Source: 53

Switchboard operators at Bell Telephone, one job that software has taken over.

Automation Going Forward: Amazon Case Study

The Automated Warehouse

The following example is from a case study of Amazon warehouse automation.[10] **Amazon utilizes over 15,000 robots in its workforce to help drive costs down and improve efficiency in their warehouses.** They have 2 main robot types:

1. Rolling Robots
2. Stowing Robots

When a customer places an order online, a rolling robot in the warehouse is automatically directed to the product. The robot will drive itself under shelves and on robot "highways" (major robot pathways in a warehouse) until it reaches the product. The rolling robot places itself under the shelf and raises the shelf off the ground, transporting the entire shelf to a human worker that grabs the appropriate product for shipping. This robot not only decreases the time to locate a product and package it, it also optimizes warehouse space utilization.[10]

The stowing robot deals with large pallets, normally handled by forklift operators. The robotic arm lifts the large pallets of products into high shelves, faster than an experienced forklift operator could.[10]

Source: 49

Amazon's orange rolling robots decrease the amount of time of packing and optimize warehouse space better than humans can.

Introduction

Automation Technology

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Economic Effects: Abundance of Non-Labor Resources

More Resources for Less Work

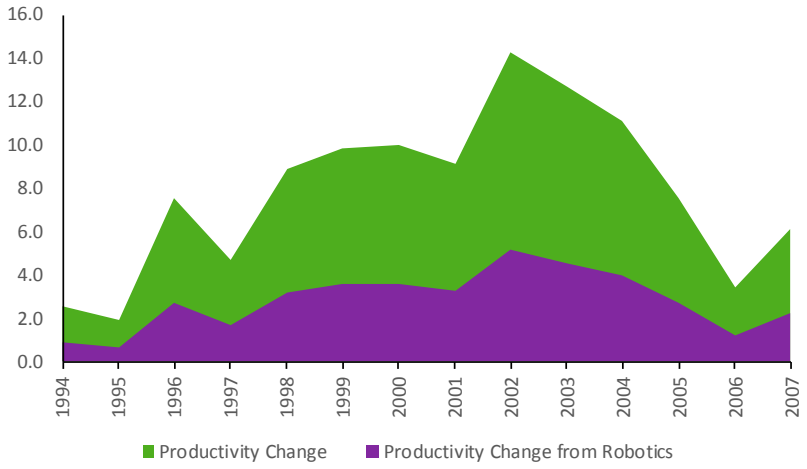
Cost reductions and other market forces has caused a proliferation of automation which has resulted in increased productivity. A 2015 study by Georg Graetz and Guy Michaels showed that despite the small amount of industrial robots in use from 1993 to 2007, robotics significantly impacted productivity growth.[23] Robotics in the workforce accounted for an average of 0.36 percentage points per year of productivity growth for the 17 developed countries studied.[23] That constitutes about 16% of total annual productivity growth.[23]

Firm Level Productivity

Firms have improved their productivity as a result of computerization and that companies that invested in IT are more productive than those who elected not to invest in IT.[25] According to research, these productivity increases were due to data driven decision-making and automating decision-making does improve productivity.[26] IT and software contributed about 15% during the 1993-2007 time period. Together, robotics and software made up one third of all productivity growth.

One third of productivity increases between 1993-2007 were from automation and computerization.

Change in Productivity (%)[23]



Economic Effects: Decreased Production Costs

Reducing Costs to Produce

Automation improves productivity which means less need for workers. As the Boston Consulting Group (BCG) shows, labor costs account for 15%-40% of manufacturing production costs in the U.S.[24] This means that automation can reduce the cost of production. BCG estimates that by 2025, U.S. labor-costs will be reduced by 22% as a result of automation which will result in goods becoming cheaper and more plentiful.

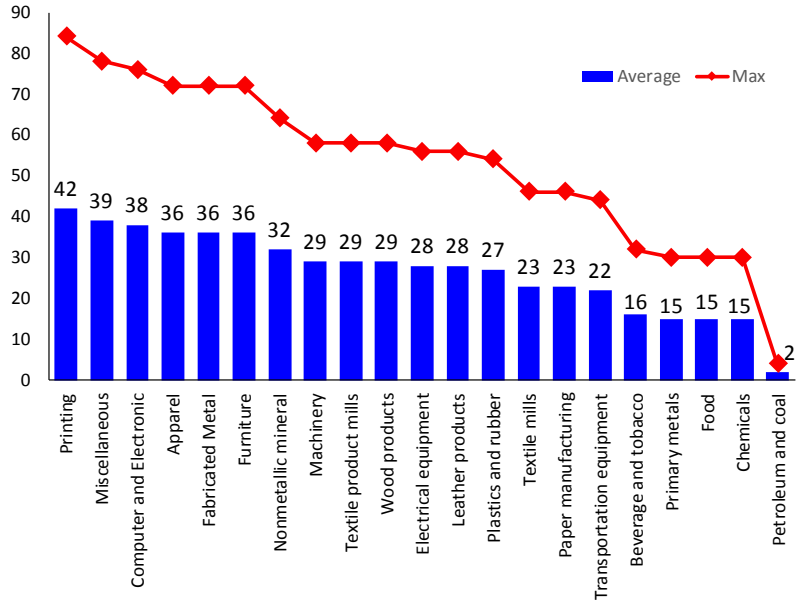
Labor accounts for 15%-40% of production costs. Automation will cut 22% of labor costs by 2025.

Widespread Benefits

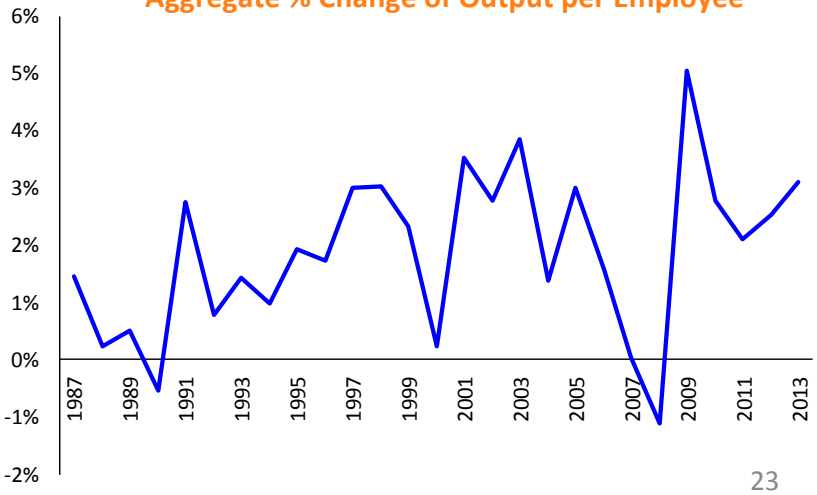
This increase in productivity is not only happening in manufacturing but also on the software side. For example, travel agencies have increased their output per employee by over 100% since 2001 by utilizing automation.[27] This has been in response to fully automated services like Expedia.

Every section of the supply chain can benefit from automation – from raw materials and manufacturing to distribution and retail.

