Automation v Procreation

aka

Bots v Tots

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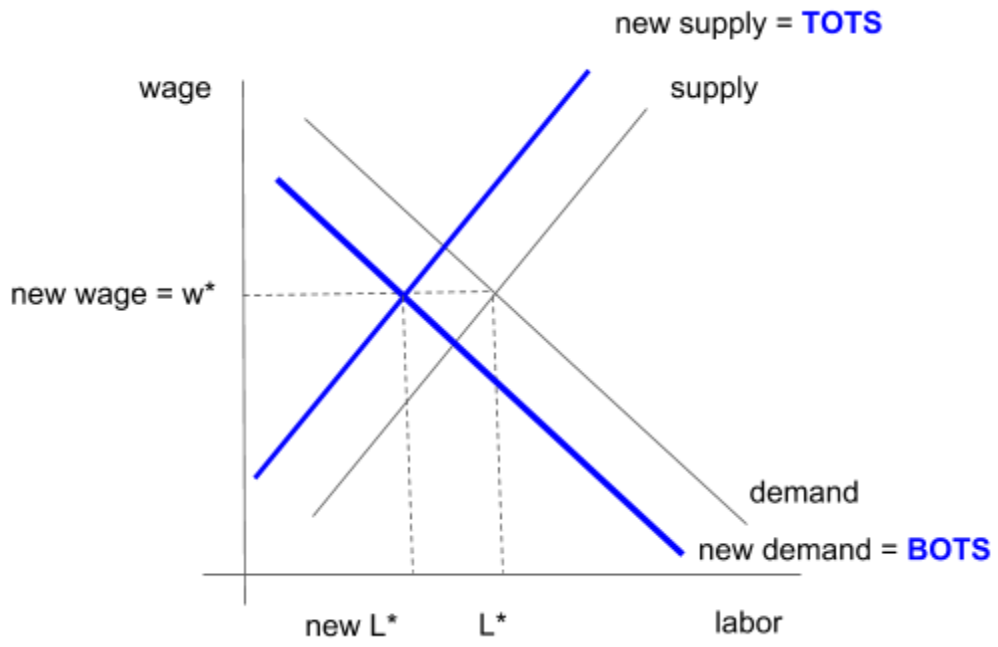
Abstract. Several recent papers have considered the impact of automation on labor demand in the coming decades. But demand is only one side of the labor market: the supply of labor will also change dramatically in the next 50 years. The net outcome on wages and employment will depend on the relative magnitude of these shifts in demand and supply. I conclude that the expected demographic changes are of similar magnitude to forecasts of demand changes due to automation at least in the next 20 years.

Figure 1 depicts a simple model of the labor market where demand and supply depicts the equilibrium wage and employment level. It is widely thought that we will see a reduction in demand for (human) labor due to technological improvements in robotics and artificial intelligence in the next few decades. This would shift the demand curve to the left. On the other hand, it is virtually certain that demographic forces---such as the retiring of the baby boom---will shift the supply curve to the left as well. These changes will result in a decrease in employment. The effect on the equilibrium wage is ambiguous: it depends on which curve shifts the most.



There is a long history of worries about machines replacing human workers. See, for example, Frey and Osborne [2015] for an overview. However, the US economy seems to be able to absorb large changes in the supply and demand for labor. Figure 2 depicts the births in the US from 1920 to 2010. Note the "baby dearth during the recession and World War II followed by the dramatic increase from 1946-1964.

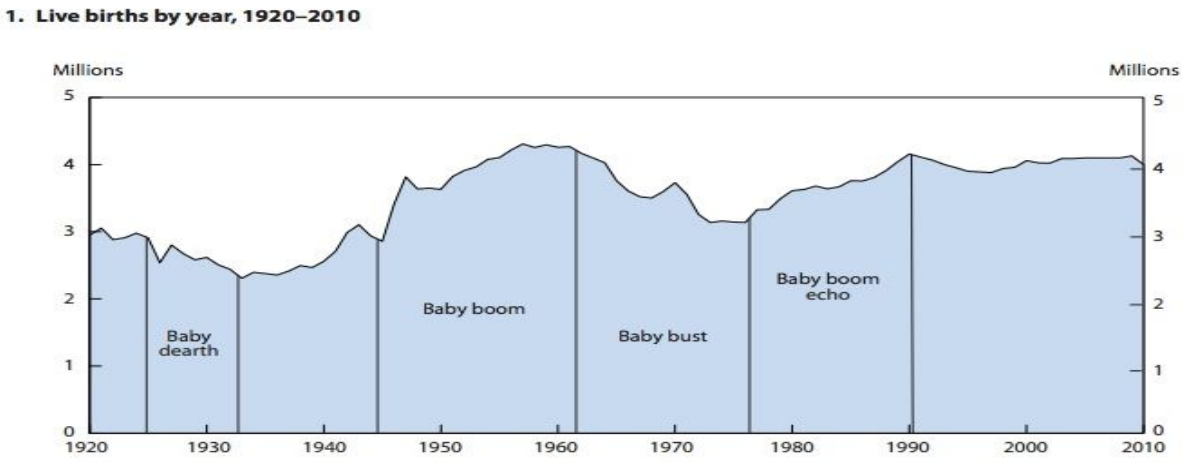


Figure 2. Live births by year

Millions of baby boomers entered the labor market during the period 1966-1986. At the same time, we saw a dramatic increase in women entering the labor market as shown in Figure 3.

