Housekeeping

• Sign up for small group chats with next Wednesday’s speakers by Monday night.
• Optional extra credit assignment will be offered during the final exam window, after you complete the exam itself. Some pre-preparation will be required. Details forthcoming.
• One more comment on mid-term course evaluations: diversity
• Assignment #3: Public policy memo now available on CS181 website
Collision with professor’s vehicle leaves student-athlete with broken wrist
Today’s Agenda

1. Regulating AI
2. Thinking about Regulation in Context: Automation of Work
3. Automation: Economic and Social Consequences
4. Automation: Implications for Liability
In our discussion of privacy, when I asked whether you preferred a European regulatory model or an American one, you overwhelmingly sided with Europe.

Now Europe is exploring general regulations for artificial intelligence.

The draft ethical guidelines emphasize the need for trustworthy AI rooted in:

- Deployment for an “ethical purpose”
- Commitment to do good, do no harm, respect for autonomy, justice, and explicability
- Incorporate accountability, data governance, respect for privacy and autonomy, transparency, non-discrimination, etc. from the design phase

Does it even make sense to think about general regulations?
Everyone loves high-level principles: you feel good that you are taking action, even though they are not particularly useful in any specific case.

This quarter we have already encountered AI in a variety of domains: the justice system, health care and diagnostics, personalized advertising, internet search, autonomous vehicles, autonomous weapons.

We may want to weigh the trade-offs differently in each domain:

- Explicability vs. accuracy in a credit context where AI may be better able to identify credit-worthy people.
- Transparency vs. efficacy in a context where AI helps the IRS identify tax fraud.
“...attempts to regulate “AI” in general would be misguided, since there is no clear definition of AI (it isn’t any one thing), and the risks and considerations are very different in different domains. Instead, policymakers should recognize that to varying degrees and over time, various industries will need distinct, appropriate, regulations that touch on software built using AI or incorporating AI in some way.”

-- AI Study Group (2016)

Europe is focused on four contexts to begin with: healthcare, autonomous driving, law enforcement, insurance.
Today’s Agenda

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How Concerned Are You?

To what extent are you concerned about the automation of work and its impact on your life?

Take a survey here: cs181.stanford.edu
More Worry than Optimism

More worry than optimism about potential developments in automation

%/ of U.S. adults who say they are enthusiastic or worried about...

- Future where robots and computers can do many human jobs
- Development of algorithms that can evaluate and hire job candidates
- Development of driverless vehicles
- Development of robot caregivers for older adults

Worried: 72%
Enthusiastic: 33%
Somewhat: 22%
Very: 44%

Development of algorithms: Enthusiastic 40%
Development of driverless vehicles: Enthusiastic 47%
Development of robot caregivers: Enthusiastic 44%
Using Automated Technologies

Many Americans would be hesitant to use various automation technologies

% of U.S. adults who say they would or would not want to ___ if given the opportunity

<table>
<thead>
<tr>
<th>Activity</th>
<th>Would not</th>
<th>Would</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ride in a driverless vehicle</td>
<td>56</td>
<td>44</td>
</tr>
<tr>
<td>Use a robot caregiver</td>
<td>59</td>
<td>41</td>
</tr>
<tr>
<td>Apply for a job that used a computer program</td>
<td>76</td>
<td>22</td>
</tr>
</tbody>
</table>
# Policies Re: Workforce Automation

## Broad public support for policies that limit the reach and impact of workforce automation

% of U.S. adults who say they support or oppose the following policies in the event that robots and computers are capable of doing many human jobs

<table>
<thead>
<tr>
<th>POSSIBLE POLICIES</th>
<th>Strongly oppose policy</th>
<th>Oppose</th>
<th>Favor</th>
<th>Strongly favor policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machines are limited to doing dangerous or unhealthy jobs</td>
<td>3%</td>
<td>11%</td>
<td>38%</td>
<td>47%</td>
</tr>
<tr>
<td>Govt offers all Americans a guaranteed income that would meet their basic needs</td>
<td>18</td>
<td>21</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>Govt creates a national service program that would pay people to perform tasks</td>
<td>12</td>
<td>29</td>
<td>37</td>
<td>21</td>
</tr>
</tbody>
</table>
Role of Private Sector

% of U.S. adults who say they agree with each statement in the event that robots and computers are capable of doing many human jobs

Businesses are justified in replacing human workers if machines can do a better job at lower cost

58%

Should be limits on number of jobs businesses can replace with machines, even if they are better and cheaper than humans