Labor as % of 2014 Industry Costs[24]



Aggregate % Change of Output per Employee[27]



Economic Effects: Mining Industry Breakdown

Abundance of Commodities

Raw materials will be cheaper in response to automation as evidence by the proliferation of automation in the mining industry. Due to recent advancements, mines can be nearly fully automated today, "with only excavators still in need of manned control."[31]

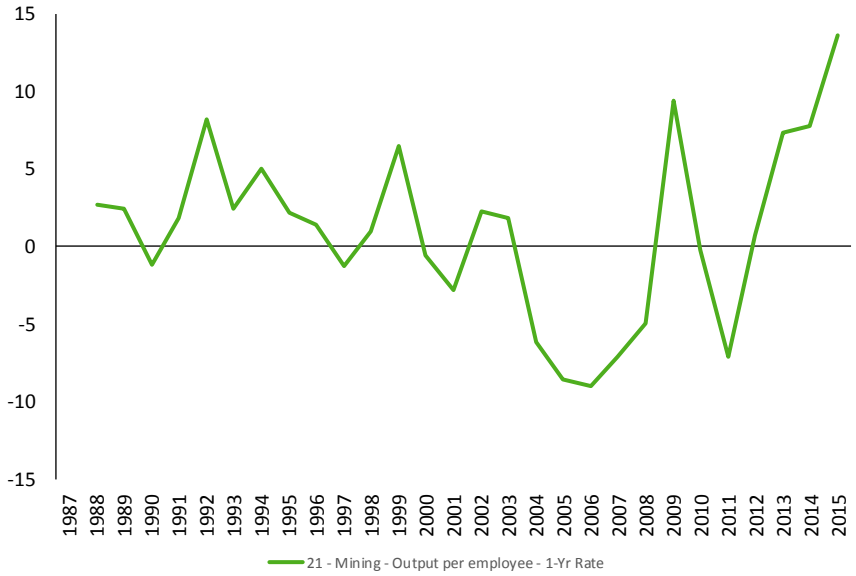
Output per employee has risen 32% since 2011, with experts expecting it to rise up to 60%.[27] This will reduce labor costs, which are around 30% of total costs for miners.[31]

This increased productivity has shown in the market prices as well. Since 2011:[32]

- Copper prices dropped 72%
- Iron prices have dropped 67%
- Gold prices dropped 31%
- Aluminum prices dropped 37%
- Platinum prices dropped 36%

These precipitous drops in price are not due to drops in demand as demand has risen an average of 3% per year since 2011.[30] Supply has increased due to the increased productivity in the mining sector due to automation.

Mining: % Change of Output per Employee[27]



The mining industry has increased its productivity by 32% since 2011 and is increasing faster than ever before. This has resulted in widespread drops in costs for mined goods.

Economic Effects: Automotive Industry Breakdown

Decreased Costs

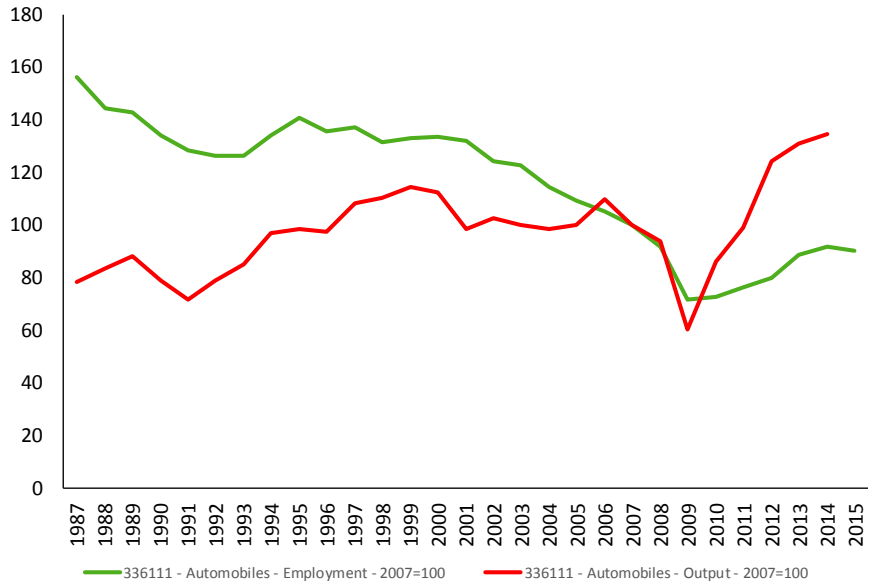
The cost saving effects of automation in manufacturing are most prevalent in the automotive sector. Automotive manufacturing was one of the first industries to introduce automation into factories.[3] This is an example of machines surpassing the machine-human skill gap; there was a need to be able to manipulate metal and humans could not fill that while machines could. Demand for robots in the industry continued, leading to more robots and a higher output per employee.

It is also worth noting how the recession affected both employment and subsequently output per employee. Output since 2009 has grown faster than ever before, with minimal increases in employment.

Cost Effective

Ultimately, the proliferation of automation into a specific industry comes down to **whether or not it is cost effective to substitute automation in for a human worker and if it is technically feasible**. The automotive industry satisfied those requirements long ago. With decreasing costs and advanced capabilities, it will not be long until cost effective robots surpass human skills and proliferate into many other industries.

Auto Manufacturing Employment & Output (Index, 2007=100)[27]



Since 2009, output in the automotive manufacturing sector grew by 74% compared while employment has only grown by 19%.

Economic Effects: Automotive Industry Breakdown

CPI: New Cars

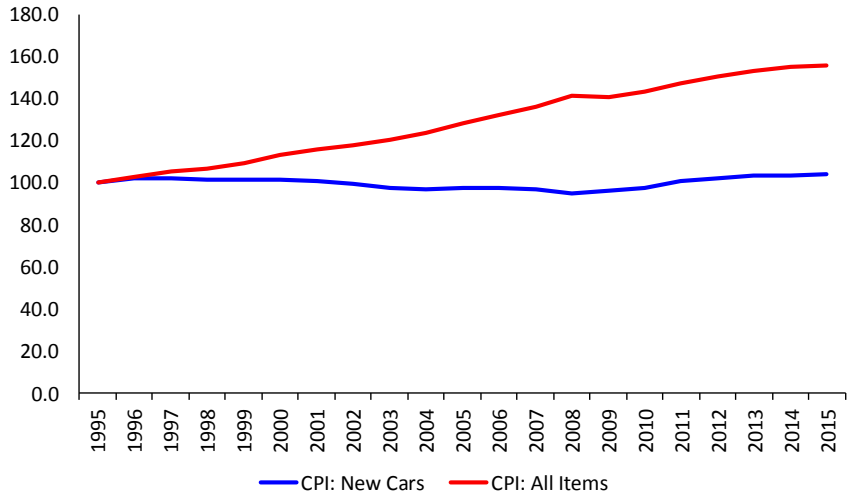
The graph to the right compares the Consumer Price Index (CPI) of all items against the CPI of new cars. While all items have continued to increase, the cost of a new car has been stagnant or even cheaper consistently since 1995.[28] This means cars are getting cheaper, relative to other necessities. Additionally, cars have never been safer, more reliable, or included so many features.[29]

The key to this is competition; since almost all automobile manufacturers use automation, their input costs are less. Once more firms adopted automation, it became a price competition, which has kept the price down.