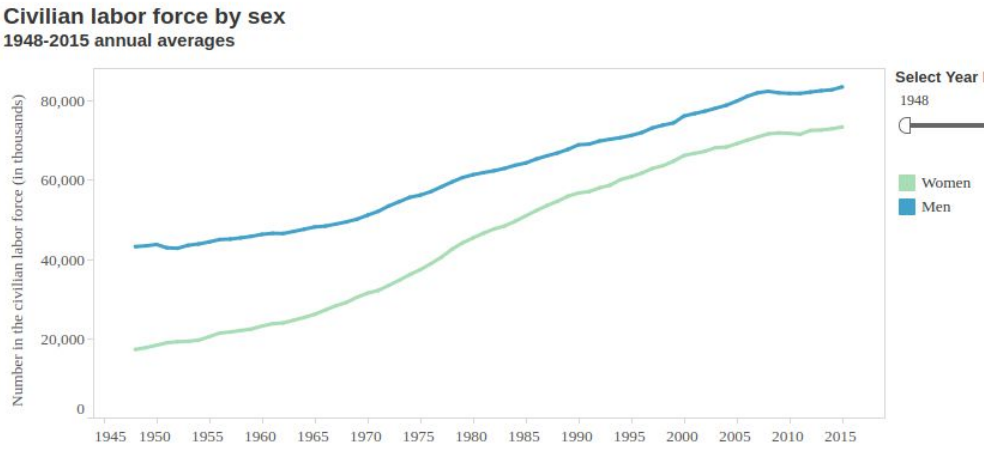


Figure 3. Civilian labor force by sex.

Women's participation was about half that of men in 1950. By 2015 women's participation was about 80% that of men's. The combination of baby boomers and female participation led to a significant increase in the labor force apparently without serious dislocation effects.

Jobs and tasks

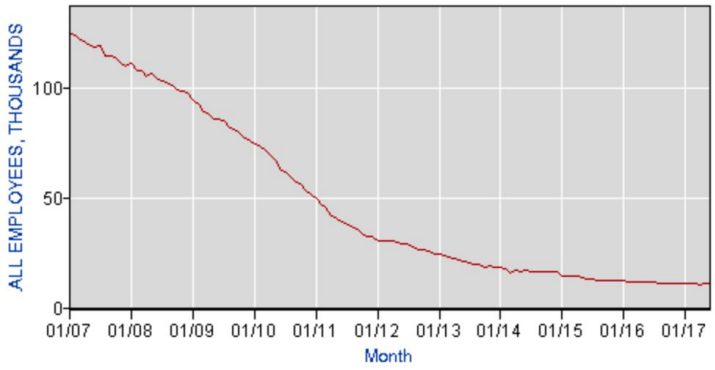
Jobs can be described by a set of tasks. The Department of Labor sponsors O*NET, a service that describes the tasks associated with about 1,000 job titles, along with other job-related data such as the skills necessary for various jobs. Of course, the relationship between jobs and tasks changes over time.

Besen [2017] examined the 270 occupations used by the Bureau of the Census and found that only one had been eliminated by pure technological change: elevator operator. But even elevator operators typically performed a variety of tasks. In addition to operating the elevator, they provided safety monitoring, security monitoring, greetings, information, services for residents, announcements of special prices or offers, and so on. When elevator operators disappeared, these tasks were supplied to users by other means, often but not entirely via other human workers such as receptionists or security employees.

In fact, most jobs are much more complicated than intellectuals think. Job titles may come and go but the tasks endure. Think for example of the job of "video store clerk".

Employment, Hours, and Earnings from the Current Employment Statistics survey (National)

Series Id: CES5553223001 (I)
Seasonally Adjusted
Series Title: All employees, thousands, video tape and disc rental, seasonally adjusted
Super Sector: Financial activities
Industry: Video tape and disc rental
NAICS Code: 53223
Data Type: ALL EMPLOYEES, THOUSANDS



In 2000 there were about In 27,882 video rental stores US but by late 2015 only 4,445 were left. (Wikipedia), with the numbers of employees being reduced proportionally. As with elevator operators, tasks involving video access, recommendations, marketing and so on still exist, they have simply been provided by other technologies and other communication channels.

What sort of tasks can be automated?

