ME 370:
The Mechanical Engineering Profession

Lecture 10: Automation and It's Growing Impact

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Purpose

Introduce trends in automation and computing that will have growing impact on our lives.

To state the obvious, automation and computing are becoming increasingly ubiquitous

Communication

- ‣ Mobile technology
- ‣ Government monitoring of all communication
- ‣ Cameras everywhere
- ‣ Redefining the meaning of privacy

Industrial automation

- ‣ Robots for manufacturing, 3D printing, imaging, sensing
- ‣ Supply chain analytics and business-to-business info flow
- ‣ Genomic drug development

Self-driving cars as an example of advanced robotics with everyday applications

Potential advantages

‣ Mobility for disabled

‣ Safer?

‣ New mode of public transportation?

Potential disadvantages

‣ Safer?

‣ Threat to taxi and truck drivers

http://blogs-images.forbes.com/ellenhuet/files/2014/05/googlecar-e1401261602733.jpg
http://www.technologyreview.com/news/530276/hidden-obstacles-for-googles-self-driving-cars/
http://www.design-engineering.com/general/toyota-sees-future-fully-driverless-car-132263

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Autonomous vehicles may not proliferate soon despite impressive technology demonstrations

Limits of the current version of Google's self-driving car

- ▶ Extensive reliance on mapping
    - ✳ Testing on roads with high resolution maps
    - ✳ Maps are custom made and updated with human effort
- ▶ Not used in heavy rain or snow
- ▶ Cannot differentiate types of people, e.g. a police officer waving to give directions and a pedestrian waving to a friend
- ▶ Legal liability issues need to be sorted out before mass deployment

http://www.technologyreview.com/news/530276/hidden-obstacles-for-googles-self-driving-cars/
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Before widespread use, autonomous vehicles will be a source of technological innovation

Current and forthcoming safety innovations

▸ Detection and warning systems

 ✳ Other vehicles in blind spots

 ✳ Unsafe following distances

 ✳ Vehicle leaving its lane or the roadway

▸ Monitoring of driver behavior

 ✳ Hand position – both hands on wheel

 ✳ Eye tracking – excessive looking down or falling asleep

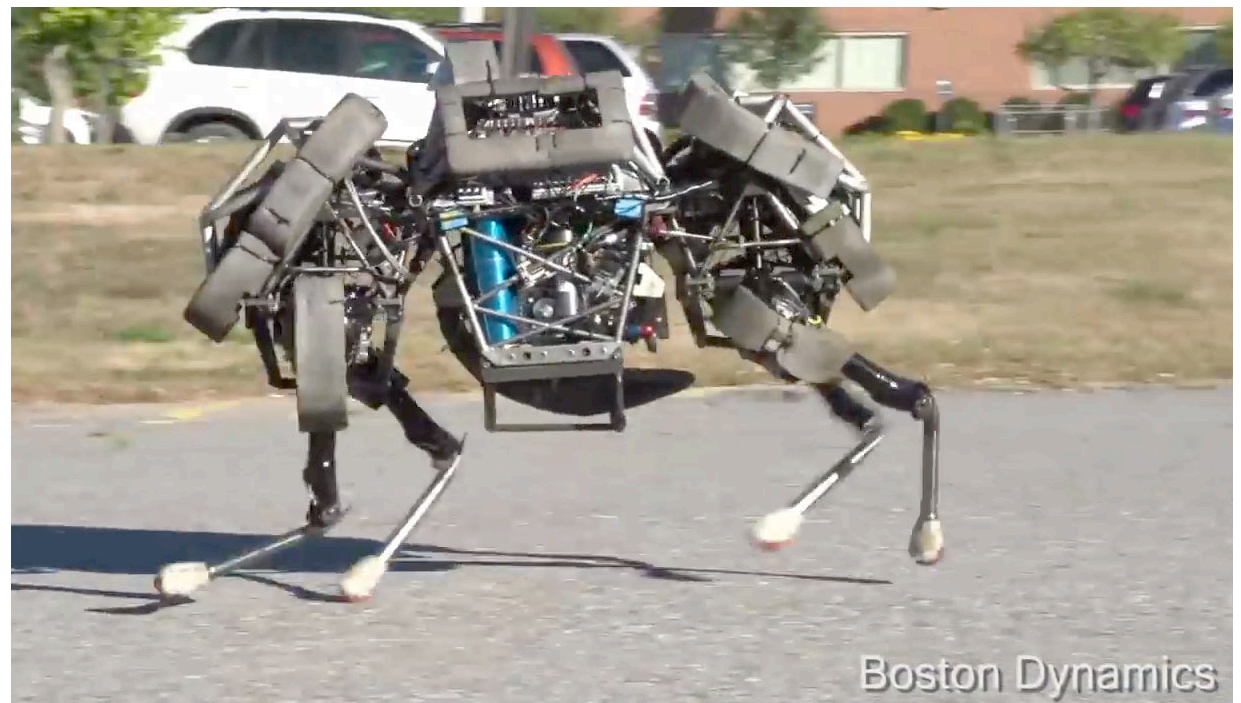http://www.technologyreview.com/news/530276/hidden-obstacles-for-googles-self-driving-cars/
http://www.design-engineering.com/general/toyota-sees-future-fully-driverless-car-132263