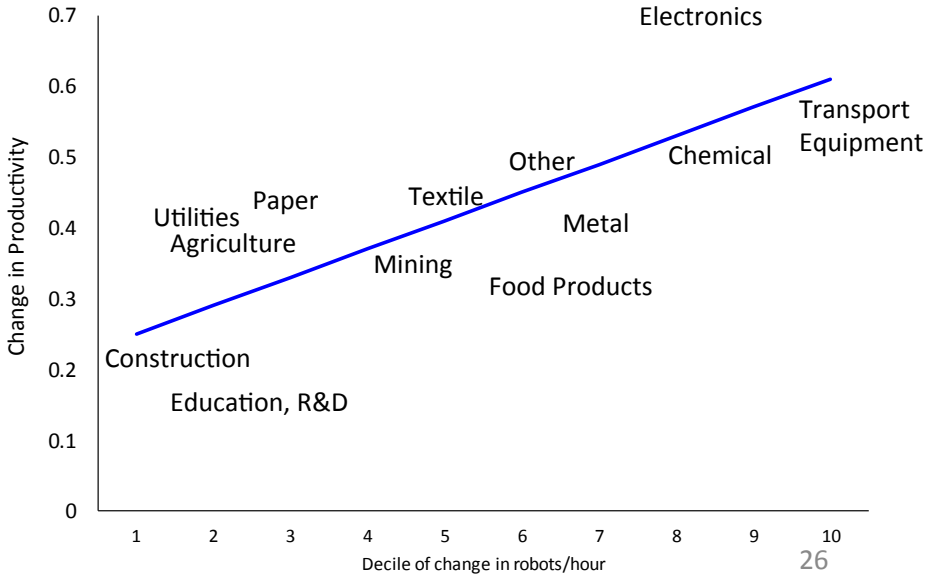
Not Just Autos

From the study by Graetz and Michaels, **we can determine where robots add the greatest value as well as the greatest amount of productivity.** The graph to the right shows which industries benefit the most from robotics. It demonstrates why Moore's law has held so true: electronic manufacturing is the only industry that sees extremely disproportionate productivity with the introduction of robotics.

CPI of New Cars versus CPI of All Items (Index, 1995=100)[28]



Productivity Change by Robot Workhours and Industry (% Change)[23]



Economic Effects: Scarcity of Jobs

Economic "Recovery" in the 21st Century

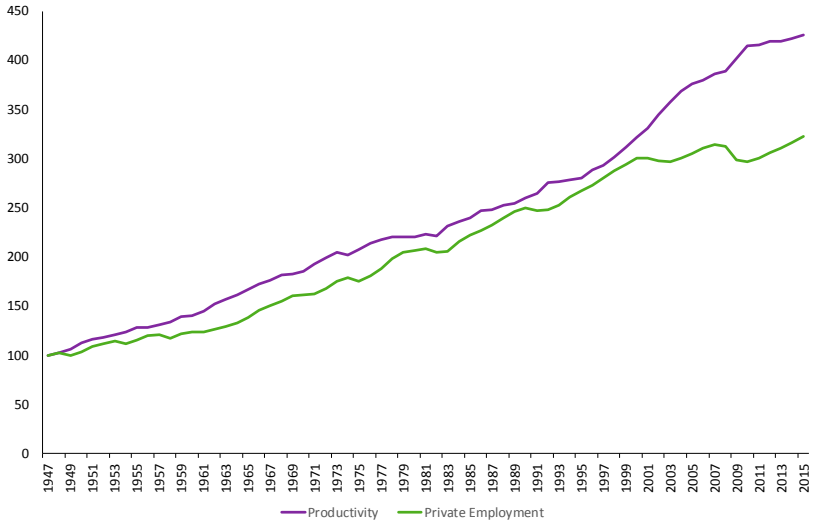
The recessions in the 21st century have been accompanied by the longest recoveries in history. The recessions also have marked the greatest decrease in labor force participation rate since it began being measured in 1948**. The U.S. has entered into a period of jobless recoveries**.[33]

Recall how even though employment dropped in the automotive industry, output increased. This shows the demand for labor has decreased even as productivity increased.

This trend is not restricted to the automotive industry, it is endemic of a larger trend. **Employment and productivity decoupled starting with the 2000 dot.com bubble.**[3] Firms were able to remain productive through downturns due to investment in technology.

This jobless recovery is in part a result of automation hitting "middle-skilled" jobs hardest, ones that pay enough that it is economically feasible to invest in automation and that are technologically feasible.[23] While this has been the main cause of the polarization of the labor market, that will soon change to include low-skilled workers as well.

Productivity and Employment (Index, 1947=100)[34]



Employment and productivity are no longer bound to each other, due to technology.

Economic Effects: Unemployment and Discouraged Workers

Endangered: Low-Skill Jobs

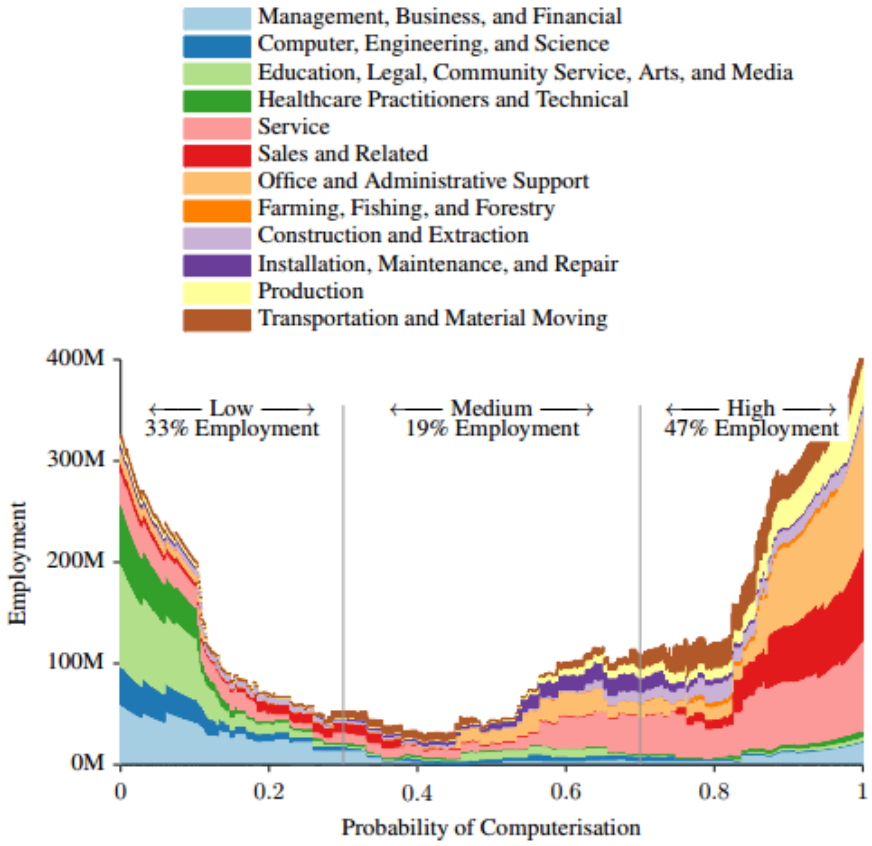
A study done by researchers at the University of Oxford showed that 47% of U.S. employment is easily automatable.[35] This means that many people will be displaced from their jobs, and not just middle-skilled workers. A report from the White House estimates that 83% of all jobs that pay under $20/hour will be automated.[36] With the decreasing cost of automation, Moore's law, better machine learning capabilities, and modularity, these jobs will be automated.