Generally, it is the dull, repetitive and unpleasant tasks that are replaced by automation. In the late 19th century, home automation enabled the automation of many sorts of manual tasks, such as washing clothes, drying dishes, mowing lawn, digging holes, and chopping wood. Similarly, computeration has eliminated many tedious tasks such as making change for purchase, memorizing maps, adding columns of numbers, and so on. As Figure 4 illustrates, routine jobs---both cognitive and manual---have been falling while non-routine jobs in both categories have increased.

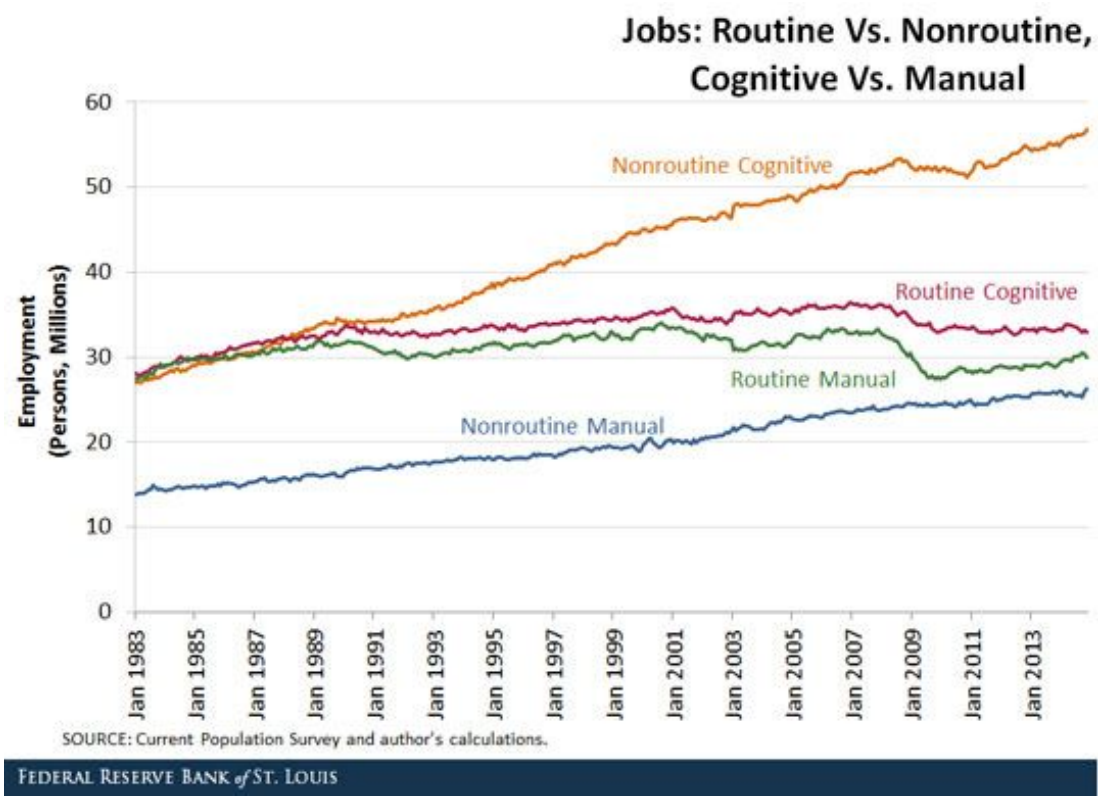


Figure 4. Routine v non-routine and cognitive v manual

We can illustrate this by looking at a job category on O*NET such as Groundskeeper. Some tasks seem likely to be automated such as “Mow or edge lawns, using power mowers or edgers.” However, other tasks like “Attach wires from planted trees to support stakes” are easily performed by humans, but a long way from being fully automated.

This is generally true for agricultural jobs. Driverless tractors have been available for at least a decade and mechanical harvesting for wheat, corn, soybeans, oats, and so on are commonplace. But soft fruits like raspberries, strawberries, apples, peaches, plums, cherries and so on are still harvested by hand.[1] If DARPA set “Prune or trim trees” as a grand challenge, and was willing to spend a billion dollars over a decade, this task could be likely be automated, at least in part. But that is only one task performed by a groundskeeper, there dozens of other tasks that need to be automated in order to completely replace a Groundskeeper.

The situation is quite different with an assembly line worker. This is a highly controlled environment that manufacturers have spent mover than 100 years optimizing.[2] Ideally, there is

[1] If some damage can be tolerated because of immediate processing (as with grapes to be made into wine), then some mechanical processing can be used.
[2] One of the earliest assembly lines was used in the Venetian Arsenale to convert merchant ships to war ships. However, process was highly secretive. The class assembly lines of the century was due to

one task performed at one station and this task can be repeated over and over again. This may not be a very pleasant task for humans, but it is ideal for robots. Perhaps that is why half of all industrial robots are in automobile plants, and another 30% is is electronics assembly.