To state the obvious, automation and computing are becoming increasingly powerful & ubiquitous

Military Robots

- ‣ http://youtu.be/wE3fmFTtP9g
- ‣ http://youtu.be/QVdQM47Av20
- ‣ http://youtu.be/cr-wBpYpSfE

Boston Dynamics

http://cbssanfran.files.wordpress.com/2013/12/boston-dynamics-wildcat.jpg

MQ-9 Reaper

MQ-1B Predator

Techno-optimists think that technology will solve problems that seem insurmountable

Diamandis and Kotler wrote *Abundance,* in which they advocate for technology as a solution to our environmental problems

- ‣ We focus too much on the negative
- ‣ Exponential technologies
  - ✳ Moore's law for computing
  - ✳ Improvements that compound
- ‣ Communication increases the number of people solving problems
- ‣ Encourage good risk-taking
  - ✳ X-prizes for solving world's problems

http://www.abundancethebook.com
http://www.ted.com/talks/peter_diamandis_abundance_is_our_future

Some techno-optimists are eagerly awaiting the "singularity"

"Within a quarter century, nonbiological intelligence will match the range and subtlety of human intelligence. It will then soar past it because of the continuing acceleration of information-based technologies, as well as the ability of machines to instantly share their knowledge."

— Ray Kurzweil, 2005, http://www.kurzweilai.net/singularity-q-a

http://www.ted.com/talks/ray_kurzweil_get_ready_for_hybrid_thinking
http://www.kurzweilai.net
http://en.wikipedia.org/wiki/Technological_singularity

Techno-pessimists think that technology will run away and leave humans as lesser or unnecessary

Singularity

‣ Why would higher intelligence forms need or "want" to listen to us?

Gray goo apocalypse

‣ Out-of-control, self-replicating technology consumes all matter on earth

‣ Bill Joy: Why the future does not need us http://archive.wired.com/wired/archive/8.04/joy.html

Techno-managers: we have no choice but to cooperate with machines

Brynjolfsson and McAfee: Second Machine Age

- ‣ Exponential Growth of Computing
- ‣ Digitization of Everything
- ‣ Combinatorial Innovation
  - ✳ Communication, computing, people
  - ✳ Social innovation

http://www.ted.com/talks/erik_brynjolfsson_the_key_to_growth_race_em_with_em_the_machines
Brynjolfsson and McAfee, *The Second Machine Age*, 2014, WW Norton

Brynjolfsson and McAfee: 3 forces that put us into the second machine age

1. Steady exponential improvement

   ‣ Moore's law: doubling of chip count

   ‣ Exponential growth appears to be slow at first*

   "The accumulated doubling of Moore's Law, and the ample doubling still to come, gives us a world where supercomputer power becomes available to toys in just a few years, where ever-cheaper sensors enable inexpensive solutions to previously intractable problems, and where science fiction keeps becoming reality." Brynjolfsson and McAfee, 2014