Discouraged Workers

Workers will be structurally unemployed and struggle to find a job due to their job no longer being performed by humans. They will not have the skills necessary for a different line of work. Many of these displaced workers will leave the workforce due to being discouraged from the mismatch of skills needed. Therefore, there will be a decrease in labor force participation rate.

Automation taking jobs is not the only reason for the declining labor force but it is significant. People are staying in school longer, knowing that the job market is tough and looking for better skill sets. Refer to glendonTodd's 2014 report on labor force participation rate for a deeper look at other causes for current the drop.

Probability of Automation by Industry[35]



47% of all U.S. jobs are easily automatable. 83% of jobs that pay under $20/hour will be automated.

Economic Effects: Programming and Software

Help Wanted: Coders

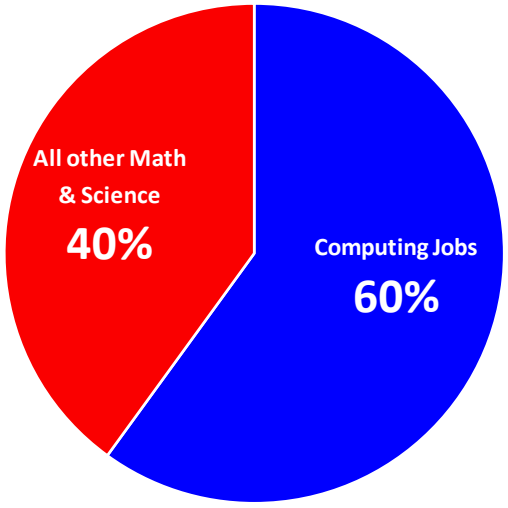
While there are issues with automation displacing workers, there is another systemic issue: **a misalignment of education with skills needed for tomorrows workforce.**

Mark Zuckerberg (Facebook), Jack Dorsey (Twitter), Bill Gates (Microsoft), joined together in a video to talk about the need for programmers in the workforce. Not only is there an estimated 1 million jobs that go unfilled in programming, there is not enough education to fill this gap.

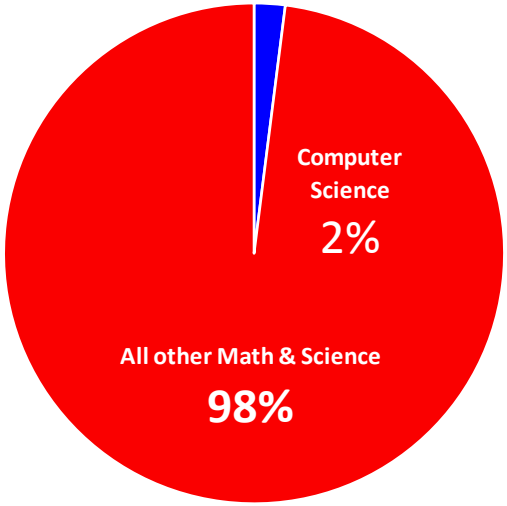
Automatable or Not?

While there is a chance that programmers can be automated, this is mostly for non-creative automation. Since automation will be in everyday life the amount of opportunities that will be presented a skilled programmer is incredibly high. **People who know how to program will be able to utilize their creativity to make computers do things that would take years for a automated system to learn how to do to**.

Jobs[59]



Students[59]



Economic Effects: Transportation

Overview

The distribution portion of the supply chain in the form of transportation also benefits from automation. Transportation is not just automated truck drivers, but it is mobilization of fracking equipment, automated taxi services, etc. The core of transportation is utilizing existing U.S. highway infrastructure and navigating it autonomously.

Labor Costs

The cost of drivers is estimated to be around 35% of total costs in the trucking industry.[39] When restrictions on driving hours are taken into account, that number increases substantially. Drivers are only allowed to operate 11 hours a day.[40] This means that not only is labor a high cost, it also is slowing down efficiencies. Autonomous vehicles not only would be able to run all day, they offer significant cost savings across the board.

Truck driver is the number one occupation (as % of employed population) for 28 states, but is highly susceptible to automation.

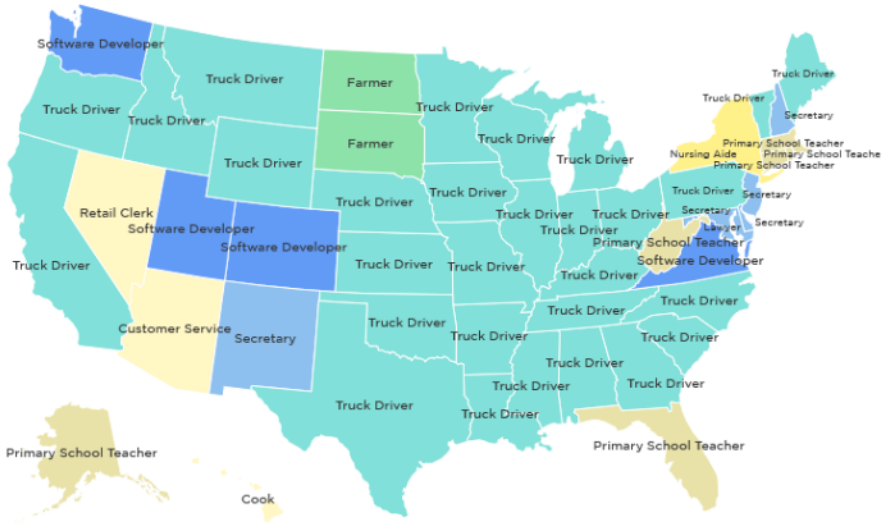
Fuel Efficiency and Insurance

Autonomous trucks can run 24 hours a day. They also go 45 miles per hour (the optimal fuel efficiency speed), and do not speed.[40] Insurance on the trucks will be cheaper, and companies will save on gas.

Displacement

Currently there are 1.8 million truck drivers in the U.S., over 1% of total employment.[38] This will prove to be one of the most dramatic shifts we will see in the near future.

Top Occupation by State (By % of Employed Population)



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Economic Effects: Transportation

Current State

However, **there is a clear roadmap to autonomous vehicles**. The National Highway Traffic Safety Administration has defined 5 levels of automation.[41]

Level 0: No Automation

Level 1: Function Specific Automation (driver assistance)

Level 2: Combined Function Automation

- Similar to Tesla's "Autopilot," able to cruise-control/switch lanes

Level 3: Limited Self-Driving, like Google's self-driving car

Level 4: Full Self-Driving, does not require human driver

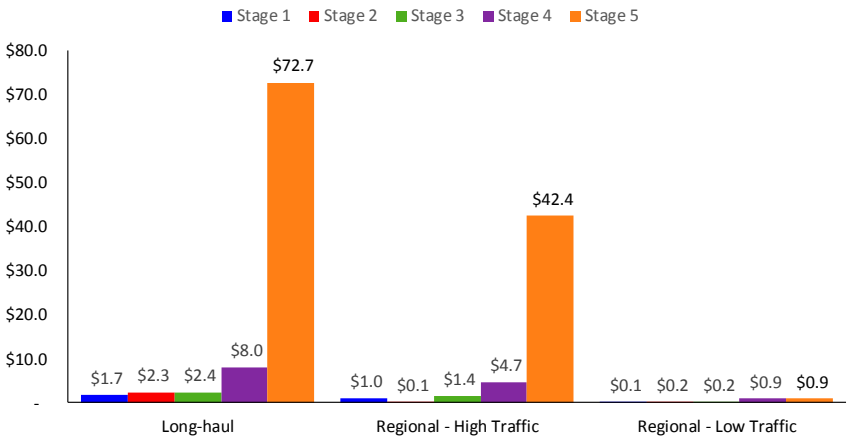
Currently, the industry is at level 2, with companies like Freightliner moving into level 3.