As another example consider the job of Maids and Housekeeping Services. If all hotel rooms were standardized it might be possible to automate some of these services provided by hotel maids. But in the real world, there is a huge variety of different environments and full automation is not feasible in the near future.

Henry Ford to Elon Musk

In the 1929 *Encyclopedia Britannica* entry on mass production, Henry Ford wrote "In mass production there are no fitters." What did he mean by that cryptic phrase? For most of the 19th century manufacturers pursued the utopian goal of making truly interchangeable parts. Unfortunately progress was slow and assembly still required "fitter" --- skilled workers who used files to smooth down imperfections on parts so the fitted where they were supposed to go.

As Ford suggests, fitters could not be integrated into mass production which relied on a steadily moving assembly line. It wasn't until 1900 that mechanical parts became sufficiently standardized to enable smooth operation of assembly lines. This dramatically improved manufacturing productivity. Hounshell [1985] tells the story of how the concept of interchangeable parts evolved from a utopian dream in 1810 to vivid reality by 1910.

Fast forward a century. By now interchangeable parts must be a fully solved problem, right? No, there are still problems. For example, Elon Musk wanted the Tesla assembly line to be more highly automated than any other auto plant. Alas, it didn't work out:

> "Yes, excessive automation at Tesla was a mistake. To be precise, my mistake. Humans are underrated." Musk [1980].

Here is a description of why Musk's vision did not materialize:

> "In final assembly, robots can apply torque consistently—but they don't detect and account for threads that aren't straight, bolts that don't quite fit, fasteners that don't align or seals that have a defect. Humans are really good at this. Have you wondered why Teslas have wind-noise problems, squeaks and rattles, and bits of trim that fall off? Now you have your answer." Bernstein [2018].

So standardized, interchangeable parts is still a problem, even now.

Henry Ford [2005].. He attributed the idea to his visit to a meat packing plant in Chicago. If they can disassemble a cow, Ford figured he could assemble a car.

Job elimination?

Which tasks --- and which jobs --- will be automated? It depends on who you ask. (Figure 5.) This is just a sample of the forecasts; Technology Review has a much more extensive list.

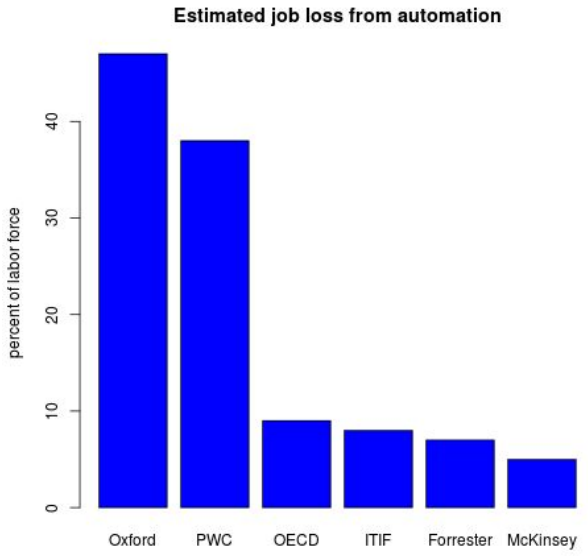


Figure 5. Estimates of job loss from automation.

It is instructive to look at the 10 largest occupations in America: retail salesperson, cashier, food preparation and serving, general office clerk, registered nurse, customer service representative, waiter/ waitress, laborer, administrative assistant, and janitor. These 10 jobs account for 21% of total employment.

All of these jobs are in services. This is not surprising since eighty percent of the labor force works in services. It is also noteworthy that only one of the occupations (registered nurse) pays more than the median wage. Certainly “cashiers” and “food preparation” are likely to be more automated in the future. I have my doubts about registered nurse, customer service representative, and janitors.

Even if we look at a relatively straightforward job like cashiers, there are a variety of exceptions to the standardized procedure. At Home Depot, one person can supervise 4 or 5 self-service checkouts. At the airport, there are perhaps 3 times as many check-in kiosks as airline personnel, due to the necessity of exception handling. This will undoubtedly be addressed as the processes become more standardized, but that will likely take years. Even Amazon’s Go store uses humans behind the scene to handle exceptions of one sort or another.

Robots and appliances

The word “robot” comes from Czech for “worker”. The popular image of a robot is some humanoid-like creature who can take over a manual task from a human. Reality is quite different. The robots on assembly lines look nothing like humans. And the major domestic appliances of the 19th century such as washing machines, dryers, dishwashers, vacuum cleaners, and sewing machines worked like humans. Washing machines don’t scrub clothes the way humans did, dishwashers work completely differently than humans, and so on.

The fact that domestic robots worked differently than humans is that not unusual: airplanes don’t fly by flapping their wings, cars don’t walk, boats don’t have tails, and so on. These days hear a lot about “retail robots” but in fact we have had retail robots for decades: they’re called vending machines. Progress in automation is likely to come from machines that bear little resemblance to humans.