41%

No answer 1%
## Benefits/Costs of Driverless Vehicles

### % of U.S. adults who say the following about driverless vehicles

<table>
<thead>
<tr>
<th>Positive views/attitudes</th>
<th>Would not ride in a driverless vehicle</th>
<th>Would ride in a driverless vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expect they would help elderly and disabled be more independent</td>
<td>62%</td>
<td>91%</td>
</tr>
<tr>
<td>Would feel safe sharing road with a driverless passenger vehicle</td>
<td>19%</td>
<td>85%</td>
</tr>
<tr>
<td>Are very/somewhat enthusiastic about their widespread use</td>
<td>13%</td>
<td>74%</td>
</tr>
<tr>
<td>Expect that they would reduce traffic injuries/deaths</td>
<td>17%</td>
<td>68%</td>
</tr>
<tr>
<td>Would feel safe sharing road with a driverless freight truck</td>
<td>10%</td>
<td>66%</td>
</tr>
<tr>
<td>Expect that driverless vehicles would reduce traffic in major cities</td>
<td>16%</td>
<td>43%</td>
</tr>
</tbody>
</table>

### Negative views/attitudes

- Are very/somewhat worried about their widespread use: 34% (69%)
- Strongly favor requiring human at the wheel in case of emergency: 38% (65%)
- Strongly favor that they travel in dedicated lanes: 33% (58%)
- Strongly favor restricting them from certain areas: 16% (48%)
### Differential Risks of Automation

% of U.S. adults who think it is ____ likely that the following jobs will be replaced by robots or computers in their lifetimes

<table>
<thead>
<tr>
<th>Job</th>
<th>Not at all</th>
<th>Not very</th>
<th>Somewhat</th>
<th>Very</th>
<th>NET likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast food worker</td>
<td>6%</td>
<td>17%</td>
<td>39%</td>
<td>38%</td>
<td>77%</td>
</tr>
<tr>
<td>Insurance claims processor</td>
<td>7%</td>
<td>27%</td>
<td>44%</td>
<td>22%</td>
<td>65%</td>
</tr>
<tr>
<td>Software engineer</td>
<td>12%</td>
<td>35%</td>
<td>38%</td>
<td>15%</td>
<td>53%</td>
</tr>
<tr>
<td>Legal clerk</td>
<td>12%</td>
<td>38%</td>
<td>36%</td>
<td>13%</td>
<td>50%</td>
</tr>
<tr>
<td>Construction worker</td>
<td>19%</td>
<td>39%</td>
<td>32%</td>
<td>10%</td>
<td>42%</td>
</tr>
<tr>
<td>Teacher</td>
<td>26%</td>
<td>38%</td>
<td>26%</td>
<td>10%</td>
<td>36%</td>
</tr>
<tr>
<td><strong>Own job or profession</strong></td>
<td><strong>30%</strong></td>
<td><strong>40%</strong></td>
<td><strong>23%</strong></td>
<td><strong>7%</strong></td>
<td><strong>30%</strong></td>
</tr>
<tr>
<td>Nurse</td>
<td>34%</td>
<td>46%</td>
<td>16%</td>
<td>4%</td>
<td>20%</td>
</tr>
</tbody>
</table>
Your Perspective on Work

• What is the job you’d most like to have in five years?

• How concerned are you that it might be replaced or transformed by robots or automation?

• Do you think that technology will make the job more interesting?

• Are you taking the potential for automation into account as you consider career pathways?

• If machines can do the job you are capable of better than humans, might you be happier not working? Why or why not?
What Do the Experts Say?

JOBS THREATENED BY AUTOMATION
PROJECTED PERCENTAGE OF US JOBS AT HIGH RISK OF AUTOMATION BY 2030

- FREY & OSBORNE (OXFORD) - 47%
- PRICEWATERHOUSE COOPERS (PWC) - 38%
- ORGANIZATION FOR ECONOMIC COOPERATION & DEVELOPMENT (OECD) - 9%

Source: PwC, Frey and Osborne, OECD
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Not a New Concern

“We are being afflicted with a new disease of which some readers may not have heard the name, but of which they will hear a great deal in the years to come—namely, technological unemployment.”

-- John Maynard Keynes (1930)

“Labor will become less and less important... More and more workers will be replaced by machines. I do not see new industries can employ everybody who wants a job.”