*Kevin Drum has a vivid description of the effects of exponential doubling in *Welcome, Robot Overlords. Please don't fire us,* 13 May 2013, Mother Jones

Brynjolfsson and McAfee: 3 forces that put us into the second machine age

2. Digitization
   ‣ New ways of acquiring knowledge
      ✶ Sensors, automated data collection
      ✶ Data mining of existing information
   ‣ Higher rates of innovation
      ✶ Faster testing
      ✶ Computer simulation to augment/replace physical testing
   ‣ Zero marginal cost of reproduction

Brynjolfsson and McAfee: 3 forces that put us into the second machine age

3. Recombinant Innovation

- ▸ Digitization enables
  - ✳ Collaboration over large geographic scales
  - ✳ Social networks form and evolve quickly
  - ✳ Rapid exchange of data and methods
- ▸ Location of innovation migrates to avoid obstacles
  - ✳ Avoid regulation
  - ✳ Move to where the talent is
- ▸ Rapid proliferation in building blocks of information
- ▸ Rapid iteration (agile programming and design)
  - ✳ Quick deployment of ideas
  - ✳ Testing in real situations

Rapid pace of innovation will challenge economic systems that adapt more slowly
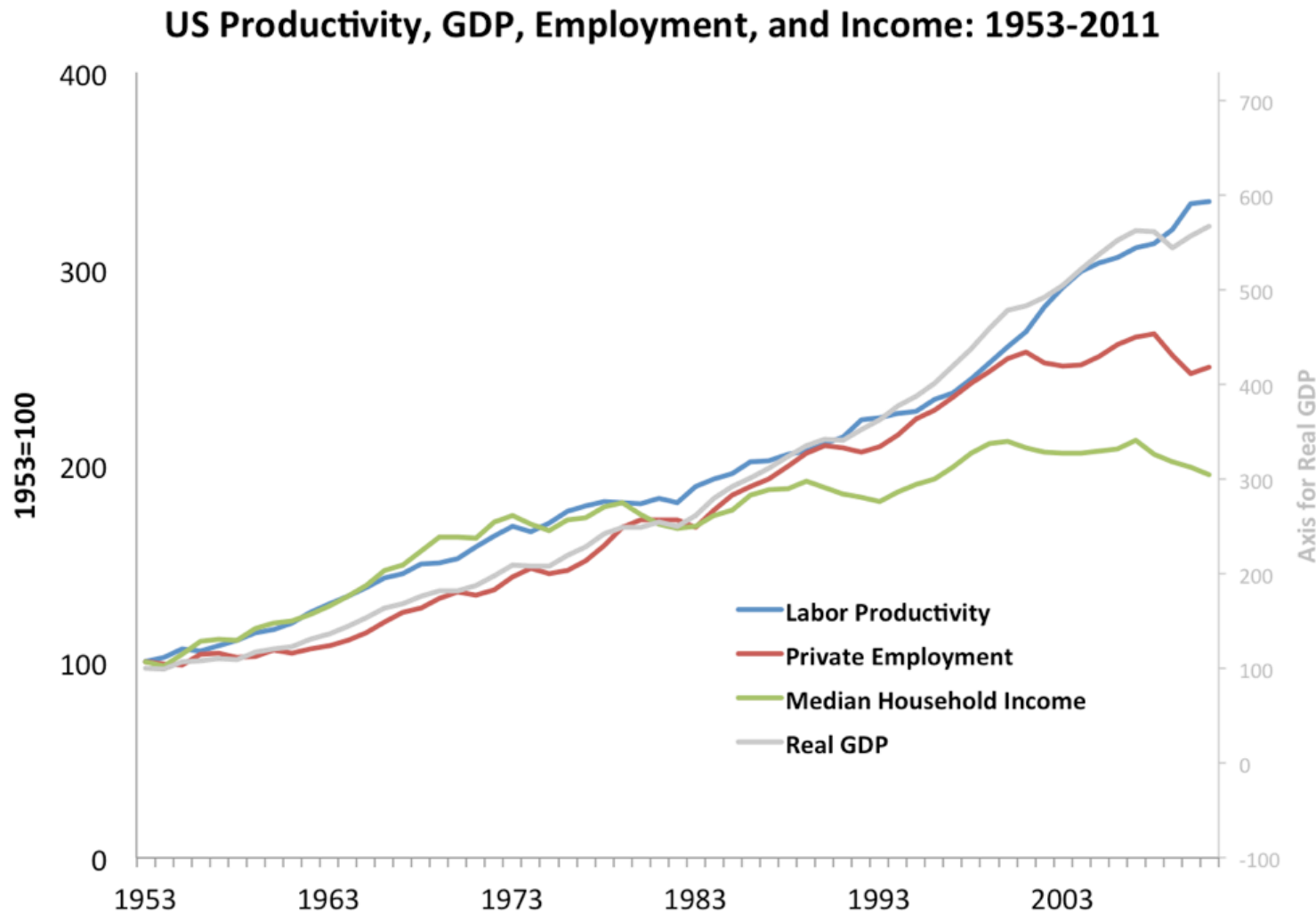
1. Global competition among nations
   - US is no longer guaranteed a leadership position
   - Information technology is both an economic and a military tool