Work week by year and country

Suppose that automation moves faster than anticipated and we do become so highly productive in 10 or 20 years that at least some workers become redundant. What can be done? One interesting social phenomenon that could easily be adjusted is the 5-day workweek. Two centuries ago people worked nearly 70 hours a week and even today there are quite significant differences across countries.

Year	Hours
1850	66
1870	62
1890	60.0
1900	59.6
1910	57.3
1920	51.2
1930	50.6
1940	37.6
1955	38.5

Country	Hours
Belgium	35.2
Denmark	32.1
France	36.1
Germany	34.5
Italy	35.5
Mexico	45.2
Netherlands	29.1
Spain	36.5
Sweden	35.9
United Kingdom	36.5
United States	38.6

Figure x. The work week over time and space.

Note that the average workweek in the Netherlands more than a full day less than the workweek in the US. They accomplish this by social policies that make flexible schedules more appealing in a number of ways. [Describe more based on Booth and van Ours [2012].

What is it that people really want? Answer: more jobs and less work. And that is exactly what technology can deliver: it can take over more tedious, dull, and repetitive tasks and replace them with more fulfilling labor or more fulfilling leisure if that is what is desired. If technology really can make us 25% more productive we can work 4-day weeks and keep consumption constant. Everybody loves a 3-day weekend, why not make them permanent? A shorter workweek is a lot easier to implement than a Universal Basic Income.

Education and training

Every discussion about jobs of the future gets around to education and training, and this one is no exception.

In my view, there is a significant fallacy of composition for education: it is good for any particular individual to become more educated, but is it good if everyone becomes more educated? Who will do the jobs that don't require much education, like groundskeeper and hotel maids?

As I indicated earlier, these jobs are too complex to be fully automated; for the foreseeable future there will be jobs for groundskeepers and housemaids. The question is, who will do them?

One possibility is immigration. This is a policy that many advanced countries have followed and we have seen it has its problems. Do we want to offer immigration to applicants a with high level of skills, or do we want to offer immigration to those who have a low level of skills and will perform tedious and unpleasant tasks such as harvesting or maid service that are unlikely to be automated.

Leaving aside the fallacy of composition, how should education and training be provided? It is likely that the best way to acquire skills is on the job. There is a lower opportunity cost, since the workers do not have to sacrifice income to get training. The training can be more relevant and more focussed, and of course workers are more highly motivated since the training should be directly relevant to their job.

It would be ideal if we had some advanced technology that allowed skills to be delivered as necessary, on a non-threatening device, for free to everyone who wants it. Well, we've got that technology already: it is called YouTube!

Every day there are over one billion views of educational and training videos on YouTube. These videos teach both cognitive skills (such as Khan Academy) and manual skills (such as how to weld). There are videos on how to cook, how to paint, how to provide medical assistance, and thousands of other topics.

This is unparalleled in human history: we now have an effective, universally available, and free source for education and training of every sort. Yes, surprisingly, no one seems to think of YouTube as part of the educational infrastructure.

Cognitive assistance

If the employer wants a certain skill and and the employee did not have that skill you can either bring the employee skill up the required level, or lower the required level and provide cognitive assistance using machine learning.

It used to be that being a ...

- cashier required knowing how to make change
- writer required knowing how to spell
- taxi driver meant knowing city streets
- hospitality worker in an international you know a bit of foreign languages
- gardener, you needed to recognize plants
- veterinarian how to recognize dog breeds
- physicist required knowing how to solve 50 different sorts of integrals

None of these skills are necessary now since tools like spell checking, online maps, translation apps, symbolic mathematical manipulation, and image recognition can provide all these capabilities using inexpensive or free hardware and software tools. Cognitive assistance helps people get jobs, by reducing the tasks they need to master in order to be qualified In 1880 machines offered manual assistance; but today then can offer cognitive assistance.

Of course, eventually a worker will learn to recognize integrals, plants, dog breeds, etc. so that cognitive assistance becomes a form of on-the-job learning. Lowering the cost of entry for an occupation is a good thing of course, except for those already in the industry. Think of a London taxi driver who spent 2 years learning The Knowledge who has to compete on equal terms with an online map. This is a case of “stranded human capital”, a phenomenon likely to become more common in the future.