-- Wassily Leontief (1952)
If ‘displace more jobs’ means ‘eliminate dull, repetitive, and unpleasant work,’ the answer would be yes. How unhappy are you that your dishwasher has replaced washing dishes by hand, your washing machine has displaced washing clothes by hand, or your vacuum cleaner has replaced hand cleaning?

My guess is this ‘job displacement’ has been very welcome, as will the ‘job displacement’ that will occur over the next 10 years. The work week has fallen from 70 hours a week to about 37 hours now, and I expect that it will continue to fall. This is a good thing.

Everyone wants more jobs and less work. Robots of various forms will result in less work, but the conventional work week will decrease, so there will be the same number of jobs (adjusted for demographics, of course). This is what has been going on for the last 300 years so I see no reason that it will stop in the decade.”

-- Hal Varian, Chief Economist, Google
# Differential Effects Across Industries

## Catalogue of fears

Probability of computerisation of different occupations, 2013 (1 = certain)

<table>
<thead>
<tr>
<th>Job</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational therapists</td>
<td>0.003</td>
</tr>
<tr>
<td>Dentists</td>
<td>0.004</td>
</tr>
<tr>
<td>Athletic trainers</td>
<td>0.007</td>
</tr>
<tr>
<td>Clergy</td>
<td>0.008</td>
</tr>
<tr>
<td>Chemical engineers</td>
<td>0.021</td>
</tr>
<tr>
<td>Editors</td>
<td>0.06</td>
</tr>
<tr>
<td>Firefighters</td>
<td>0.17</td>
</tr>
<tr>
<td>Actors</td>
<td>0.37</td>
</tr>
<tr>
<td>Health technologists</td>
<td>0.40</td>
</tr>
<tr>
<td>Economists</td>
<td>0.43</td>
</tr>
<tr>
<td>Commercial pilots</td>
<td>0.55</td>
</tr>
<tr>
<td>Machinists</td>
<td>0.65</td>
</tr>
<tr>
<td>Word processors and typists</td>
<td>0.81</td>
</tr>
<tr>
<td>Real-estate sales agents</td>
<td>0.86</td>
</tr>
<tr>
<td>Technical writers</td>
<td>0.89</td>
</tr>
<tr>
<td>Retail salespeople</td>
<td>0.92</td>
</tr>
<tr>
<td>Accountants and auditors</td>
<td>0.94</td>
</tr>
<tr>
<td>Telemarketers</td>
<td>0.99</td>
</tr>
</tbody>
</table>


Economist.com
Differential Effects Across Countries

**Wage against the machine**
Automation risk* and GDP per person, selected countries

*50% risk or higher

Source: OECD

Economist.com
Impact on Professional Drivers

- ~3.5 million professional truck drivers in the U.S.
- Additional 5.2 million people employed in trucking
- Approximately 40% are ethnic minorities
## Benefits of AVs

### Quantified Benefits of Autonomous Vehicles

<table>
<thead>
<tr>
<th>Public Benefits by 2050 (annual)</th>
<th>$633 Billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion Mitigation</td>
<td>$71 Billion</td>
</tr>
<tr>
<td>Accident Reduction – Economic Impact</td>
<td>$118 Billion</td>
</tr>
<tr>
<td>Accident Reduction – Quality of Life Improvements</td>
<td>$385 Billion</td>
</tr>
<tr>
<td>Reduced Oil Consumption</td>
<td>$58 Billion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consumer Benefits by 2050 (annual)</th>
<th>$163 Billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of Time</td>
<td>$153 Billion</td>
</tr>
<tr>
<td>Reduction in Cost of Current Taxi Service</td>
<td>$10 Billion</td>
</tr>
</tbody>
</table>

**Total Annual Benefits (by 2050)** $796 Billion

How can we think systematically about the effects of automation on wages, employment, and economic growth? Acemoglu and Restrepo (2018) offer an economic framework for assessing the impact of automation:

1. A *displacement effect* where by AI and robotics replace workers in tasks they previously performed
2. A *productivity effect* as the cost of producing automated tasks declines
3. *Capital accumulation* triggered by increased automation will increase the demand for labor
4. *Deepening of automation* as productivity increases further in automated tasks
5. A *reinstatement effect* in which *new tasks* increase the demand for labor
Historical Examples: Agriculture

The mechanization of agriculture transformed agricultural production processes and reduced the demand for labor.
Historical Examples: Manufacturing

Not what it was
US employment by sector, % of total employment

Sources: US Bureau of Labour Statistics

Rise of the machines
US manufacturing
Employment, m

Output, 2007=100
Sources: BLS; Federal Reserve

Economist.com
Acemoglu and Restrepo (2017) measure the empirical effects of automation on employment and wages.