2. Dislocation of workers unleashes hard to manage political forces
   - Immigration debate in the US
   - Loss of blue collar and white collar jobs to automation

The great decoupling: Productivity increase without job growth

US Productivity, GDP, Employment, and Income: 1953-2011

- Labor Productivity
- Private Employment
- Median Household Income
- Real GDP

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Sources: Census Bureau, Bureau of Labor Statistics

http://andrewmcafee.org/2012/12/the-great-decoupling-of-the-us-economy/

The great decoupling: Productivity increase without job growth

Cumulative change in total economy productivity and real hourly compensation of production/nonsupervisory workers, 1948–2013
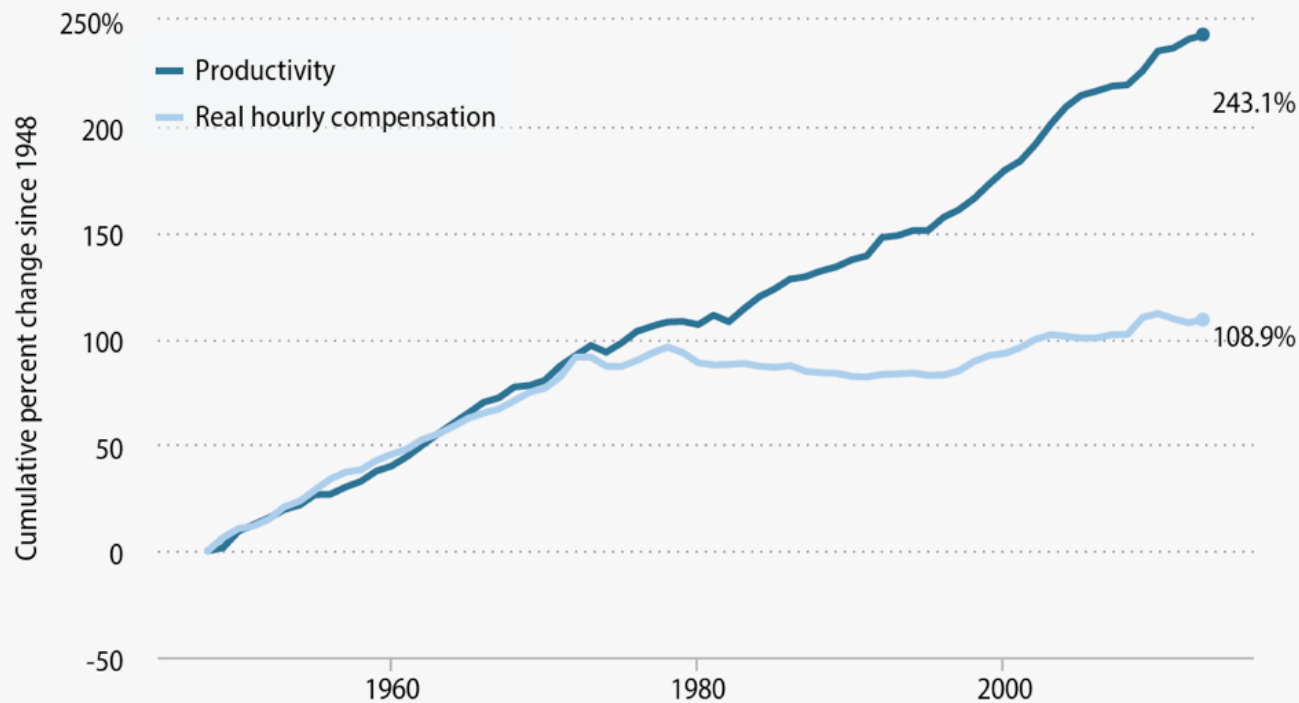
Note: Data are for compensation of production/nonsupervisory workers in the private sector and net productivity of the total economy. "Net productivity" is the growth of output of goods and services less depreciation per hour worked.

