Automation versus procreation (aka bots versus tots)

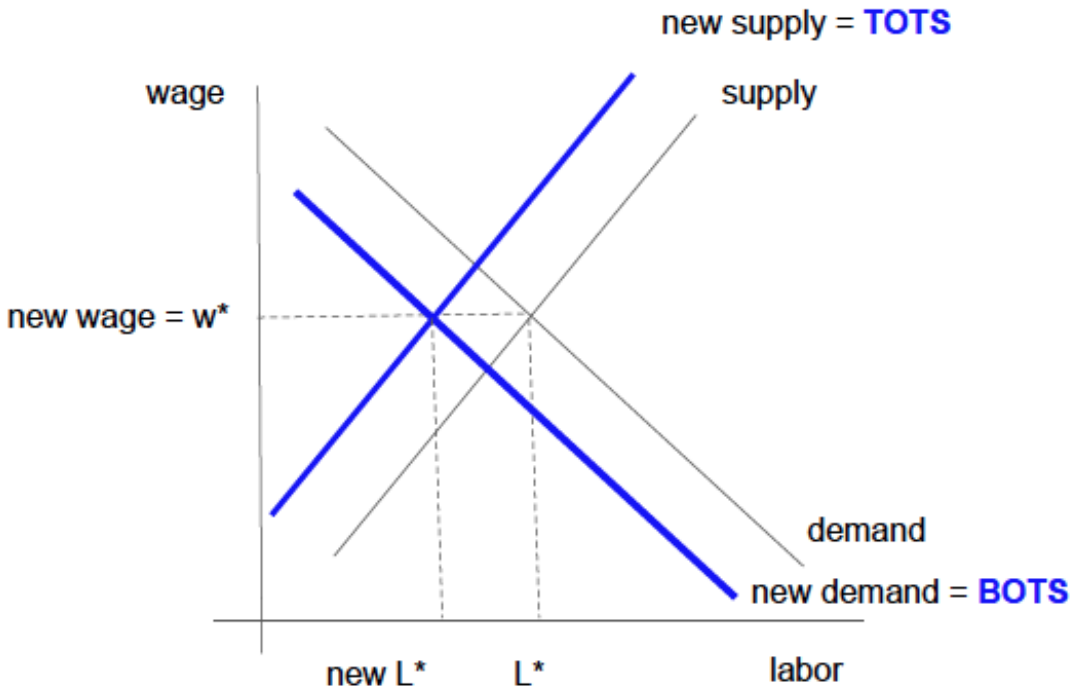
voxeu.org/article/automation-versus-procreation-aka-bots-versus-tots

Hal Varian, *voxeu*, March 30, 2020

Several recent studies have considered the impact of automation on labour demand in the coming decades. But demand is only one side of the labour market – the supply of labour will also change dramatically in the next 50 years due to demographic effects. This column discusses how the net outcome for wages and employment will depend on the relative magnitude of these shifts in demand and supply. The supply-side effects due to demographic forces appear likely to be somewhat greater than the demand-side changes due to automation for at least the next decade, and possibly longer.

It is widely thought that we will see a reduction in demand for (human) labour due to technological improvements in robotics and artificial intelligence in the next few decades. Figure 1 depicts a simple model of the labour market where demand and supply interact to determine an equilibrium wage and employment level. Automation 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 boomers – will shift the *supply* curve to the left as well. Both demand and supply suggest that there will be a decrease in employment. The effect on the equilibrium wage is ambiguous: it depends on which curve shifts the most.

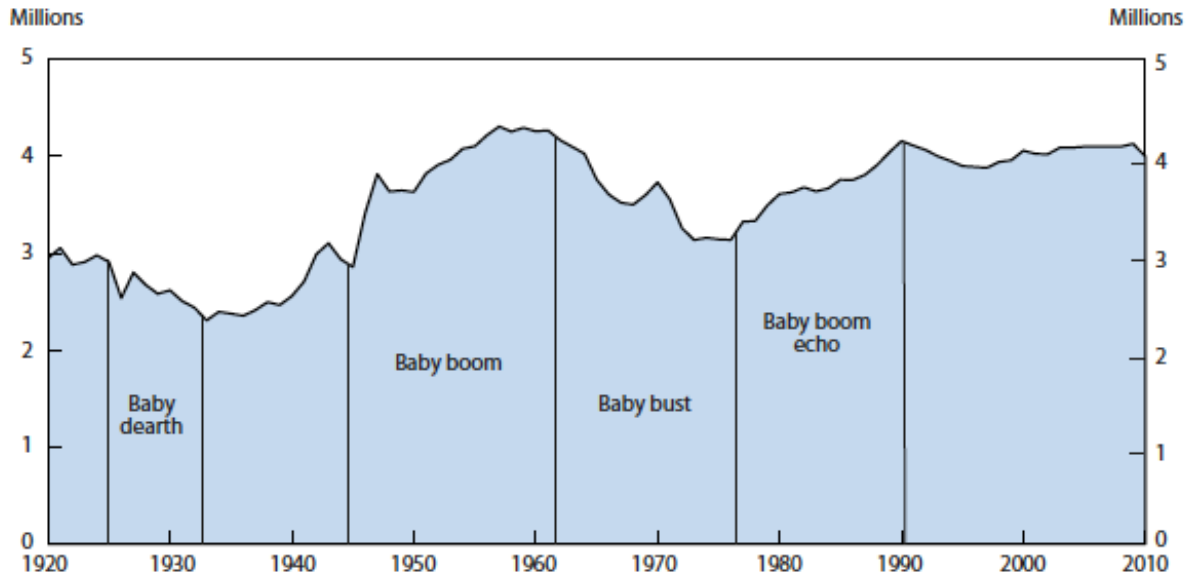
Figure 1 Demand and supply of labour



There is a long history of concern about automation replacing human workers (see, for example, Frey and Osborne 2013 for a historical overview). However, the US economy has been able to absorb large changes in the supply and demand for labour during the 20th century. Figure 2 depicts births in the US from 1920 to 2010. Note the 'baby dearth'

during the recession and WWII followed by the dramatic increase in the birth rate of the 'baby boomers' during the period 1946-1964.