They exploit variation in the degree to which different commuting zones were exposed to automation in their major industries.

Quantitatively, they find that robots decrease both employment and wages. One additional robot per thousand workers is associated with a drop in employment of 6.2 workers and a decrease in wages of 0.73 percent.
Empirical Estimates
While we do not have estimates of the impact of automation on social dynamics, there is a growing literature on the political and social impacts of off-shoring induced job losses:

• Feigenbaum and Hall (2015) find that job losses drive politicians to adopt much more protectionist positions in Congress
• Ballard Rosa et al (2018) find that job losses drive the adoption of more “authoritarian values” and support for anti-establishment parties (in both the U.S. and U.K.)

How might automation-induced job losses affect political behavior and attitudes?
The Costs of Adjustment

Even if the displacement effects of automation may potentially be counteracted by other forces, we should not underestimate just how challenging it might be.

• The reallocation of workers from existing jobs and tasks to new ones is a complex and often slow process
• The transition might be associated with a period of stagnant wages, expanding poverty, and unemployment ("living standards paradox")
• Adjustment depends on the educational system providing the training, skills that people need for new jobs, tasks
• Some groups may be disproportionately affected by automation
The Critical Role of Policy

Rather than regulating AI per se, it may make more sense to explore the role of policies in mitigating the costs of adjustment.

For example, addressing the potential of AI and automation to increase inequality is one valid societal concern.
Policy Options

• Universal Basic Income vs. Social Safety Nets
  • A regular, unconditional cash grant to every individual instead of our traditional, means-tested social benefit programs

• Investments in education and skills training
  • To reverse the decline in labor force participation among people without a college education, policies that address skills deficits may make a big difference
Today’s Agenda

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One of the promises of autonomous vehicles is a reduction in crashes and human injury. More than 40,000 people are killed each year in crashes, and 2.5m are injured. Most crashes are the result of human error.

If autonomous vehicles are adopted broadly, what should happen when the inevitable crash occurs? Who should be responsible and to what extent?
An Uber self-driving car in Scottsdale was involved in a fatal accident with a pedestrian in March 2018. This was the first known fatal accident involving a driverless car.

- The vehicle was operating in autonomous mode at the time of the crash
- A human operator was in the vehicle
- The car did not slow down before hitting the pedestrian
- The pedestrian was jaywalking in the dark

Who should be held legally responsible for the accident?
Liability and Regulatory Regimes

We have liability and regulatory regimes in place in order to:

1. Incentivize safe driving behavior, given the potential costs associated with accidents
2. Encourage automobile companies to adopt safe technologies and to innovate in these areas
3. Facilitate corrective justice and compensate victims when accidents occur
In terms of civil liability, a person is liable for a harm they cause if there is the existence of a duty, the breach of that duty, causation, and injury. The duty is a reasonable care in operation.

Parties are held liable for negligence if they *unreasonably* fail to prevent the risk. But measuring reasonableness is difficult!

Many states have adopted a *no-fault* system to avoid litigation around crashes unless the severity of injuries surpasses a *threshold*.

Self-driving cars will likely dilute the sense that drivers are directly and solely responsible for their automobiles.
With self-driving cars, we can expect a shift in liability from the driver to the manufacturer.

Theories of manufacturer liability include: (1) negligence (2) tortious misrepresentation (3) violation of warranty and (4) strict products liability.

Manufacturers can also be held responsible for: manufacturing defects, design defects, and warning defects.

Manufacturer liability is likely to be a major area of contestation around driverless cars, and concerns about legal exposure may impede the adoption of these technologies.
What About Criminal Liability?

Can autonomous systems be held criminally liable for a harm they cause?

Criminal liability depends on the commission of a crime which involves an *act* by an individual (not simply thoughts, beliefs, or intentions). Some have defined an act as involving “bodily movement”; others focus on acts as “controllable” by the person.

- Are AI agents acting in the sense of criminal law?
- Should the crime be attributed to the human operator in the vehicle or the author of the algorithm?
- Should the act be attributable to bad luck or nature?
Arizona Governor Doug Ducey, who had previously criticized other states for over-regulating autonomous vehicles, has now put a halt to the testing of self-driving cars in the state. The state and the governor are also being sued by the family.

Raises key questions:

Under what conditions should states allow the use of self-driving cars?

Should the federal government regulate autonomous vehicles?