Cost Analysis

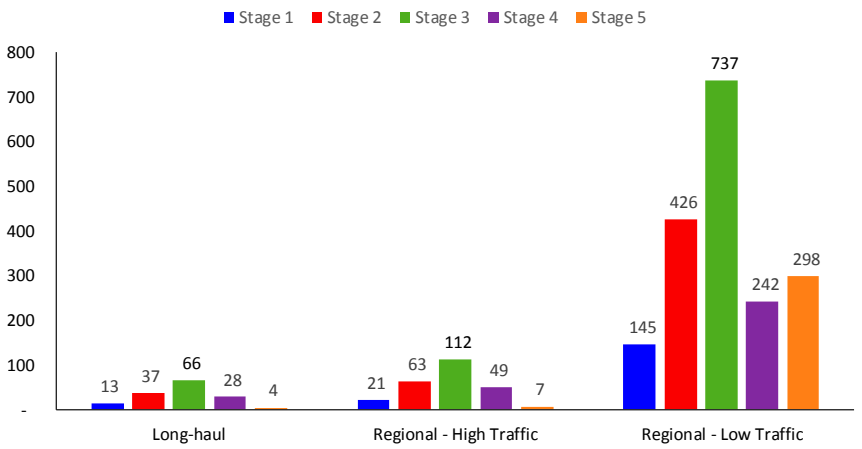
For heavy trucks, it is estimated that each additional level is between $4,000 and $7,000 plus a $5,000 premium for full automation. That means **that the additional costs of a fully autonomous truck is likely not more than $24,000 in additional capital to the base cost of a truck.**[42] This is not taking into account software, which is where most of the cost lies right now.

Current level 2 systems are paving the way for future automation. They are gathering more data than ever before thanks to cheap sensors, which will help develop the necessary software.

Total Savings per Year (Thousands)[42]



Payback Period (Months)[42]



Fully autonomous trucks can save up to $72,000 a year by displacing drivers, lowering insurance premiums, and optimizing fuel efficiency.

Economic Effects: Fast Food Industry

Overview

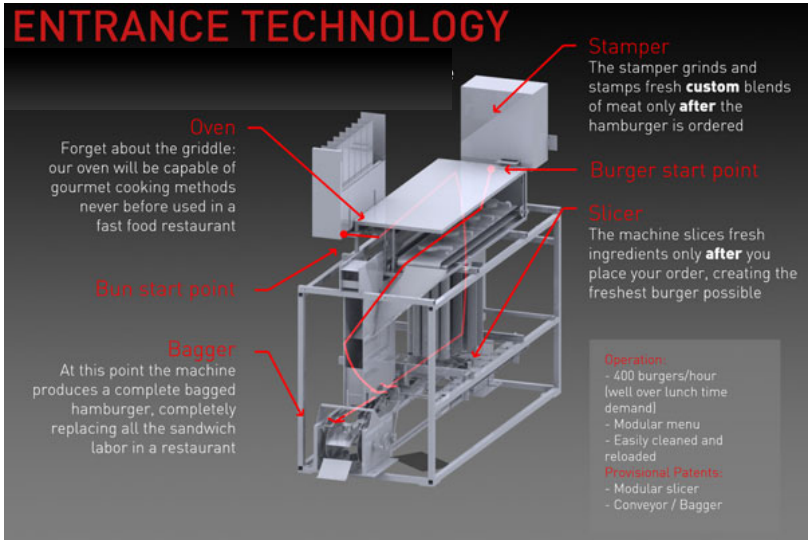
Automation is consumer facing as well; one industry that is primed for this move is fast food restaurants. McDonalds has been facing declining profits for the past 4 years, and they are moving toward automation. They have introduced digital kiosks for order in a number of locations, and are pushing the technology out into more. [43] To go further, Momentum Machines has created a hamburger making robot that can do the work of three employees.[44] Their machine can: grill, slice tomatoes, add lettuce, apply sauces.[44] It can produce 400 burgers an hour.

Goodbye, Low-Skilled Jobs

This machine marks the beginning of the end for low-skilled jobs. In the past, many teenagers' first job was working at a fast food restaurant; however, going forward these jobs will be automated.

The Automated Supply Chain

These industry breakdowns are specific examples a the larger trend: **supply chain automation at the expense of human labor**. Machines are surpassing human capabilities in terms of skill and price per hour due to Moore's law, better software, and reductions in cost. This is leading to a decrease in labor demand.



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"This device isn't meant to make employees more efficient. It's meant to completely obviate them."

Economic Effects: Lower Aggregate Demand

Aggregate Demand

Aggregate demand is calculated as:

Y = C+I+G+NX

Y = Aggregate Demand

C = Consumer Spending

I = Investments

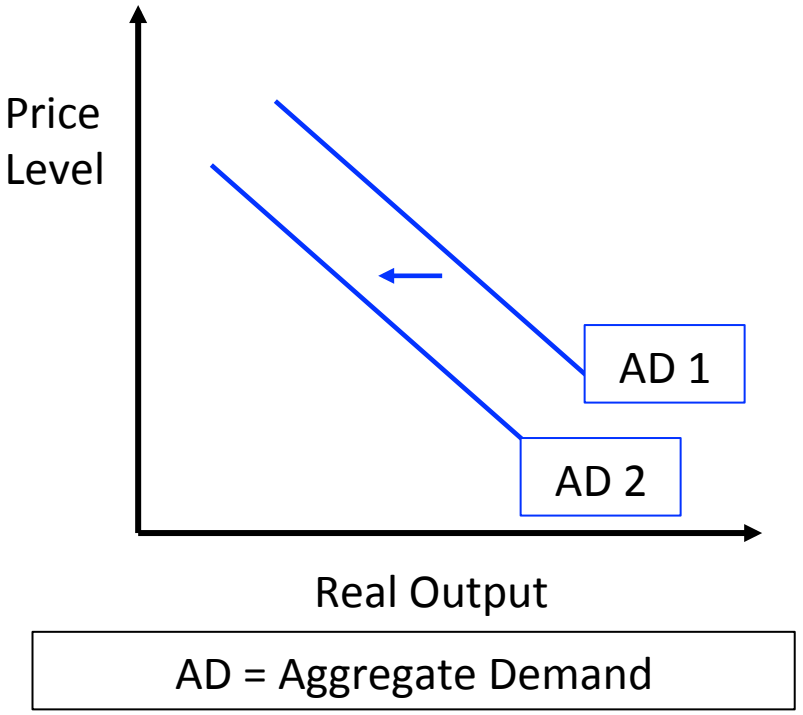
G = Government Spending

NX = Net Exports

Shifts in aggregate demand come from changes in one of these variables**. In the case of automation, there will be a change in consumer spending**. Consumer spending is dependent on wages, salaries, and real disposable income.