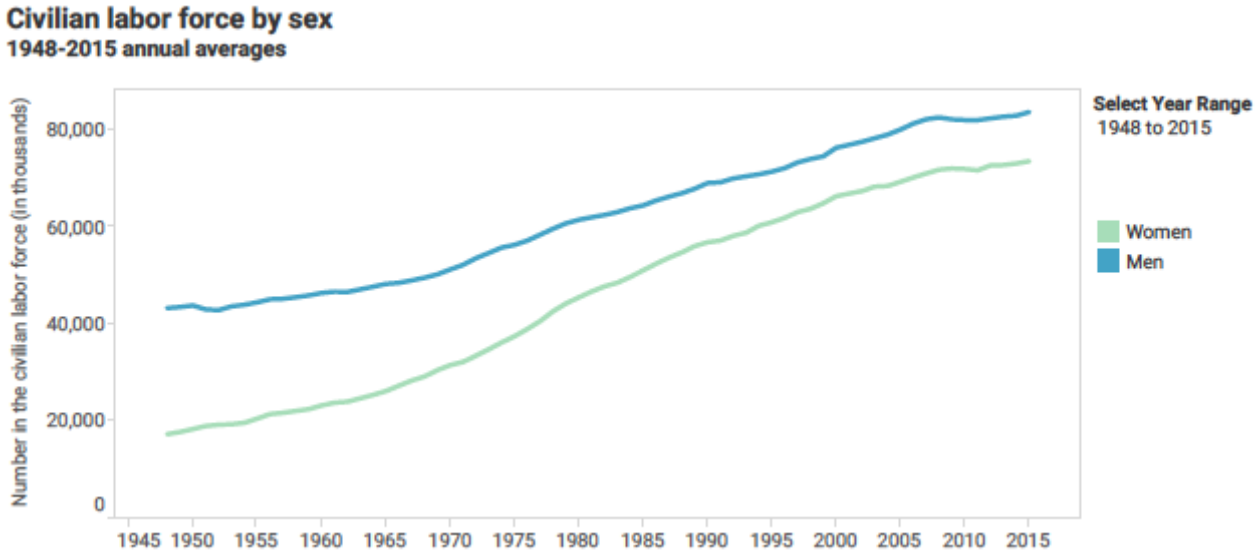
Figure 2 Live births by year



Source: Bureau of Labour Statistics

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

Figure 3 Civilian labour force by sex



Source: Department of Labor

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

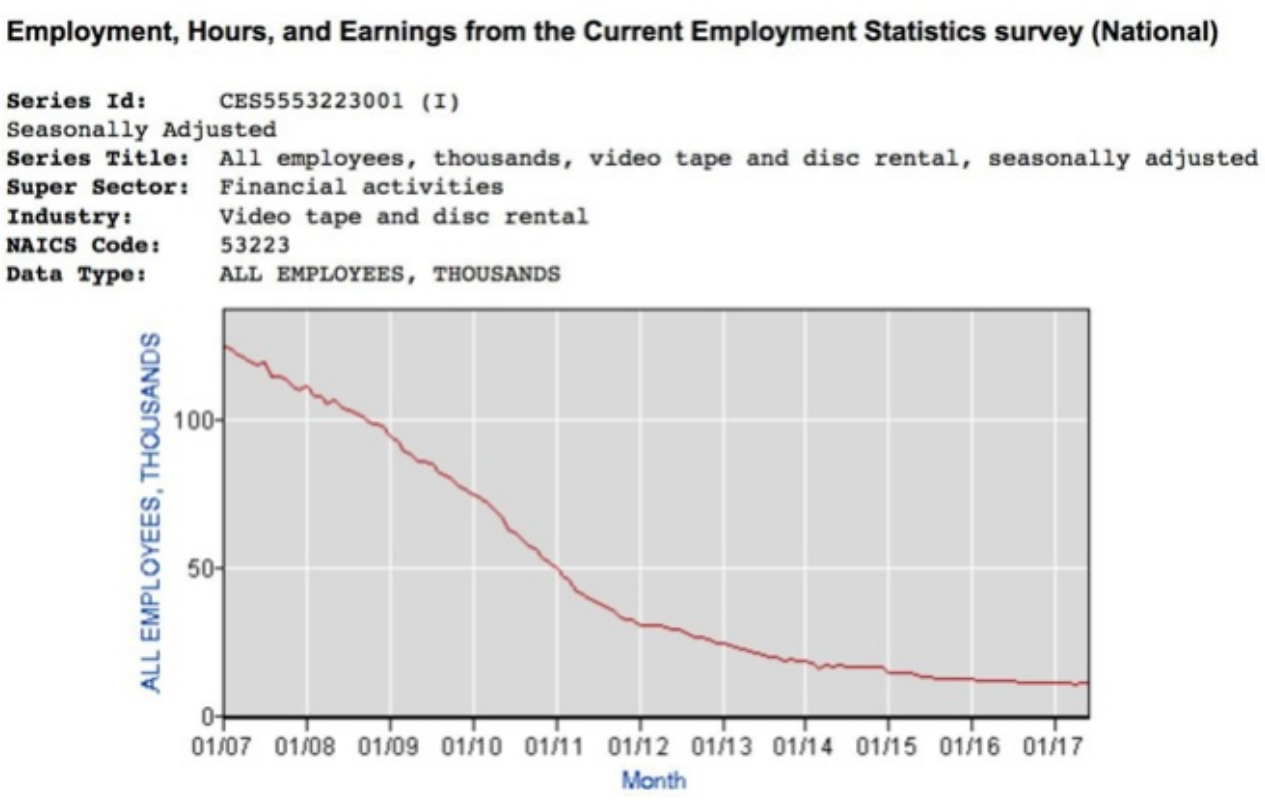
Jobs and tasks

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 necessary skills needed for various jobs. Of course, the relationship between jobs and tasks changes over time, with different tasks being associated with different jobs at different times.

Besen (2017) examined the 270 occupations used by the Bureau of the Census in 1950 and found that only one job had been subsequently eliminated by pure technological change, namely, the job of being an 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 of the job of video store clerk, for example. In 2000, there were about 27,882 video rental stores in the US, but by late 2015 only 4,445 were left (source: Wikipedia), with the numbers of employees being reduced proportionally (Figure 4). 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.

