Automation v Procreation

Hal Varian
Oct 2019

These are the author’s personal views and do not necessarily reflect the views of his employer.
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Bots v Tots

Hal Varian
Economics of the labor market

[Graph showing the labor market with wage and labor axes.]
Economics of the labor market

Automation reduces demand

new wage

w*

new demand

new L*

L*

wage

supply

demand

labor
Economics of the labor market

Demography reduces supply

new wage = $w^*$

new demand

new supply
Economics of the labor market

New wage = $w^*$

New supply = TOTS

New demand = BOTS
Internet of Things

Smart robots could soon steal your job

by Ivana Kottasova  @ivankottasova

January 15, 2016: 1:23 PM ET

Robots are taking over China's factory floors

Think you are too smart to be replaced by a robot in your job? Think again.

Jason Furman
DETOIT — Technological innovation is widely billed as a miracle cure for the United States’ economic doldrums. Its aftereffects, however, may be far from benign. The introduction of revolutionary new technologies such as robots — versatile computer-controlled mechanical arms — raise two painful possibilities: sizable losses of jobs and a deteriorated quality of working life.

The threat of lost jobs, although also dependent on social and economic factors, is especially critical. Auto makers are already buying robots in record numbers, despite a downturn that has resulted in 350,000 indefinite layoffs. Even the faltering Chrysler Corporation has added 138 of these new “recruits” to its work force for the 1981 model year.

But the robot is only one part of a larger computerization that is affecting virtually every productive activity in society from the office to the machine shop. In fact, many white-collar occupations that promised jobs to displaced blue-collar workers in the past are themselves being automated.

In the case of robots, relatively conservative estimates predict that sales in this country will grow at a compound rate of 25 percent a year for the next decade, culminating in annual sales of $550 million and production of 17,000 robots a year by 1990. While this hardly seems threatening to a manufacturing work force of 20 million people, robots are only one of the labor-displacing technologies being introduced. Moreover, the employment effects are cumulative and have a disproportionate impact on a few key industries. Robots that begin work tomorrow will still be on the job in 1990, giving us a robot population of about 80,000. If 40 percent wind up in the auto industry (compared to 55 percent worldwide today), 32,000 robots could displace more than 100,000 auto workers. In fact, the potential loss of jobs is more serious than these figures indicate. New breakthroughs in robot technology such as “sight” and “feel” mean that each robot could displace far more workers in a decade. In addition, some industry observers feel that companies that sell computers may enter the market, resulting in a robot population explosion in the hundreds of thousands, not tens of thousands.

The quality of working life will also change. While the first generation of robots primarily did such hazardous and hot jobs as welding and foundry work, robots are now being created for jobs where workers have the most control over the pace of work: machine loading and light assembly, among the most desirable production tasks.

A Robot Is After Your Job

By Harley Shalaken

1980: job stealing

Jason Furman
Robots' Rise
They Bid for Big Jobs
Both in Outer Space
And in U.S. Factories

A.M.F. Designs Robot to Send 'To Moon; G.E. Works on One to Paint New Autos

Beetle's Hazardous Mission

By Thomas O'Toole
Staff Reporter of THE WALL STREET JOURNAL

GREENWICH, Conn.—America's first astronaut to reach another planet may have long spiderly arms and a bell-shaped head with a window in it.

Such an inhuman-appearing space traveler is not as far-fetched as it seems. Even now the creature—a robot—is taking shape here at the Greenwich Engineering division laboratories of American Machine & Foundry Co. A.M.F. engineers believe their robot, remotely controlled from earth, would be far more useful than a human in exploring outer space—at least until rockets can be made powerful enough to be readily capable of returning home from trips to the Moon, Mars, Venus of even more distant targets.

Elsewhere around the country in laboratories and on drawing boards, increasing attention is being paid to robots, once regarded as science-fiction characters with little or no practical value. Indeed, most of the robots in use and development today bear little resemblance to the mechanical bipeds popularized by movie makers and cartoonists. But these machines, nevertheless, are true robots—automatic devices that perform human functions, or operate with seemingly human intelligence.
1935: job stealing

Robot Brains Outdo Man’s Mind in Speed and Accuracy of Results

‘Thinking Machines’ Replace the Thinker
They Predict Tides, Pick Criminals’ Fingerprints, Calculate Mathematical Problems, and Perform Amazing Tasks.