With middle-skilled and low-skilled workers being displaced (like McDonalds employees and truck drivers), there will be fewer workers. Since there will be a drop in employment due to automation, there will be a drop in wages, salaries, and disposable income. This drop in wages results in less consumer spending, thus lowing aggregate demand.

Shift in Aggregate Demand



Fewer workers means less income, and in turn lower consumer spending. This lowers aggregate demand.

Economic Effects: Higher Aggregate Supply

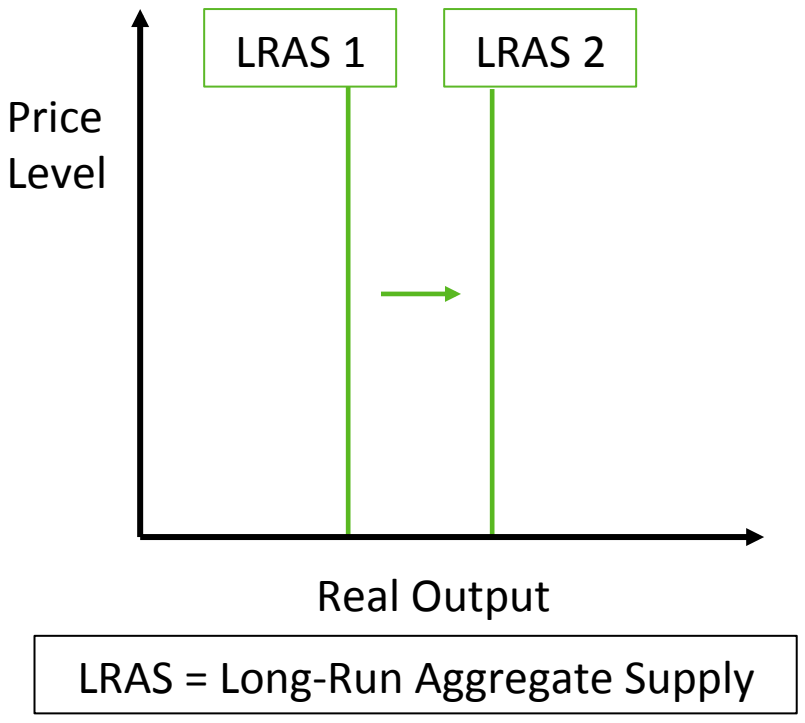
Aggregate Supply

Long run aggregate supply (LRAS) is the amount of real output. It is price inelastic, thus the verticality of the curve. Shifts in LRAS are due to productivity changes as a response to a sustainable increased quantity of scarce resources, technological advances, decreased input costs, or historically, increases in the workforce.

With automation, we have already seen increased quantity of scarce resources (mining example), productivity improvements (automotive manufacturing example), and decreased input costs (across the board labor cost reductions as well as material costs). **Automation will have a greater impact on supply as it proliferates into more industries.**

One issue of the increased LRAS theory is a decrease in the workforce. In theory, this could stifle aggregate supply, but that is not the case. This is because the technological advances are *becoming* the workforce, thus replacing the need for it to increase. This follows the 21st century trend of increased productivity despite constant employment. Therefore, automation will increase the LRAS.

Shift in Long Run Aggregate Supply



LRAS = Long-Run Aggregate Supply

Lower input costs, productivity improvements, and a technological workforce will increase LRAS.

Economic Effects: The Changing Nature of Scarcity

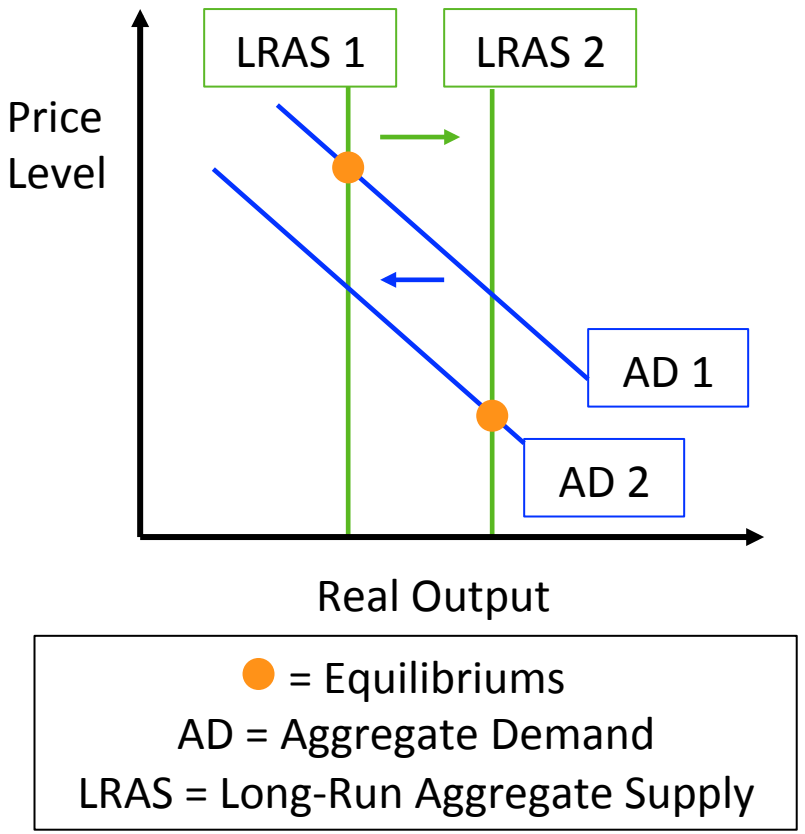
Scarcity of Jobs and Abundance of Resources

The combined effect of increased aggregate supply and decreased aggregate demand results in a new price-output equilibrium, marked with lower prices and higher output. This means **automation technology is deflationary.** Everyday goods and services will cost less due to automation, and so cost of living will go down.

There have been periods where deflation has been good or bad. In the case of deflation from automation, standard of living will increase.

While deflation is not inherently good or bad, it is important to have a historical context to see what factors make deflation good or bad.

Macroeconomic Results of the Changing Nature of Scarcity



Economic Effects: History of Deflation

Types of Deflation

Deflation comes in three types, "The good, the bad, and the ugly." A study done by Michael Bordo and Andrew Filardo looked at each period of deflation and classified them. This **historical context is key to determining if a period of deflation is going to have a positive or negative effect.**

1873-1896: The Bad

This era marked good deflation that turned bad. The deflation was caused by productivity growth and countries switching to the gold standard. The distribution of benefits turned this deflation from good to bad. Groups (debtors, farmers, etc.) that saw their real income fall before prices dropped responded with "disruptive social and political agitation." The reason prices did not drop fast enough was rampant formation of cartels and coordination that forbade price cuts. Ultimately, this deflation started good but later turned bad and resulted in multiple recessions and one serious recession in 1890.