Figure 4 Employment, hours and earnings of video rental clerks in the US, 2007-2017

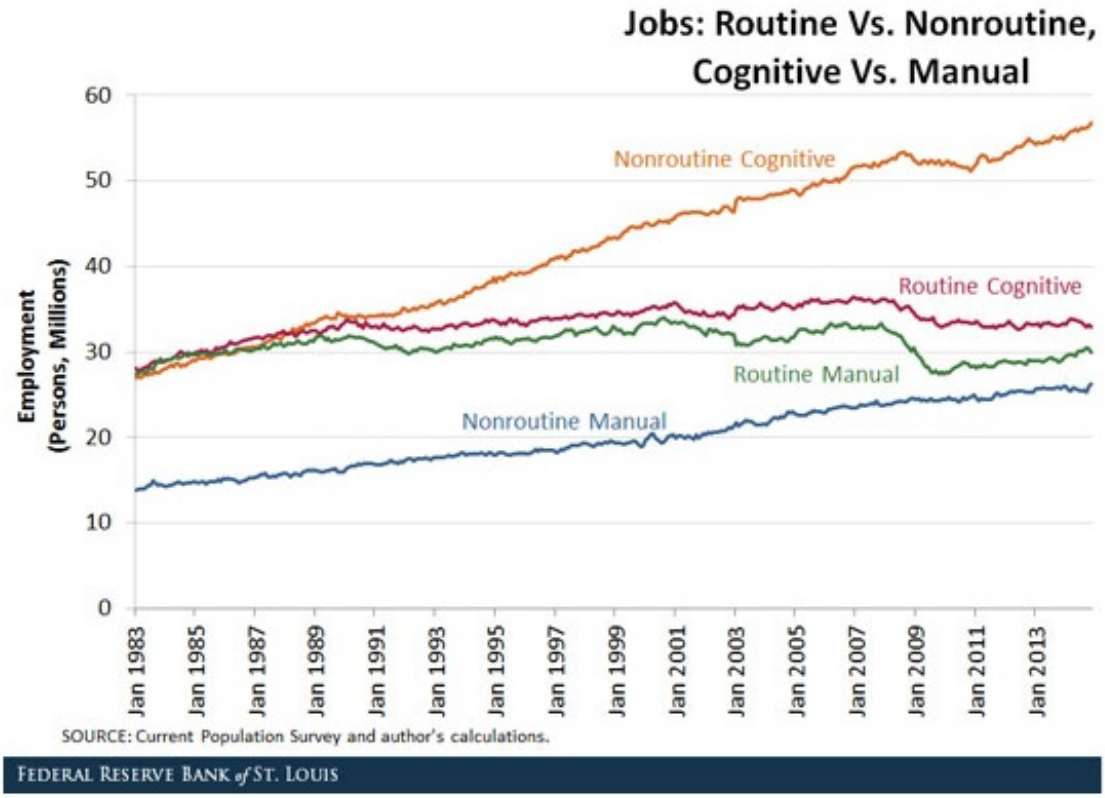


What sort of tasks can be automated?

Generally, it is the dull, repetitive and unpleasant tasks that are replaced by automation. In the late 19th century, technology enabled the automation of many sorts of manual tasks, such as washing clothes, cleaning dishes, mowing the lawn, digging holes, and chopping wood.

Similarly, computerisation has eliminated many tedious tasks such as calculating change for purchases, memorising maps, adding columns of numbers, and so on. As Figure 5 illustrates, routine jobs – both cognitive and manual – have been falling while non-routine jobs in both categories have increased.

Figure 5 Routine versus non-routine and cognitive versus 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, such as "Attach wires from planted trees to support stakes", are easily performed by humans but a long way from being fully automated.[1] See this account for the state of the art of robotic gardening.

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 is commonplace. But soft fruits such as raspberries, strawberries, apples, peaches, plums, and cherries are still harvested by hand.[2] 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 likely

be automated, at least in part. But that is only one task performed by groundskeepers; there dozens of other tasks that need to be automated in order to completely replace a groundskeeper.

The situation is quite different with assembly line workers. This is a highly controlled environment that manufacturers have spent more than 100 years optimising.[3] Ideally, one task is performed at one station, and this task must be repeated over and over again. This may not be very pleasant for humans, but it is ideal for robots. Perhaps that is why half of all industrial robots are in automobile plants, and another 30% of robots are used for electronics assembly.

As another example, consider the job of maids and housekeeping services. If all hotel rooms were standardised it might be possible to automate some of the services provided by hotel maids. As a case in point, consider the Japanese capsule hotels or the French automated toilets (or, for that matters, McDonalds). Once the environment has been standardised, tasks become much easier for both humans and machines. As the supply of labour declines and the cost increases, there will be increasing incentives to standardise.

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 'fitters' – skilled workers who used files to smooth down imperfections on parts so they 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 standardised 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."[4]

Bernstein analysts provide an explanation of why Musk's vision did not materialise:

"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

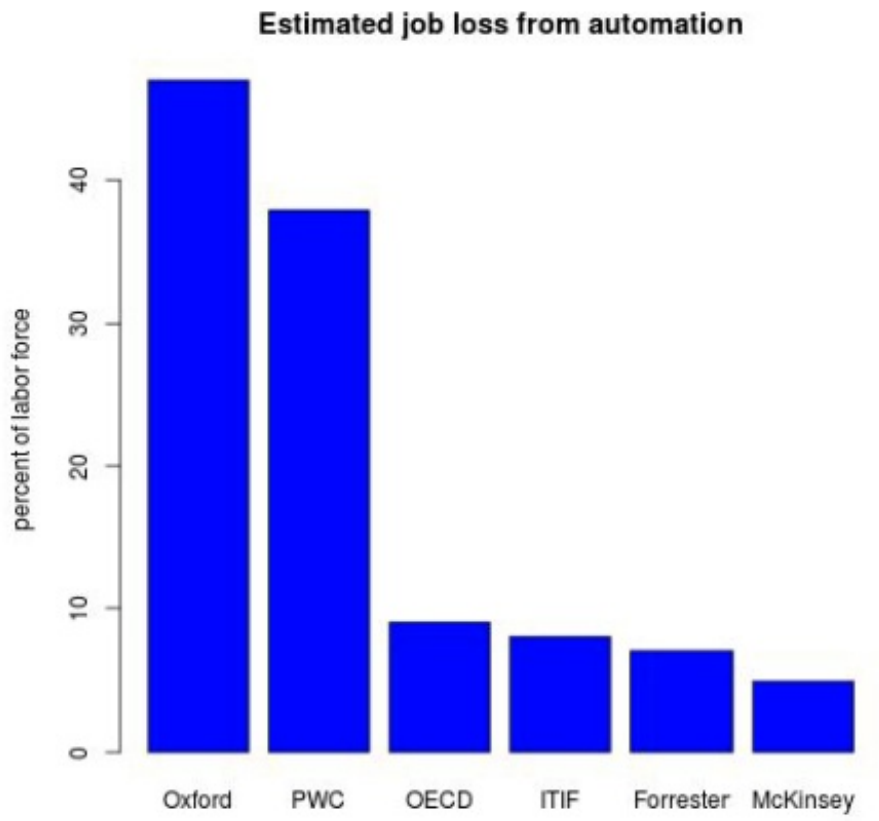
align or seals that have a defect. Humans are really good at this. Have you wondered why Teslas have wind-noise problems, squeaks and rattles, and bits of trim that fall off? Now you have your answer." (quoted in Edwards and Edwards 2018)

So the availability of standardised, interchangeable parts is still a problem, even now. The same is true of other tasks – those automatic boarding pass printers often need human intervention. Other forms of automation, such as warehouse automation, often require humans to manage exceptions.

Job elimination?

Which tasks – and which jobs – will be automated? It depends on who you ask. Figure 6 presents a sample of forecasts.[5]

Figure 6 Estimates of job loss from automation



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

All of these jobs are in services. This is not surprising, since 80% of the labour 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 become more automated in the future; I have my doubts about the automation of registered nurses, customer service representatives, and janitors.

Even if we look at a relatively straightforward job such as cashier, there are a variety of exceptions to the standardised procedure. At Home Depot, one person is needed to supervise four or five self-service checkouts. At the airport, there are perhaps only three 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 standardised, but that will likely take years. Even Amazon's Go Store uses humans behind the scenes to handle exceptions of one sort or another.

Robots and appliances

The word "robot" comes from the Czech word for "worker". The popular image of a robot is some humanoid-like creature who can take over a manual task from a human. The 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 – don't work like humans. Washing machines don't scrub clothes the way humans do, dishwashers work completely differently than human dishwashers, 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 and boats don't have tails. These days we hear a lot about 'retail robots', but in fact we have had retail robots for decades – they are called vending machines. Progress in automation is likely to come in the form of machines that bear little resemblance to humans.

Evolution of the work week

Suppose that automation moves faster than anticipated and we do become so highly productive in the next 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 five-day work week. Two centuries ago people worked nearly 70 hours a week, and even today there are quite significant differences across countries.

Figure 7 The work week over time and space

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

Source: Economic History Association and OECD

Figure 7 shows that the average work week in the Netherlands is more than a full day less than the work week in the US. The Dutch accomplish this through social policies that make flexible schedules more appealing to both employers and employees (see Booth and van Ours 2012 for some examples of how the Dutch system works).

One particularly interesting innovation involves the Dutch equivalent of Social Security payments. In the Dutch system, if a retired person wants to work, neither the worker nor the employer has to pay Social Security taxes. Compare this to the US programme, which requires both workers and employers to pay Social Security, even after retirement.

What is it that people really want? The answer is more jobs and less work. And that is exactly what technology can deliver: it can eliminate tedious, dull, and repetitive tasks and replace them with more fulfilling labour or leisure, if that is what is desired. If technology really can make us 25% more productive, we can work four-day weeks and maintain current consumption. Everybody loves three-day weekends, so why not make them permanent? A shorter work week is a lot easier to implement than a universal basic income. There is considerable evidence that many workers would prefer more flexible work sessions. Automation, of one sort or another, could enable more flexibility.

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, such as groundskeeper or hotel maid?

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 take these jobs?

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

Leaving aside the fallacy of composition, how should education and training be provided? The best way to acquire skills is likely to be on the job. This has a much lower opportunity cost since the workers do not have to sacrifice income to get training, the training can be more relevant and more focused, and of course workers are more highly motivated since the training is 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 (e.g. 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 of education and training of every sort. Yet, surprisingly, no one seems to think of YouTube as part of the educational infrastructure. Of course, video training by itself is not a panacea. Students often need guidance, motivation, encouragement, discipline, and assistance. But the fact that the core instructional material is readily available to all may well have profound consequences.

Cognitive assistance

If an employer wants a certain skill and a potential employee does not have that skill, either the candidate can acquire the skill or the employer can reduce the level of skill required to perform the job.

It used to be that …

- a cashier had to know how to calculate change

- a writer had to know how to spell
- a taxi driver had to know city streets
- a hospitality worker in an international hotel needed some knowledge of foreign languages
- a gardener needed to recognise plants
- a veterinarian needed to recognise dog breeds and
- a physicist need to know how to solve 50 different sorts of integrals.

None of these skills is necessary now, since tools such spell checkers, online maps, translation applications, symbolic mathematical manipulation, and image recognition can provide all these capabilities through inexpensive or even free hardware and software. 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; today they can offer cognitive assistance.

Of course, a worker will eventually learn to recognise integrals, plants, dog breeds, and so on 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 two years learning ‘the knowledge’ and 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.