Source: EPI analysis of unpublished Total Economy Productivity data from Bureau of Labor Statistics Labor Productivity and Costs program and wage data from BLS Current Employment Statistics, BLS Employment Cost Trends, and Bureau of Economic Analysis National Income and Product Accounts

ECONOMIC POLICY INSTITUTE

http://stateofworkingamerica.org/chart/swa-wages-figure-4u-change-total-economy/   19

Job and wage polarization

Job polarization

- ‣ "middle skill" jobs are being replaced by automation

  - Supermarket cashiers

  - Information processing: legal research, sports reporting

- ‣ "middle skill" workers are migrating toward lower skill jobs that are harder to replace by automation

  - gardening

  - personal care and personal services

- ‣ High skill jobs are in demand, but numbers are low and competition is high

http://www.brookings.edu/research/papers/2010/04/jobs-autor
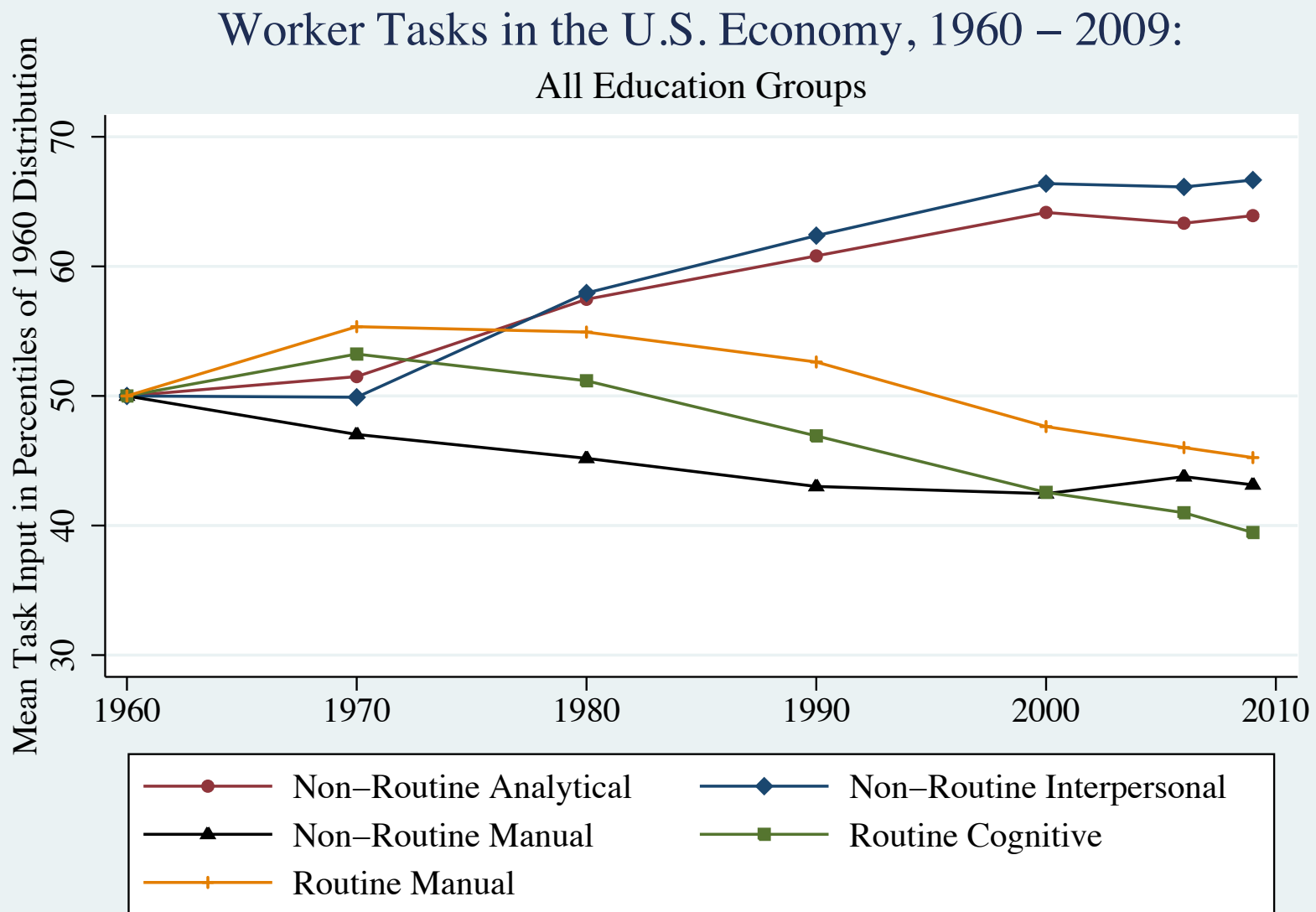David Auto, The Polarization of Job Opportunities in the US Labor Market
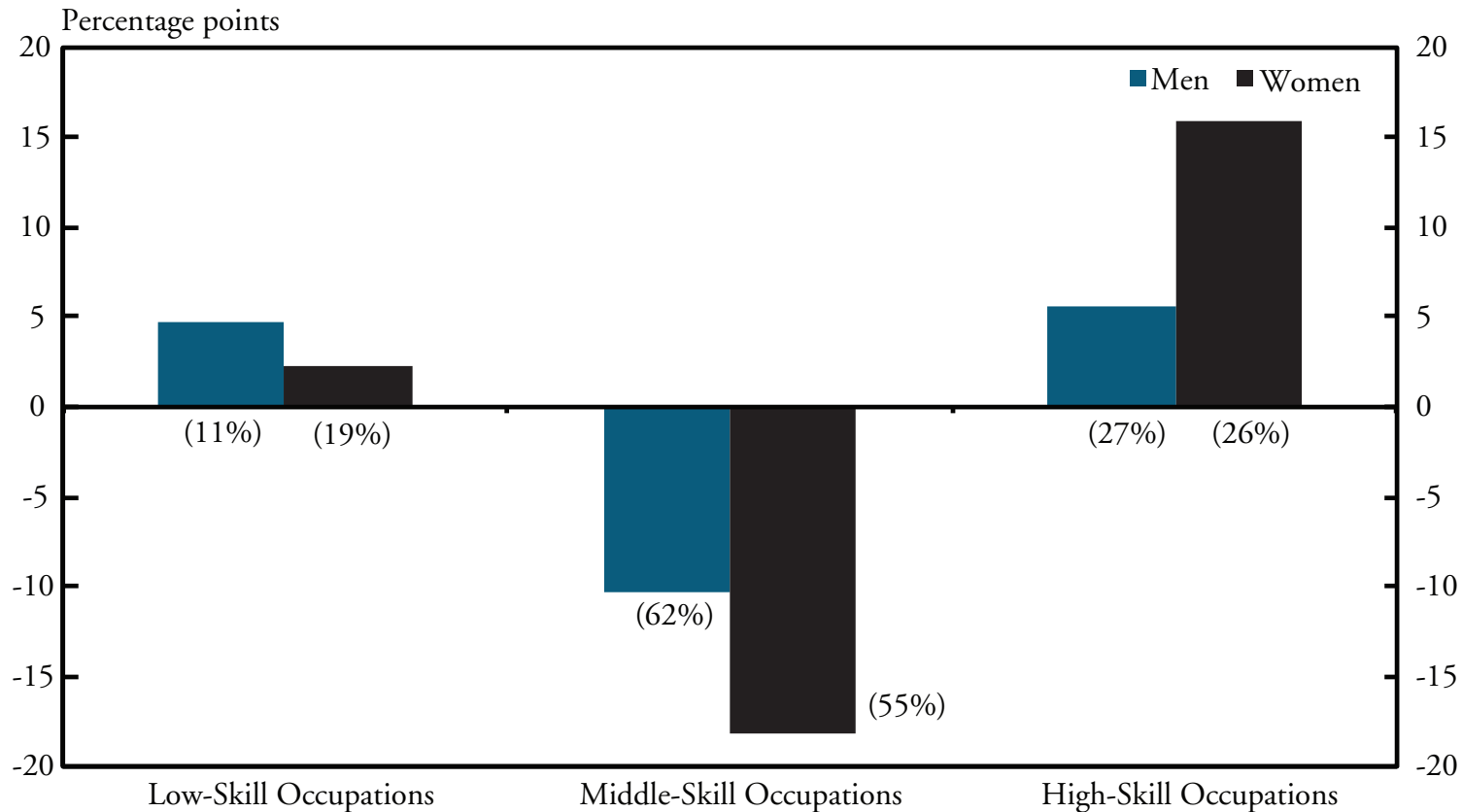
Figure 2. Replication and Extension of ALM Figure 1: 1960 - 2009