1921-1929: The Good

"The roaring twenties" was a time of real growth. There was mild deflation of ~1-2%. This deflation and prosperity was brought on by "high tech" industries like automobiles and radios. The driving force for this was an increased aggregate supply, similar to the effect of automation will have.

1929-1933: The Ugly

The Great Depression had drastic declines in real output and high deflation. Bank crises were the root of decreased aggregate demand. This ugly deflation was caused by decreases in aggregate demand with a decline in output as well.

Factors of Good, Bad, or Ugly Deflation

The study uses monetary policies, a banking crisis indicator, supply and demand shocks, real wage inflation, and growth rate of real equity prices to estimate a classification for a deflationary period. **It shows that increases in supply, and decreases in demand both increase the probability of deflation being good.**

Economic Effects: Automation Deflation

Main Factors of Automation's Deflation

Chance of Bank Crisis - Low

Unlike the Great Depression and again with the Great Recession, during which banks were insolvent, there are strong banking regulations in place today. These regulations will help banks remain solvent and keep consumer confidence in banks high, decreasing the likelihood of a bank run. With a low chance, the probability of good deflation is 93%.

Productivity Boosts - High

Increases in productivity will increase confidence in many parts of the economy. Akin to the second industrial revolution, this will lead to deflation accompanied by positive growth.

Inequality of Benefit Distribution - High

This is the main issue that will decide whether there is an overall increase in the standard of living. This inequality can lead to many negative effects.

Other Factors of Automation's Deflation

Demand Drops - High

In Bordo's analysis, he shows that drops in aggregate demand are only an issue when there is a chance of a bank crisis. In general, these drops are associated with good deflation. There also needs to be true competition and avoid the creation of cartels like during the second industrial revolution. Aggregate demand must fall smoothly with increases in supply.

Supply Increases – High

Bordo also shows that increases in supply are slightly associated with good deflation.

Monetary Policy - Unknown

Monetary policy can help control the amount of deflation experienced from automation. Assuming it is able to help keep deflation moderate, monetary policy will have a positive effect.

Economic Effects: Inequality of Benefit Distribution

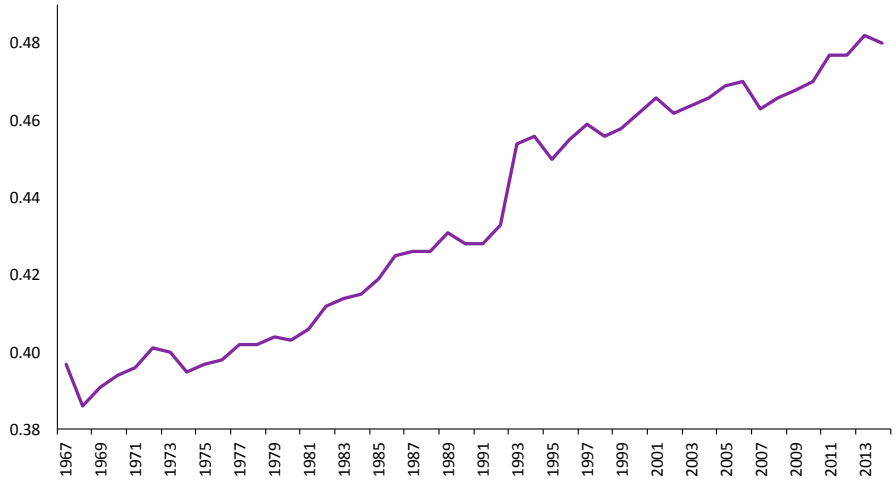
Why Inequality Matters

Economic inequality festers anger until it boils over into class warfare.[49] This inequality affects a person's perception of well-being, and while their true standard of living will be increasing, they will perceive it negatively.[49]

The Haves and Have Nots

The middle-skilled jobs that have been the core of the middle class are being substituted by automation, which has been widening the gap of the haves and the have nots.[49] The Gini coefficient, a measure of income inequality, has been steadily rising since the ICT (Information and communication technology) revolution in the 1970s. Social mobility will be decreased by the level of skills necessary to succeed in the new economy. Already the U.S. has seen how people react to the rising inequality with protests like "Occupy Wall Street," and the millennial generation being more socialist than any in U.S. history.

US Gini Coefficient[48]



The Gini coefficient is a measure of income distribution; the higher the coefficient the greater the inequality of income within a country.

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Public Response: Neo-Luddites & the Lump of Labor Fallacy

Neo-Luddites

Not only will the inequality of benefit distribution cause public discord, the lack of jobs will have negative impacts too. Going back to the industrial revolution, **Luddites were a group of workers that rebelled against technology for fear that they would lose their jobs** in textile work.[3] They destroyed cotton gins, stocking frames, and power looms that were going to replace them. Of course that did not happen, some were displaced but eventually found work in safer and better jobs.

We will see a similar response to the upcoming automation revolution. Many neo-Luddites and unions will fight vehemently against automation, and for good reasons. As machines become more advanced than humans at many tasks, there is no reason to believe that humans will find jobs once displaced. Jobs they have the skills for will have been automated. Before, the Luddites were displaced to other low-skilled work, but going forward there could be no low-skilled work.

The income inequality and poor labor market will ignite rage in workers, bringing on a type of Neo-Luddite.

Lump of Labor Fallacy

Others believe in that we will see only positive effects of technology. From the National Academy of Sciences, "By reducing the costs of production and thereby lowering the price of a particular good in a competitive market, technological change frequently leads to increases in output demand: greater output demand results in increased production, which requires more labor." This means that the amount of work available can increase without bound; implicitly then that the "lump of labor" or static total available labor, is a fallacy. This is likely wrong due to the shrinking machine-human skill gap and machines are evolving faster than humans, but it does have history on its side.

However, while demand may be infinite, that does not mean demand for human labor is infinite.

"Man is the lowest-cost, 150-pound, nonlinear, all-purpose computer system which can be mass-produced by unskilled labor."

Public Response: Sharing Economy

The Sharing Economy

One trend that has occurred is a move toward a sharing economy. The shift has been toward an asset-sharing economy with services like Uber, Lyft, and Airbnb. Through these services, users can maximize their utility from their assets. Whether that asset is their car, time, or house, people are getting a better return on these assets than without these services.

This asset sharing economy represents an economic shift we are likely see continue, one in which there is high self-employment, micro-entrepreneurship, and self-subsistence. It is easy to envision a world where automation has facilitated the optimization of one area that robots will likely never be able to overcome the capabilities of humans: complete general purpose and low-cost. Robots and automation will be able to do many tasks autonomously within their domain, but it will be a long time before we have robot butlers that have the skill humans have. Additionally, the sharing economy is paired with an on-demand economy.

Public Response: On-Demand Economy

On-Demand Everything

The on-demand economy is one where consumers order their product or service and the wait is minimal. This puts a price on convenience. Consumers decide they need to use a car, need to see a doctor, or want food from the grocery store, they order it online and within minutes it arrives at their door.

With a fleet of robots or humans, more can be accomplished faster than a personally owned general purpose butler. For example with Favor, a service that will facilitate just about anything one asks for and deliver it right to your door, people utilize their time to accomplish the task asked of them.