Summary of bots

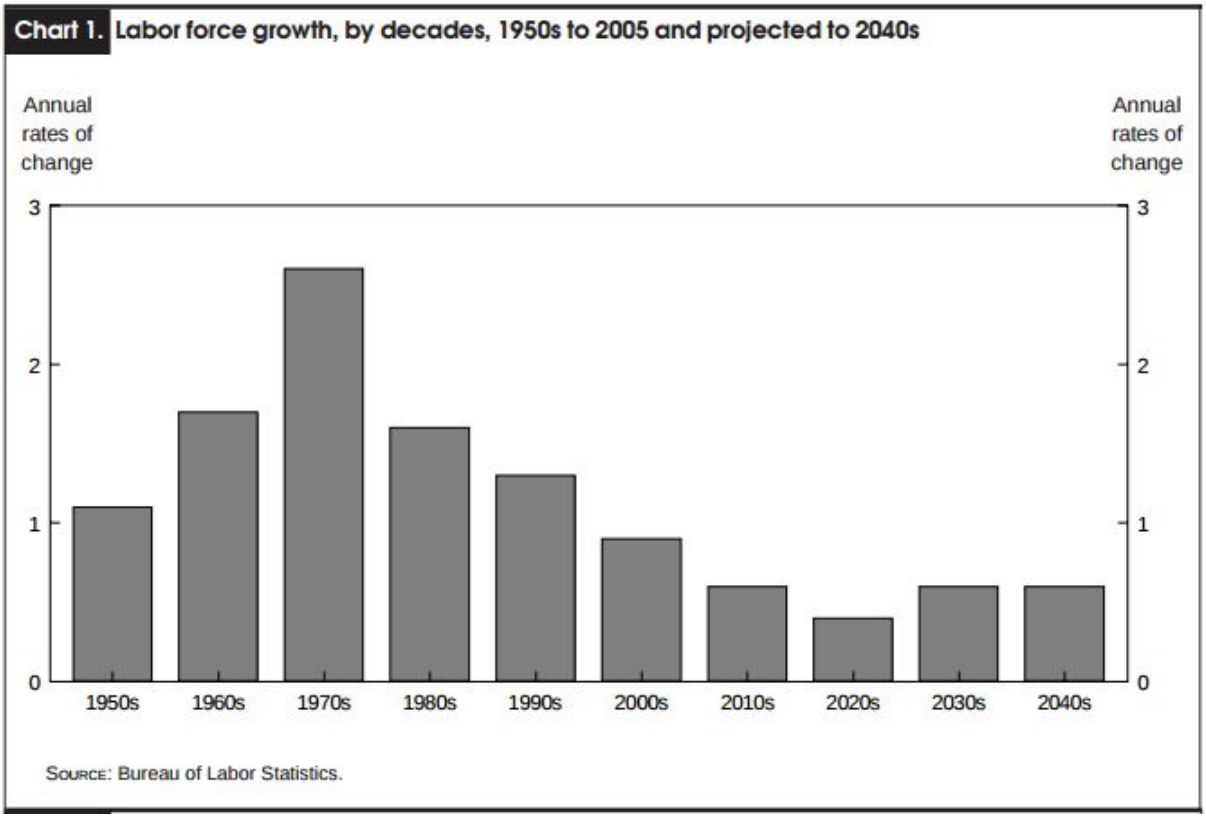
- Demand for labor and supply of labor are both important
- Automation commonly replaces tasks, rarely replaces jobs
- Historically this has led to more jobs and less work
- Most jobs are more complex than intellectuals recognize
- Job training is ideally on the job
- Technology can help deliver training as needed

Productivity

Economists decompose output per person in to three factors:

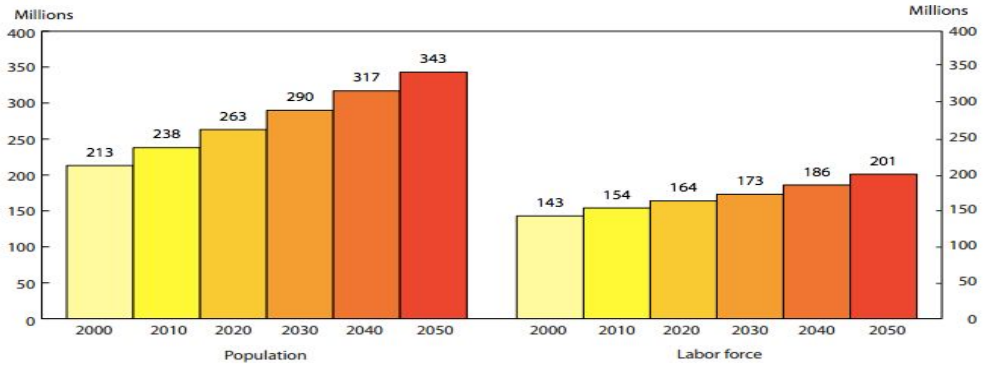
output/person = output/hour x hours/worker x workers/person
= productivity x employment x participation

As of 2018, we are basically at full employment, so it is unlikely to decrease. Participation is down in part due to aging of the baby boomers, a leveling off of female participation in the labor force and other factors so it is unlikely to increase either. In fact, in the next decade the labor force will be increasing at the slowest rate ever measured.