David H. Autor and Brendan Price, 2013, "The changing task composition of the US labor market: An update of Autor, Levy, and Murname (2003)", http://economics.mit.edu/files/9758

Chart 5

CHANGES IN EMPLOYMENT SHARES BY SKILL LEVEL AND GENDER BETWEEN 1983 AND 2012

Percentage points

Note: The chart reports the percentage point change in the employment share for each skill group, where employ-ment shares are computed separately for each respective gender. Data are restricted to workers ages 6 to 64 who are not self-employed and are not employed in military or agricultural occupations. For each group, the employment share in 1983 is shown in parentheses.
Source: Current Population Survey and authors' calculations.

Didem Tüzement and Johnath Willis, 2013, "The vanishing middle: Job polarization and worker response to the decline in middle-skill jobs", https://www.kansascityfed.org/publicat/econrev/pdf/13q1Tuzemen-Willis.pdf, accessed 3 December 2014

Job and wage polarization: futher definition of terms is helpful

Routine

- ▸ Accomplished by specific rules, therefore susceptible to replacement by automation

Non-routine

- ▸ Task cannot be easily defined by rules
- ▸ High skill jobs are in demand, but numbers are low and competition is high

http://www.brookings.edu/research/papers/2010/04/jobs-autor
David Auto, The Polarization of Job Opportunities in the US Labor Market

TABLE I
PREDICTIONS OF TASK MODEL FOR THE IMPACT OF COMPUTERIZATION ON FOUR CATEGORIES OF WORKPLACE TASKS

	Routine tasks	Nonroutine tasks
Analytic and interactive tasks		
Examples	• Record-keeping • Calculation • Repetitive customer service (e.g., bank teller)	• Forming/testing hypotheses • Medical diagnosis • Legal writing • Persuading/selling • Managing others
Computer impact	• Substantial substitution	• Strong complementarities
Manual tasks		
Examples	• Picking or sorting • Repetitive assembly	• Janitorial services • Truck driving
Computer impact	• Substantial substitution	• Limited opportunities for substitution or complementarity

Job and wage polarization

David Autor, economist at MIT:

▸ "Job opportunities are polarizing into relatively high-skill, high-wage jobs and low-skill, low-wage jobs".