This type of economy works in tandem with the sharing economy. It allows for people to utilize their skills when they want to, and allows for consumers access to the service they want faster. Instead of having to work constantly, when a consumer wants a haircut, barbers could bid on performing the job. If a barber does not need to or want to work right now, he does not have to. This ability to use skills to directly interact with customers will lead to more flexibility in how and when we work.

FAVOR

The Favor app is your personal on-demand butler. It also allows for workers to work when they want.

Public Response: The Future Workweek

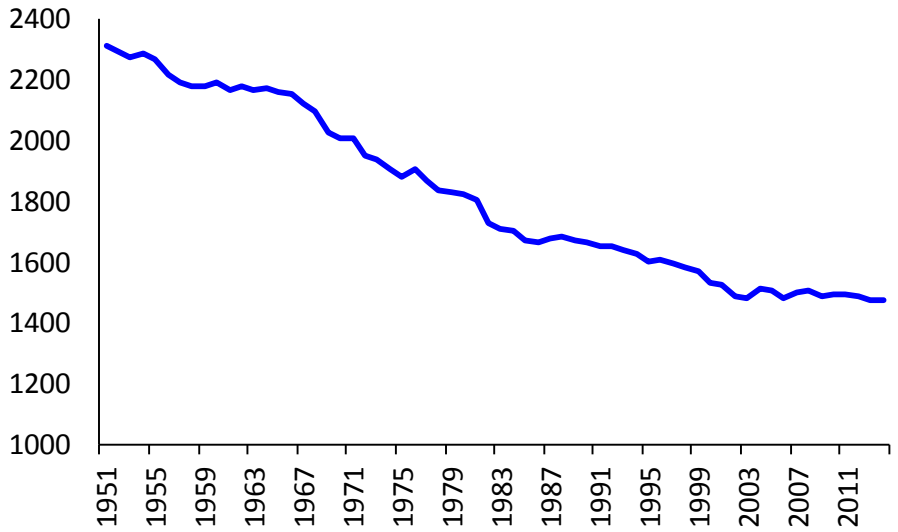
Less hours, Same Benefits

The combination of the sharing economy, the on-demand economy, and the traditional economy will lead to shorter work weeks. While work in the traditional economy will decrease due to technology, the sharing and on-demand economies are based on the individual such that the flexibility of workhours is unmatched in human history.

People are working less and less, leaving more time for leisure activities. For example, not long ago, people worked 72 hours, six days a week. With technological improvements that dropped to 60, then 48, and today's 35 hour work week. While all developed countries have seen this trend, France's is very pronounced. Average annual work hours dropped a thousand hours over the last 50 years.

This trend continue and workers will move toward a three day work week. Carlos Slim, Mexico's richest man, has already started to do this. His company offers a three day workweek, which allows for more workers to have jobs while leaving people with more free hours to pursue education, entertainment, etc. He says technology is allowing for people to "live longer, in better health, and without the need for physical effort."

Average Annual Work Hours: France[48]



Technology is allowing for people to live longer, in better health and without the need for physical effort.

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- The Right Response
  - Three pillars to ensure higher standard of living: The Federal Reserve, the government, and corporations
  - Revamping education toward the skills needed for future jobs is necessary
  - Reduce Labor Friction

Conclusion: The Right Response

What is the Right Response?

As shown, inequality of benefit distribution is one of the major issues that automation will bring. It will determine whether there will be a smooth transition into a better standard of living, or if there will be neo-Luddites rebelling against the robot workforce. Therefore, **the right solution is to take steps to slow the drop in aggregate demand to allow prices to decrease faster, increase social mobility, and decrease mobility friction**.

There are three pillars to ensuring a better standard of living:

The Fed Corporate Government

The Fed

The Federal Reserve must help keep aggregate demand from falling to fast. They can enact monetary policies that incentivize spending in times of unemployment and declining labor force participation. They can do this by printing money. Printing new money in the short term helps alleviate the drop in demand, as it gives people more money to spend.

Balancing Act

This is a balancing act though, as they must not drive deflation down to the point of inflation, but they must print enough to avoid a large spike in deflation**. The goal of this monetary policy is not to cancel the drops in aggregate demand, but to smoothly transition the economy to a lower state of aggregate demand, while supply increases.**

Corporate

John Mackey, founder of Whole Foods, is the author of a book called *Conscious Capitalism*. The main premise is **businesses create more value and wealth in the world if they treat all stakeholders with respect, especially their employees.** This idea is pivotal for the age of automation. Corporations need to be the stewards of automation.

They need to apply automation and supporting activities in ways that increase value for all stakeholders. One example, is increasing education and training programs to help workers cope with the changing demand for skills within the company. This helps keep employees employable for longer, makes them more valuable, and slows the drop in aggregate demand by giving people the skills they need to remain employed.

Conclusion: The Right Response

The Government

The government needs to help improve education to allow for social mobility. This can be accomplished by revamping the education system and in the long run, subsidizing education. This can work in conjunction with corporate, as education is key on both levels.

Traditional 9am-5pm jobs are going extinct. Where people once worked one job at one company, now they will be in multiple jobs utilizing their skills, when they want. The sharing and on-demand economy will facilitate this, but developing those skills to be useful in the economy is necessary.

Revamping Education

In the short term, there is a need to revamp the education system to align with the skills companies need most. 9 out of 10 schools do not teach computer programming in the U.S. For a necessary skill in every industry, our education system has been slow to adapt. Programming is easily taught at a young age, but we need more classes at all levels of education.

Long run Education

In the long run, development of skills will come from education**. In an economy driven by on-demand services and utilization of assets, it is necessary to lower the barriers for people to gain those skills to be productive in society.** This is done by subsidizing higher public education, whether that be a 2-year associate's or a 4-year bachelor's degree. This will help people be as active in the economy as they wish to be, and even if one does not have the assets to be a member of the sharing economy, one will have the skills to be in the on-demand economy. Subsidizing education will help improve social mobility, thereby ensuring the standard of living increases.

Conclusion: Investment Suggestions

Human Resources That Facilitate Modularity (B2B)

- **A system that intelligently manages workers around the three day workweek**
- For example:
  - A Person 2 Virtual (P2V) system that manages bringing in workers on certain days to match demand, and facilitates easy of continuation of work
    - Facilitating continuation of work is necessary to allow for productivity to not drop due to switching workers
    - For example, a system that controls when nurses work or on-site robotics technicians

Sharing/On-Demand Facilitation (I2B2C)

- **Consumer facing facilitation of Individual's Service to Customer (Individual 2 Business 2 Consumer)**
- Systems like Uber, Airbnb, or Favor
  - One like where a customer says he desires a service, and the company serves as a middle man to find an individual service provider
  - Critical mass is necessary on both sides to be effective

Connectivity (B2B)

- **Facilitate connectivity of real world devices**
- For example:
  - There is a high need for cybersecurity in a connected world
  - Specifically Industrial Control Systems

Education Support/Skill Training (B2B)

- **Automation consulting/Education facilitation at corporate and government levels**
- For example:
  - Companies that evaluate where automation can be implemented or facilitate education for employees that have a high probability of displacement
  - Skills training to help maintain employee value-add at companies
  - Education support for schools/skills training
    - ie seminars, workshops, educational materials (videos, books, etc.)

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