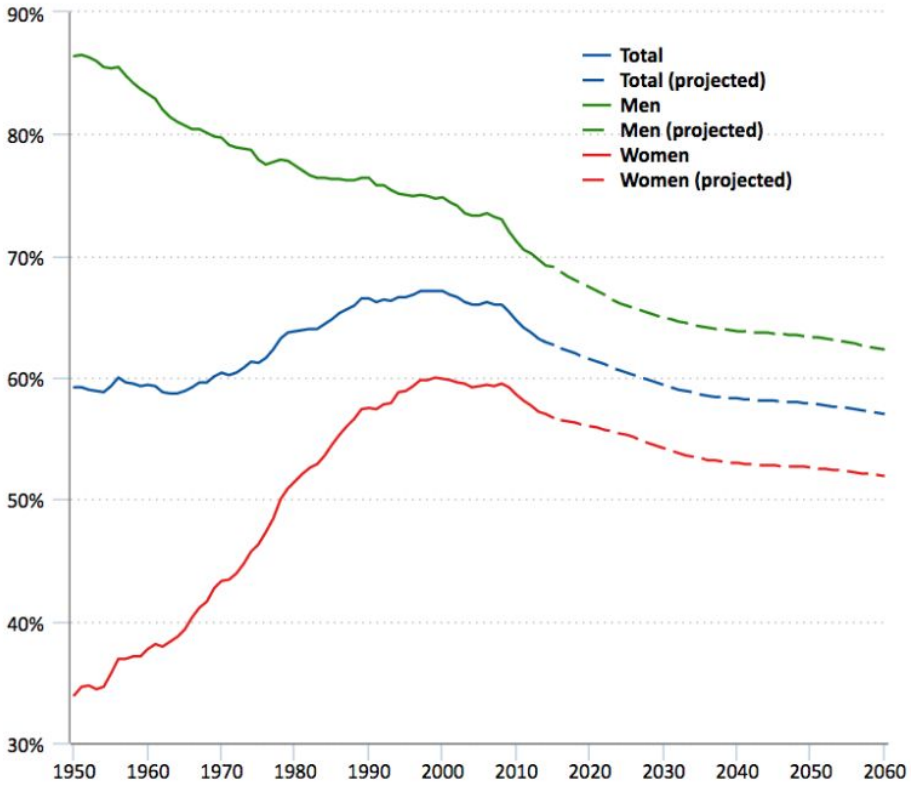


In the US, tthe labor force is growing at half the rate of the population growth; and the gap will not close until 2060. Without legal immigration the labor force will decline by 2035.

2. Population and labor force, 2000, 2010, and projected 2020, 2030, 2040, and 2050



Furthermore, the participation rate among both men and women is projected to decline.



Finally, the birth rate in the US it at its lowest level ever.

The only factor left to lead to growth in output per person is productivity growth---which essentially means automation. Unfortunately, productivity growth has been quite anemic in the last decade.

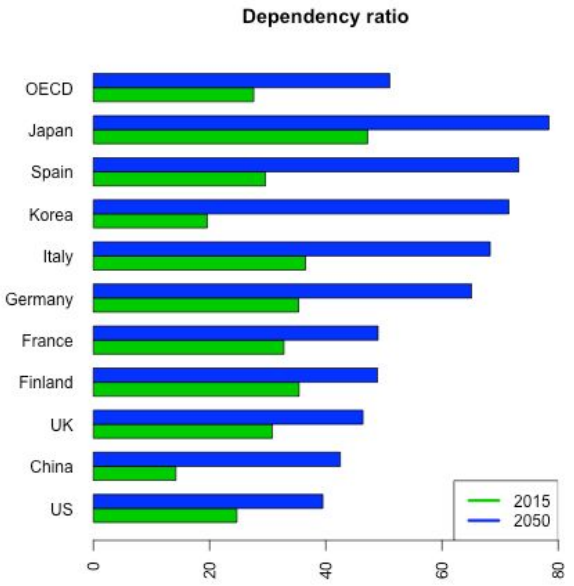
This combination of factors lead labor economists to expect tight labor markets in the US for the next 25-35 years.

THis means that widespread beliefs about the labor market will have to adjust to a new reality. The large influx of baby boomers and women into the labor market during the latter part of the 20th century led employers to expect workers to be readily available and wage growth to be slow. However, the next 50 years will be quite different: markets will be tight and wages may well increase as workers become increasingly scarce.

All of those baby boomers who are retiring expect to continue to consume. Who will produce the goods and services they need? The only plausible answer is automation. If workers are in demand, wages go up, increasing the incentive to automate. To the extent that automation increases productivity, output will increase and more consumption will be available to both workers and retirees.