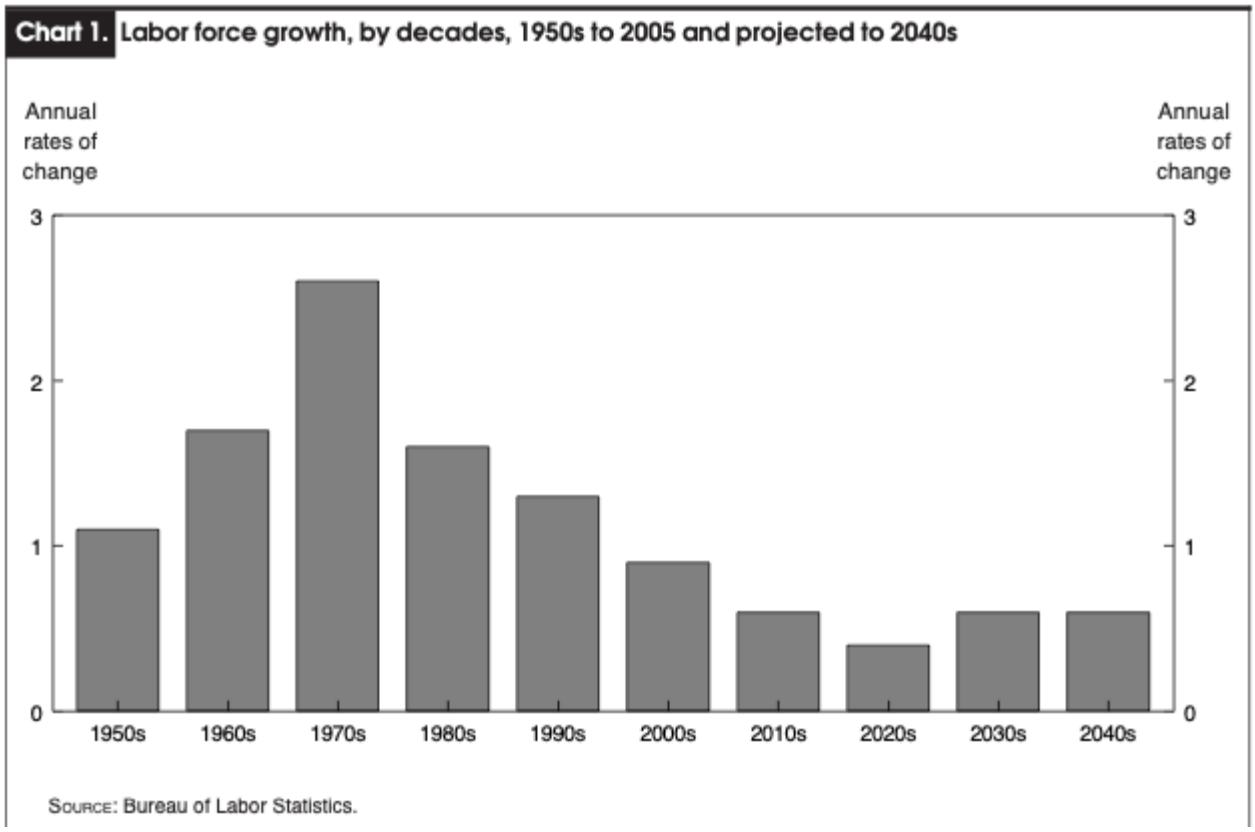
Productivity

Economists decompose output per person into three factors:

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

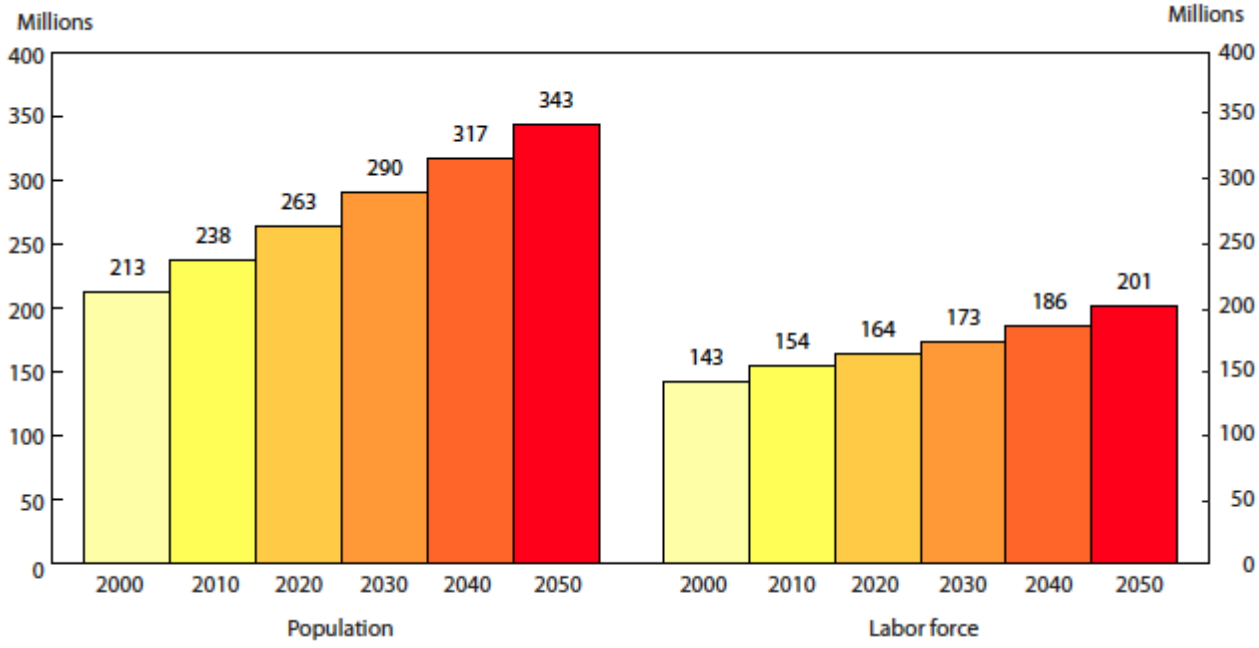
The fact that, in 2018, we were basically at full employment and labour force participation is in part due to ageing of the baby boomers.