▸ "The key contributors to job polarization are the automation of routine work and, to a smaller extent, the international integration of labor markets through trade and, more recently, offshoring".

Net effect: loss of middle-skill, white collar jobs and middle-skill blue collar jobs. Repetitive manufacturing jobs were lost to automation. Now automation is eliminating routine work that used to be associated with more highly educated workers.

http://www.brookings.edu/research/papers/2010/04/jobs-autor
David Auto, The Polarization of Job Opportunities in the US Labor Market   25

Job Polarization produces change in composition of labor

David Autor, economist at MIT, created a model that predicts

"(i) greater adoption of information technology;"

"(ii) greater reallocation of low-skill workers from routine task-intensive occupations into service occupations (i.e., employment polarization);"

"(iii) larger increases in both employment and wages at both ends of the occupational skill distribution (i.e., wage polarization); and"

"(iv) larger net inflows of both high- and low-skill labor attracted by these demand shifts."

David H. Autor and David Dorn, "The growth of low-skill service jobs and the polarization of the US labor market", 2013, American Economic Review, 103(5): 1553-1597

Engineers with jobs doing routine work will also be vulnerable to automation

Autodesk is developing design software with built-in optimization

‣ Build a solid model

‣ Create many (thousands) of design suggestions based on variations of the physical matter in the model

‣ Test design variations against engineering requirement: shape constraints, strength, thermal, etc.

‣ Suggest optimal design candidates to the designer

John Bruner, "The automation of design", O'Reilly Radar web site, 20 May 2014, http://radar.oreilly.com/2014/05/the-automation-of-design.html

Engineers with jobs doing routine work will also be vulnerable to automation

An interview with Jeff Kowalski, CTO of Autodesk

> In the past, sophisticated designs were only available to big companies with a lot of resources; now, they're accessible to small-scale entrepreneurs and people who don't necessarily have design or technical expertise. "They don't even need a computer; they just need a Chromebook," says Kowalski, "and that follows exactly the trajectory of people who create music, videos, and so forth on the web."

John Bruner, "The automation of design", O'Reilly Radar web site, 20 May 2014, http://radar.oreilly.com/2014/05/the-automation-of-design.html

Engineers with jobs doing routine work will also be vulnerable to automation

Implications for design engineers

▸ Design tools will lower threshold for skill-based expertise

- Example: automation of stress analysis

▸ Lowering skill thresholds will put pressure on engineers

- Either offer your services for less, or provide a service that is worth the premium salary.

▸ Engineers that only tool jockeys are likely to be the first to be loose their jobs to automation.

John Bruner, "The automation of design", O'Reilly Radar web site, 20 May 2014, http://radar.oreilly.com/2014/05/the-automation-of-design.html

Brynjolfsson and Macafee: Race **with** the machines, not against them

Expect three trends to accelerate

- ‣ Exponential growth in computing
- ‣ Digitization of everything
- ‣ Combinatorial innovation

Move toward higher skill, less routine tasks that require higher cognitive functioning

Example: Best chess players are not people or machines

Erik Brynjolfsson and Andrew McAfee, The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies, 2014, WW Norton

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3. Kevin Drum, *Welcome, "Robot Overlords. Please Don't Fire Us"*, Mother Jones, May 13, 2013. http://www.motherjones.com/print/223026, Accessed 15 May 2013.

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8. Didem Tüzement and Johnath Willis, 2013, *"The vanishing middle: Job polarization and worker response to the decline in middle-skill jobs"*, 2013, https://www.kansascityfed.org/publicat/econrev/pdf/13q1Tuzemen-Willis.pdf

9. David H. Autor, Frank Levy and RIchard J. Murname, 2003, *"The skill content of recent technological change: An empirical exploration"*, The Quarterly Journal of Economics, 118(4):1279-1333