Jason Furman
1812: job stealing

One Thousand POUNDS REWARD.

WHEREAS on the Night of Sunday the 19th of January, 1812, the Mill belonging to Messrs. Oates, Wood and Smithson, Situate at Oaklands, near Leeds, was maliciously set on Fire.—And on the Morning of the Twenty-fourth of March, 1812, several Persons entered the MILL of MESSRS. WM. THOMPSON & BROTHERS, Of Hiordown, destroyed the MACHINERY and MACHINES, and on the Morning of the 3d, came Persons into the Free Shop of Messrs. Dickinson, Carr and Co. Situate in Water Lane, Leeds, and Wantonly destroyed Cloth, TO A CONSIDERABLE AMOUNT.

1000 POUNDS REWARD

A hereby offered to any Person or Persons who will give such Information as shall lead to the Conviction of any of the Offenders, on Application at the Town Clerk's Office, or to any of the above-mentioned Sufferers.

MARCH 25, 1812.

Written at the Office of the Whitby Advertiser, Leeds, by GEO. THOMAS, JUN.
2017: Huh?

America’s Growing Labor Shortage

Lack of workers in ag and construction is hurting the economy.

Construction, agriculture, truck drivers, forklift drivers, dairy farms, meat packing ...
In the 20th century there were two large shocks to the labor market
Baby boomers

1. Live births by year, 1920–2010
Women entering the (paid) labor force

Civilian labor force by sex
1948-2015 annual averages

Number in the civilian labor force (in thousands)

Dept of Labor
Jobs and tasks
Automation, jobs and tasks

Automation doesn’t generally eliminate jobs. Automation generally eliminates dull, tedious, and repetitive tasks.

- **Manual**: washing clothes, drying dishes, mowing lawn, digging holes, chopping wood
- **Cognitive**: making change for purchase, memorizing maps, adding columns of numbers

If you eliminate *all* the tasks associated with a job, you have eliminated a job. But this is rare.
Tasks and jobs

There were 270 detailed occupations listed in the 1950 US Census. Only 1 has been eliminated due to automation.

Quartz article based on Jim Bessen’s work
Tasks or jobs?

There were 270 detailed occupations listed in the 1950 US Census. Only 1 has been eliminated due to automation.

Elevator operator

Quartz article based on Jim Bessen’s work
Even elevator operators had other tasks...

- Operation
  - Safety monitor
  - Security monitor
  - Greeter
  - Provide answers to questions
  - Provide services to residents
  - Announced special prices or offers
- Many such tasks were folded into other jobs (reception, security)
- ...and don’t forget those Amazon packages!
- Most jobs are more complicated than we think...
Groundskeeper tasks:  

- Gather and remove litter.
- Use hand tools, such as shovels, rakes, pruning saws, saws, hedge or brush trimmers, or axes.
- Operate vehicles or powered equipment, such as mowers, tractors, twin-axle vehicles, snow blowers, chain-saws, electric clippers, sod cutters, or pruning saws.
- Water lawns, trees, or plants, using portable sprinkler systems, hoses, or watering cans.
- Prune or trim trees, shrubs, or hedges, using shears, pruners, or chain saws.
- Mix and spray or spread fertilizers, herbicides, or insecticides onto grass, shrubs, or trees, using hand or automatic sprayers or spreaders.
- Care for established lawns by mulching, aerating, weeding, grubbing, removing thatch, or trimming or edging around flower beds, walks, or walls.
- Follow planned landscaping designs to determine where to lay sod, sow grass, or plant flowers or foliage.
Groundskeeper tasks, continued

- Trim or pick flowers and clean flower beds.
- Attach wires from planted trees to support stakes.
- Plant seeds, bulbs, foliage, flowering plants, grass, ground covers, trees, or shrubs and apply mulch for protection, using gardening tools.
- Mow or edge lawns, using power mowers or edgers.
- Rake, mulch, and compost leaves.
- Decorate gardens with stones or plants.
- Provide proper upkeep of sidewalks, driveways, parking lots, fountains, planters, burial sites, or other grounds features.
- Shovel snow from walks, driveways, or parking lots and spread salt in those areas.
- Maintain irrigation systems, including winterizing the systems and starting them up in spring.
- Plan or cultivate lawns or gardens.
- Install rock gardens, ponds, decks, drainage systems, irrigation systems, retaining walls, fences, planters, or playground equipment.
Robots and tasks

Could we build a robotic groundskeeper?