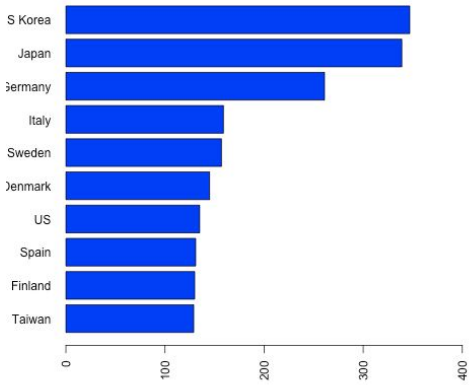
Rest of world

US is in good shape compared to many developed countries. For example,
here is a plot of the dependency ratio for 2015, 2025, and 2050. Countries such as Japan, Korea, Germany, Spain, and Italy are showing alarming growth in dependency.

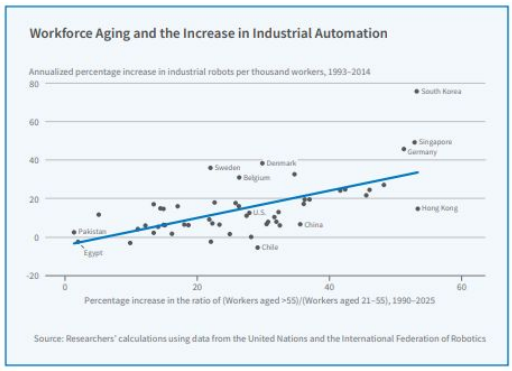


People over 65 for every 100 people of working age. Source: OECD

Not surprisingly, many of these same countries are investing heavily in robotics as shown in Figures x and y.



Source: Robotics and Automation News



This demographic effect is also leading to an extension of official retirement age in many countries, Boulhol and Geppert [2018] contain an interesting chart showing how much retirement age must increase to stabilize the dependency ratio in various countries. The average amount in the EU is 8 years; the amount in the US is about 6 years. Korea has the largest extension of nearly 16 years. Needless to say, increasing the retirement age by 6 years suddenly would be very difficult from a political viewpoint.

Supply and demand for labor

We have seen that both the demand and supply are shifting to the left. Which effect is likely to be stronger?

The Boston Consulting Group (2015) “aggressive scenario” estimates that the employment/population declines by 1.76% in next decade The Bureau of Labor Statistics (2006) estimates that the employment/population ratio will declines by 2.7% based on demography during next decade. In net, the demographic effect is 53% larger than than the automation effect! This suggestions that we will see tight labor markets, rising wages and an increased incentive to economize on labor.

In future studies of jobs lost (and gained) due to automation, it would be useful to compare the employment/population ratio for both supply and demand of labor. Focusing on the demand side alone is misleading from a policy perspective.

Medical care

So far, we have looked only at the impact of ageing on the size of the labor force. This is only part of the effect: as retirees age, they become more costly. For example there are 46 million people over 65 today, representing 15 percent of the population. By 2060, we will see 98 million people over 65, or 24% of the population. There are 5 million people suffering from Alzheimer's; if there is no cure found, there will be nearly 3 times as many people suffering from this disease in in 2050.

As mentioned above the birth rate is at an all time low. According to the Wall Street Journal (May 17, 2018).

> "This dearth of births could exacerbate the problems of America's aging population. Many baby boomers are in or are near retirement, leaving a smaller share of young workers to pay into Social Security and Medicare. That is creating a funding imbalance that strains the social safety net that supports the elderly."

[Say something about health care.]

Summary

Most jobs, even low level jobs, consist of a variety of tasks that are difficult to automate, so we can expect them to be with us for a long time. The demographic shifts, on the other hand, are hitting us in the near term future, and it is likely that we will see a tight labor market for decades to come. Increasing productivity, most likely with automation, will become increasingly important.

Possible additions

Other estimates

Predicted Jobs Automation Will Create and Destroy

When	Where	Jobs Destroyed	Jobs Created	Predictor
2016	worldwide		900,000 to 1,500,000	Metra Martech
2018	US jobs	13,852,530	3,078,340	Forrester
2020	worldwide		1,000,000-2,000,000	Metra Martech
2020	worldwide	1,800,000	2,300,000	Gartner
2020	sampling of 15 countries	7,100,000	2,000,000	World Economic Forum (WEF)
2021	worldwide		1,900,000-3,500,000	The International Federation of Robotics
2021	US jobs	9,108,900		Forrester
2022	worldwide	1,000,000,000		Thomas Frey
2025	US jobs	24,186,240	13,604,760	Forrester

Predicted Jobs Automation Will Create and Destroy

When	Where	Jobs Destroyed	Jobs Created	Predictor
2025	US jobs	3,400,000		ScienceAlert
2027	US jobs	24,700,000	14,900,000	Forrester
2030	worldwide	2,000,000,000		Thomas Frey
2030	worldwide	400,000,000-800,000,000		McKinsey
2030	US jobs	58,164,320		PWC
2033	US jobs	67,876,460		Oxford University
2035	US jobs	80,000,000		Bank of England
2035	UK jobs	15,000,000		Bank of England
No Date	US jobs	13,594,320		OECD
No Date	UK jobs	13,700,000		IPPR

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