Figure 8 Labour force growth by decade projected to the 2040s



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

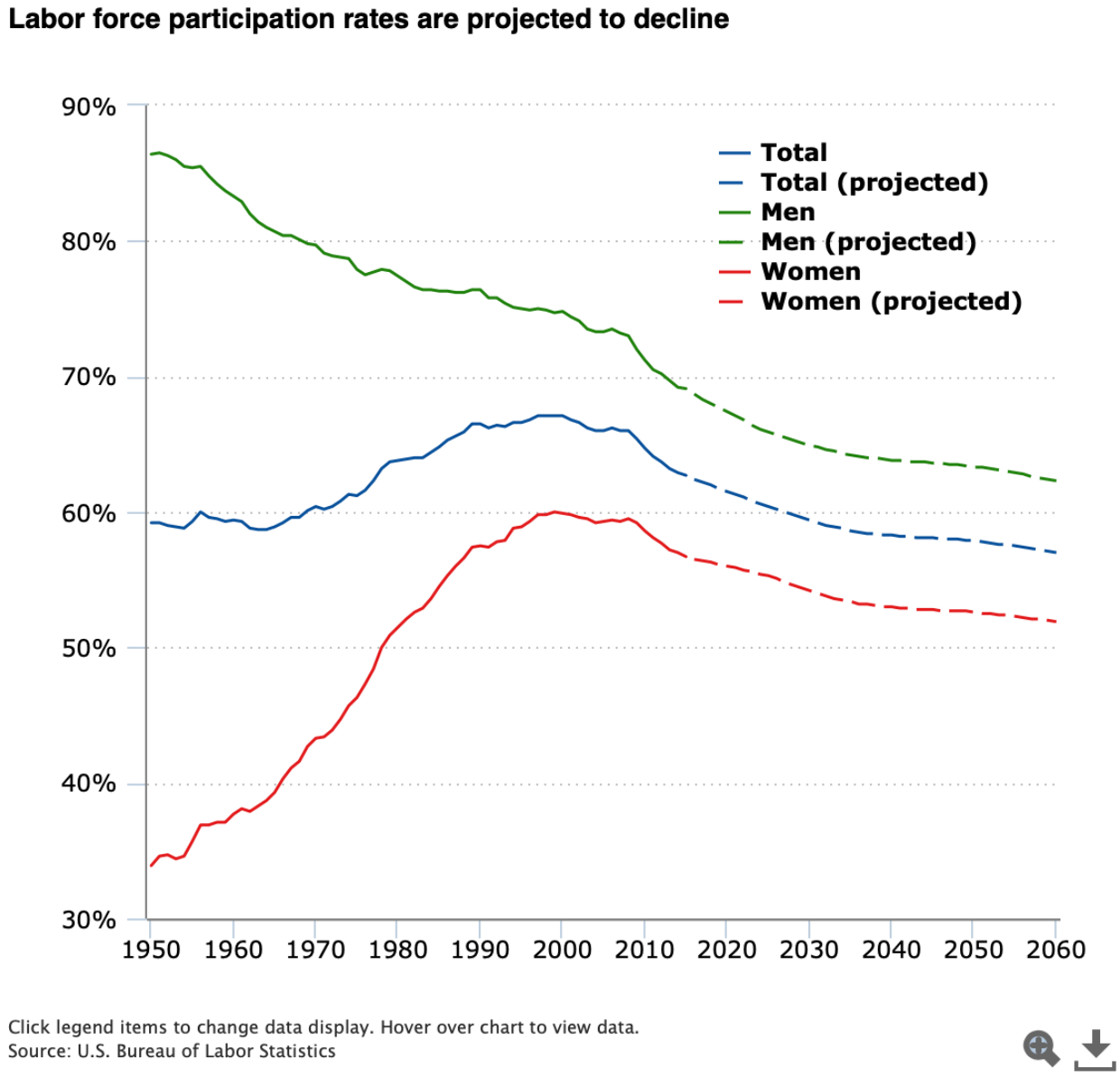
Figure 9 Population and labour force growth projected to 2050



Source: Bureau of Labor Statistics.

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

Figure 10 Participation rates projected to 2060



Source: Bureau of Labor Statistics.

Finally, the birth rate in the US is at its lowest level ever. No matter how productive you are, it takes 20 years to raise a 20-year old.

This leaves productivity growth as the only factor that can spur growth in output per person – which essentially means automation. Unfortunately, productivity growth has been quite anaemic in the last decade.

This combination of factors leads labour economists to expect tight labour markets in the US for the next 25 to 35 years.

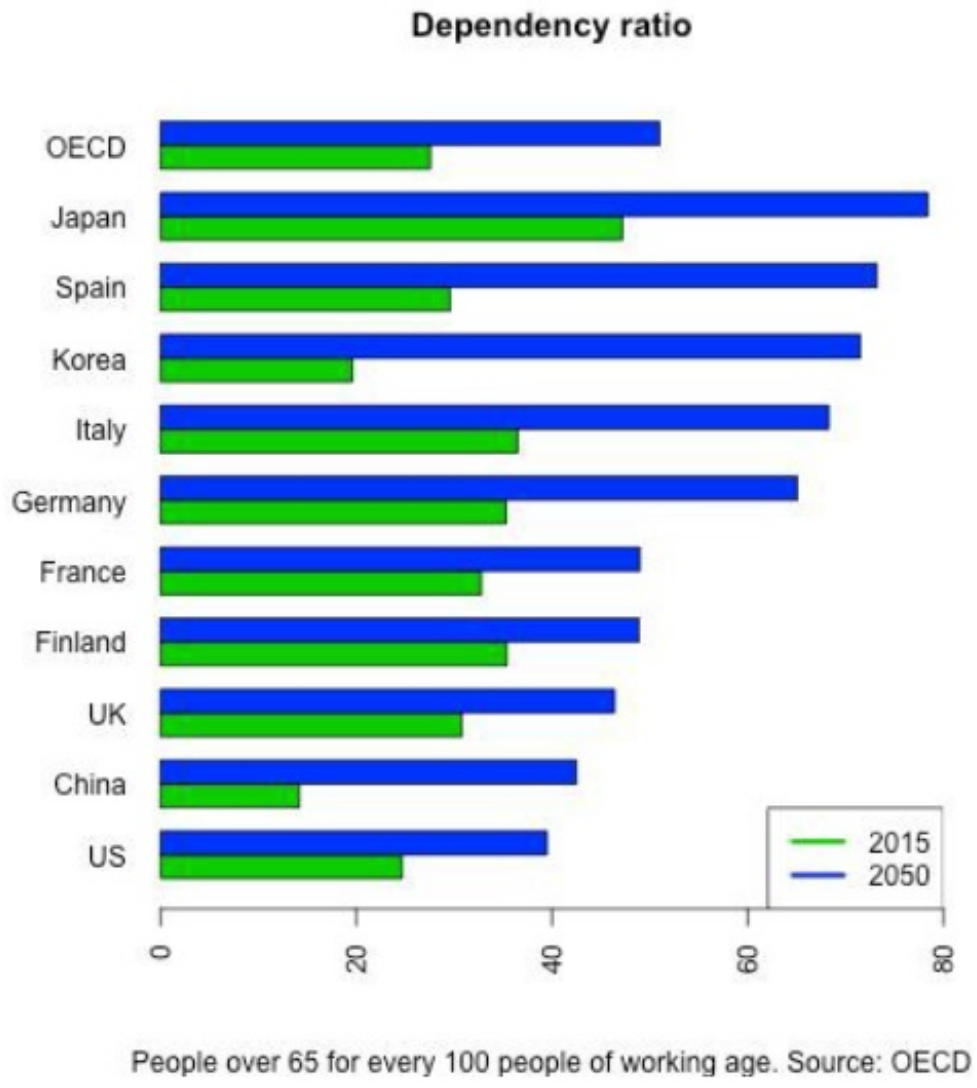
This means that expectations about the labour market will have to adjust to a new reality. The large influx of baby boomers and women into the labour market during the latter part of the 20th century led employers to expect workers to be readily available and wage growth to be slow. The next 25 to 35 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 consuming. Who and what 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 the world