- You could likely automate any single task with enough money and time
- But automating them all would be very challenging

Robots work best with standardized environment and repetitive tasks.

- We have been optimizing the assembly line with humans for 100 years
- It’s not surprising that this environment is (relatively) easy to automate
- Half of all industrial robots are in auto plants

A heterogeneous environment is much more difficult, even when each task is relatively simple. Generally, we have seen machines that augment humans, not replaced them.
Ideal environment for robot gardener
Traditional orchard v modern orchard

Make the environment as homogeneous as possible (like the assembly line).

Source: Goodfruit
Easier for humans and robots
Tasks and jobs

- What tasks can be automated?
- How will tasks associated with jobs change?
- What jobs can be automated?
- What fraction does it make economic sense to automate?
- Depends what and who you ask...

![Estimated job loss from automation](chart)
### Other estimates

#### Predicted Jobs Automation Will Create and Destroy

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

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<th>Jobs Destroyed</th>
<th>Jobs Created</th>
<th>Predictor</th>
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<tbody>
<tr>
<td>2025</td>
<td>US jobs</td>
<td>3,400,000</td>
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<td>US jobs</td>
<td>24,700,000</td>
<td>14,900,000</td>
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<tr>
<td>2030</td>
<td>worldwide</td>
<td>2,000,000,000</td>
<td></td>
<td>Thomas Frey</td>
</tr>
<tr>
<td>2030</td>
<td>worldwide</td>
<td>400,000,000-800,000,000</td>
<td></td>
<td>McKinsey</td>
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<tr>
<td>2030</td>
<td>US jobs</td>
<td>58,164,320</td>
<td></td>
<td>PWC</td>
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<tr>
<td>2033</td>
<td>US jobs</td>
<td>67,876,460</td>
<td></td>
<td>Oxford University</td>
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<td>2035</td>
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<tr>
<td>2035</td>
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<td>Bank of England</td>
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<td>OECD</td>
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<tr>
<td>No Date</td>
<td>UK jobs</td>
<td>13,700,000</td>
<td></td>
<td>IPPR</td>
</tr>
</tbody>
</table>

*Source: Technology Review*
Ten largest occupations in US

Retail salesperson, cashier, food preparation, office clerk, registered nurse, customer service representative, waiter/waitress, laborer, administrative assistant, and janitor.

1. These 10 jobs account for 21% of total employment.
2. All are in services (which is 80% of private US employment.)
4. Most of these jobs are too difficult for robots, but many of the tasks could be automated to a degree.
Work week across time and space
### Workweek

<table>
<thead>
<tr>
<th>Year</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>66</td>
</tr>
<tr>
<td>1870</td>
<td>62</td>
</tr>
<tr>
<td>1890</td>
<td>60.0</td>
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<tr>
<td>1900</td>
<td>59.6</td>
</tr>
<tr>
<td>1910</td>
<td>57.3</td>
</tr>
<tr>
<td>1920</td>
<td>51.2</td>
</tr>
<tr>
<td>1930</td>
<td>50.6</td>
</tr>
<tr>
<td>1940</td>
<td>37.6</td>
</tr>
<tr>
<td>1955</td>
<td>38.5</td>
</tr>
</tbody>
</table>

### Time

<table>
<thead>
<tr>
<th>Country</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>35.2</td>
</tr>
<tr>
<td>Denmark</td>
<td>32.1</td>
</tr>
<tr>
<td>France</td>
<td>36.1</td>
</tr>
<tr>
<td>Germany</td>
<td>34.5</td>
</tr>
<tr>
<td>Italy</td>
<td>35.5</td>
</tr>
<tr>
<td>Mexico</td>
<td>45.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>29.1</td>
</tr>
<tr>
<td>Spain</td>
<td>36.5</td>
</tr>
<tr>
<td>Sweden</td>
<td>35.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>36.5</td>
</tr>
<tr>
<td>United States</td>
<td>38.6</td>
</tr>
</tbody>
</table>

### Space

**Economic History Assoc** and **OECD**
But education and training will still be necessary
Unemployment rates and earnings by educational attainment, 2016

<table>
<thead>
<tr>
<th>Unemployment rate (%)</th>
<th>Median usual weekly earnings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctoral degree</td>
<td>1.6</td>
</tr>
<tr>
<td>Professional degree</td>
<td>1.6</td>
</tr>
<tr>
<td>Master's degree</td>
<td>2.4</td>
</tr>
<tr>
<td>Bachelor's degree</td>
<td>2.7</td>
</tr>
<tr>
<td>Associate's degree</td>
<td>3.6</td>
</tr>
<tr>
<td>Some college, no degree</td>
<td>4.4</td>
</tr>
<tr>
<td>High school diploma</td>
<td>5.2</td>
</tr>
<tr>
<td>Less than a high school diploma</td>
<td>7.4</td>
</tr>
<tr>
<td>Total: 4%</td>
<td></td>
</tr>
<tr>
<td>All workers: $885</td>
<td></td>
</tr>
</tbody>
</table>

Note: Data are for persons age 25 and over. Earnings are for full-time wage and salary workers.
Delivery of instruction and training

Can technology help deliver on-the-job job skills?

Not only can technology deliver this, it already does!

There are 1 billion views a day of “how to videos” on YouTube

This is unprecedented in human history.
## How to videos on YouTube: cognitive

### Math by subject
- Early math
- Arithmetic
- Pre-algebra
- Algebra
- Geometry
- Trigonometry
- Precalculus
- Statistics & probability
- Calculus
- Differential equations
- Linear algebra
- Math for fun and glory

### CS by subject
- Intro to algorithms
- Binary search
- Asymptotic notation
- Selection sort
- Insertion sort
- Recursive algorithms
- Towers of Hanoi
- Merge sort
- Quick sort
- Graph representation
- Breadth-first search
- Further learning
How to videos on You Tube: manual

- how to sweat copper pipe
- how to install a prehung door
- how to care for mums
- how to do planks
- how to weld cast iron
- how to remove a stripped bolt
- how to shorten blinds
- how to clean glass pipe
- how to program a garage door opener
- how to get a stripped screw out
- how to remove a stripped screw
- how to clean a pipe
- how to shingle a roof
- how to tig weld
- how to solder copper pipe
- how to weld aluminum
- how to mig weld
- how to balance a ceiling fan
- how to install a storm door
Cognitive assistance

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
- a hospitality worker in an international you know a bit of foreign languages
- gardener, you needed to recognize plants
- veterinarian how to recognize dog breeds

Where there is a skills gap, you can bring the worker’s skills up to the requirement, or bring the job down to workers’ competencies. Cognitive assitances helps people get jobs, by reducing the tasks they need to master.

- In 1880 machines offered manual assistance
- In 2018 machines offer cognitive assistance.
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 provided on the job
- Technology can help deliver training as needed
- Cognitive assistance helps match skills to jobs by 1) educating workers 2) educating machines
  - Training spinners or build a spinning jenny
  - Training taxi drivers or GPS system
Tots: demography
Productivity

output/person = output/hour \times \text{hours/worker} \times \text{workers/person}

= \text{productivity} \times \text{employment} \times \text{participation}
Productivity

output/person = output/hour \times hours/worker \times workers/person

= productivity \times employment \times participation

full
Productivity

output/person = output/hour \times hours/worker \times workers/person

= productivity \times employment \times participation

full \quad declining
Productivity

output/person = output/hour \times \text{hours/worker} \times \text{workers/person}

= \text{productivity} \times \text{employment} \times \text{participation}

anemic full declining
Growth in productivity

Cumulative TFP growth since 1973

Growth in productivity

Cumulative TFP growth since 1973

Growth of the labor force

Chart 1. Labor force growth, by decades, 1950s to 2005 and projected to 2040s

Demography is destiny

1. Live births by year, 1920–2010

Immigration

Without future immigrants, working-age population in U.S. would decrease by 2035

Working-age population (25-64), in millions

Labor force participation rates

Bureau of Labor Statistics
Where will labor shortage be worst?