The US is in good shape compared to many developed countries. Figure 11 plots dependency ratios for selected countries for 2015 and 2050. Countries such as Japan, Korea, Germany, Spain, and Italy are already showing alarming growth in dependency, and by 2050 their dependency ratios will be at record highs.

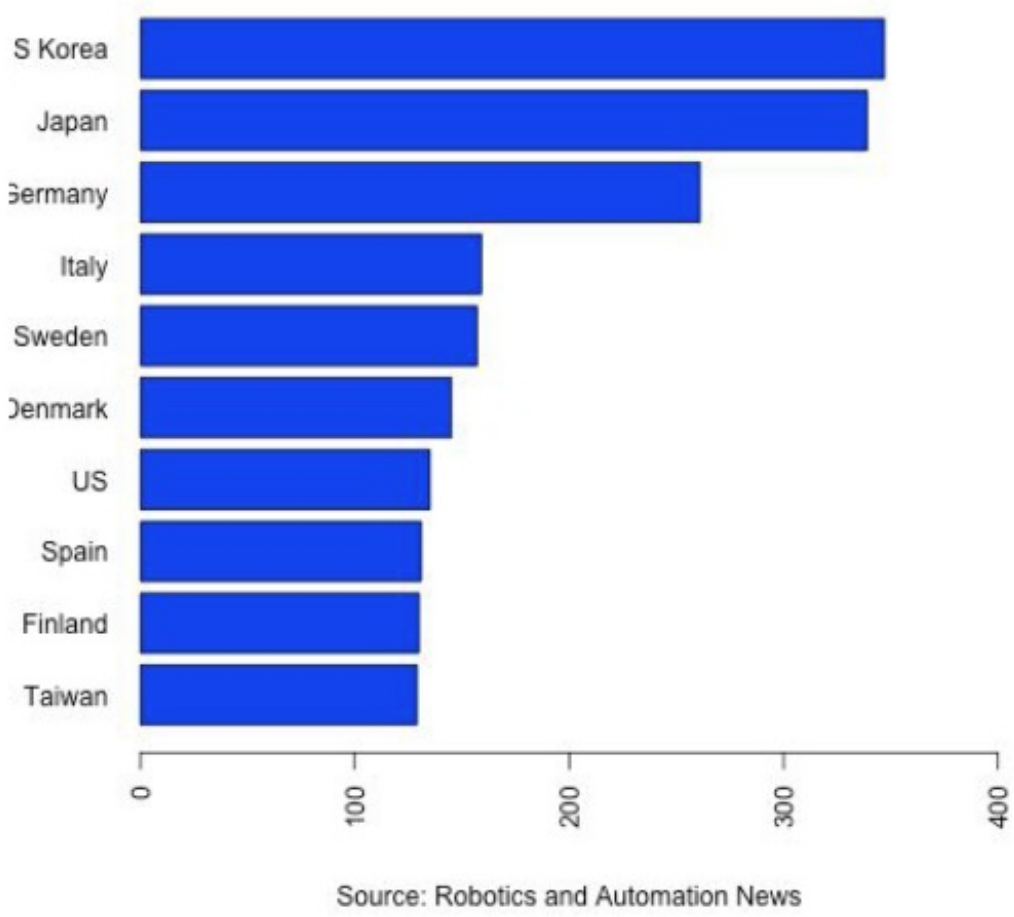
Figure 11 Dependency ratios, 2015 and 2050



Source: OECD.