Chart 1: Change in ratio of people aged 20 to 64 over total population, 2015 to 2030 (Click to expand).

The Conference Board
Growth in population and labor force

<table>
<thead>
<tr>
<th>Decade</th>
<th>Population growth</th>
<th>Labor Force growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>18.4%</td>
<td>7.7%</td>
</tr>
<tr>
<td>2020</td>
<td>10.5%</td>
<td>6.5%</td>
</tr>
<tr>
<td>2030</td>
<td>10.3%</td>
<td>5.5%</td>
</tr>
<tr>
<td>2040</td>
<td>9.3%</td>
<td>7.5%</td>
</tr>
<tr>
<td>2050</td>
<td>8.2%</td>
<td>8.1%</td>
</tr>
</tbody>
</table>

- US labor market is already beginning to tighten
- Expect a tight labor market for the next 15-25 years
- Retirees continue to consume
- Labor supply is growing more slowly than labor demand.
- Old intuitions no longer helpful
- Countervailing forces
  - 2000: 3% of 65+ working
  - 2016: 12.4% of 65+ working

Gad Levanon, Conference Board
US is in good shape compared to many countries
China population growth

Source: New York Times

Annual population growth

- Great Chinese Famine
- "Later, longer, fewer" policy is promoted.
- One-child policy is introduced.
- One-child policy becomes constitutional.
- Two-child policy is introduced.

Source: U.S. Census International Data Base
And the US birth rate is at an all-time low!

“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.”

Source: WSJ, May 17, 2018
Supply of industrial robots

Estimated worldwide annual supply of industrial robots
15 largest markets 2017

<table>
<thead>
<tr>
<th>Country</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>137.9</td>
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<tr>
<td>Japan</td>
<td>45.6</td>
</tr>
<tr>
<td>Rep. of Korea</td>
<td>39.7</td>
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<tr>
<td>United States</td>
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<tr>
<td>Germany</td>
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<td>Taiwan</td>
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<td>Vietnam</td>
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<td>Singapore</td>
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<tr>
<td>Spain</td>
<td>4.2</td>
</tr>
<tr>
<td>Canada</td>
<td>4.0</td>
</tr>
<tr>
<td>India</td>
<td>3.4</td>
</tr>
<tr>
<td>Thailand</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Source: IFR World Robotics 2018
Bots v Tots: which is bigger effect?

- **Boston Consulting Group (2015)** aggressive scenario + **Acemoglu-Restrepo (2017)**: employment/population ratio declines by 1.76% in next decade
- **Bureau of Labor Statistics (2006):** employment/population ratio declines by 2.7% based on demography in next decade
- **Net:** demographic effect is 53% larger than the automation effect!
  - Tight labor markets
  - Rising wages
  - Increased incentive for employers to economize on labor
  - Increase incentive workers to provide more labor (part time, flexwork, delayed retirement)
- **Suggestion**
  - Estimated impact of automation should be compared to demographic realistic baseline, not a zero baseline
  - Both demand and supply matter!
As retirees age, they become more costly

**Fact sheet: Aging in the United States**

- People over 65 in US today: 46 million, 15 percent
- People over 65 in US in 2060: 98 million, 24 percent
- People with Alzheimer’s today: 5 million
- People with Alzheimer’s 2050: 14 million

**Productivity growth in 2015:**

- 1.3% productivity growth implies GDP will be 78% larger in 2060 than today
- Population over 65 doubles, Alzheimer’s triples, and GDP only goes up by 78%
- If productivity growth were 1.6% we would could cover the doubling of the elderly

*Harnassing automation for a future that works*, McKinsey
THE END
Robots, Automation, and Jobs

New Statesman: [The automation delusion: why robots aren’t the biggest threat to your job](#)

The narrative that robots are coming for your jobs is dubious. An influential 2013 Oxford University paper suggesting that 47 per cent of US jobs were vulnerable to automation remains widely cited, but when its methods were replicated with different weightings, researchers obtained radically different results. A recent paper by the Institute for Public Policy Research (IPPR) found that the number of US jobs that could be wholly automated was relatively low: an estimated 5 per cent.