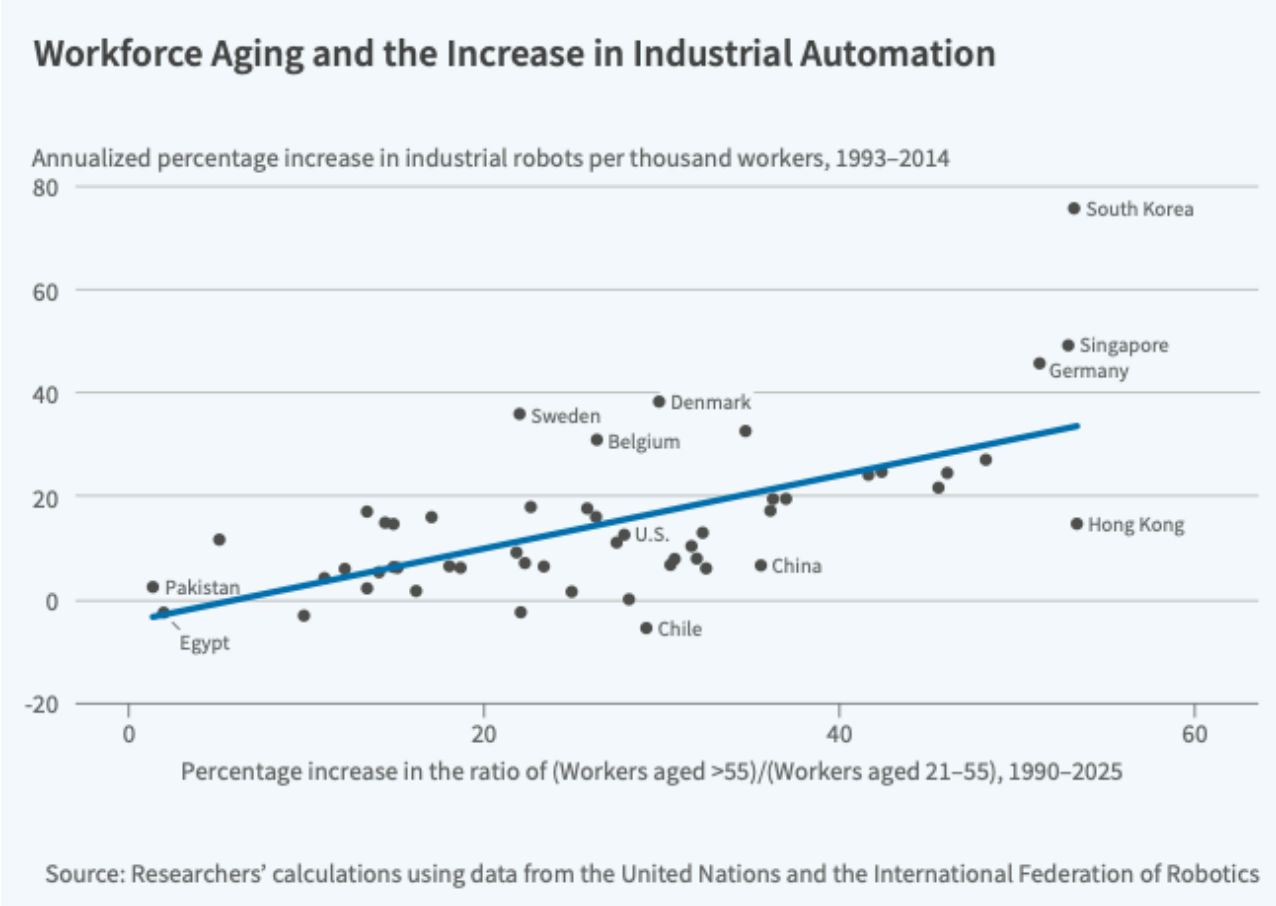
Not surprisingly, many of these same countries are investing heavily in robotics, as shown in Figure 12.

Figure 12a Robots per 10,000 workers



Source: Robotics and Automation News.

Figure 12b Workforce ageing and the increase in industrial automation



Source: Acemoglu and Restrepo (2018).

This demographic effect is leading to an extension of the official retirement age in many countries. Boulhol and Geppert (2018) provide an interesting figure showing how much the retirement age must increase to stabilise the dependency ratio in various countries. The average increase in the EU is eight years; the amount in the US is about six years. Korea requires the largest extension of nearly 16 years. Needless to say, suddenly increasing the retirement age by six years would be politically very difficult.

Supply of and demand for labour

We have seen that both the demand for and supply of labour are shifting to the left, but the impact on the wage is theoretically ambiguous. Which effect is likely to be stronger?

The Boston Consulting Group's (2015) "aggressive scenario" estimates that the employment/population ratio will declines by 1.76% in next decade as a result of automation, while tThe Bureau of Labor Statistics (2006) estimates that the employment/population ratio will declines by 2.7% based on demographicsy during over next decade. In On net, the demographic effect is 53% larger than than the automation effect! This suggests that at least for the next decade, (and likely longer), we will see tight labour markets, rising wages, and an increased incentive to economisze on labour.

Medical care

So far, we have looked at the impact of ageing on the size of the labour force. But that is only the initial impact of retirement. As retirees age, they become more costly. There are 46 million people aged over 65 in the US today, representing 15% of the population. By 2060, we will see 98 million people over 65, or 24% of the population. There are currently 5 million people suffering from Alzheimer's in the US; if there no cure is found, there will be nearly three times as many people suffering from this disease in 2050.

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

"This dearth of births could exacerbate the problems of America's aging population. Many baby boomers are retired or close to it 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."

Concluding remarks

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. Demographic shifts, on the other hand, will hit us in the near-term future, and it is likely that we will see a tight labour market for decades to come. Increasing productivity, most likely with automation, will become increasingly important.

References

Acemoglu, D and P Restrepo (2018), "Demographics and automation", working paper.

Besen, J E (2017), "How Computer Automation Affects Occupations: Technology, Jobs, and Skills", Boston University School of Law, Law and Economics Research Paper No. 15-49.

Booth, A L and J C van Ours (2013), "Part-time jobs: what women want?", *Journal of Population Economics* 26: 263–283.

Boston Consulting Group (2015), *The Robotics Revolution: The Next Great Leap in Manufacturing*.

Boulhol, H and C Geppert (2018), "Population ageing: Pension policies alone will not prevent the decline in the relative size of the labour force", VoxEU.org, 4 June.

Bureau of Labor Statistics (2006), "A new look at long-term labor force projections to 2050", *Monthly Labor Review*, November.

Edwards, H and D Edwards (2018), "How Tesla "shot itself in the foot" by trying to hyper-automate its factory", Quartz, 1 May.

Ford, H (1922), *My life and work* (available through Project Gutenberg here).

Frey, C and M Osborne (2013), "The Future of Employment".

Hounshell, D (1985), *From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States*, Johns Hopkins University Press.

Endnotes

1 See this account for the state of the art of robotic gardening.

2 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.

3 One of the earliest assembly lines was used in the Venetian Arsenale to convert merchant ships into war ships. However, the process was highly secretive. The classic assembly lines of the 20th century were based on designs by Henry Ford (1922). He attributed the idea to his visit to a meat packing plant in Chicago – if they could disassemble a cow, Ford figured he could assemble a car.

4 https://techcrunch.com/2018/04/13/elon-musk-says-humans-are-underrated-calls-teslas-excessive-automation-a-mistake/

5 For a much more extensive list, see Technology Review, 25 January 2018.