"Demographics and Robots" by Daron Acemoglu and Pascual Restrepo

Discussion by

Valerie A. Ramey

University of California, San Diego and NBER

EFEG July 14, 2017

Merging of two literatures

1. **"The Robots are Coming and They're Taking Our Jobs!"**

- Brynjolfsson & McAfee (2014) *The Second Machine Age"*

- Graetz & Michaels (2015) "Robots at Work"

- Acemoglu & Restrepo (2016) "The Race Between Machine and Man"

- Acemoglu & Restrepo (2017a) "Robots and Jobs"

Merging of two literatures

2. "We're Getting Old and Slow and So is the Economy."

- Larry Summers (2013) "Why Secular Stagnation Might Prove to be the New Normal"

- Maestas, Mullin, Powell (2016) "The Effect of Population Aging on Economic Growth, the Labor Force, and Productivity"

- Acemoglu & Restrepo (2017b) "Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation"

What the paper does

Argues that robots are our friends because they will save us from the effects of aging.

1. Extends previous Acemoglu-Restrepo directed technological change robot models to allow for two types of labor.

2. Assumes that robots are gross substitutes for middle-aged workers (ages 35-55) and complements for older workers (ages 56+).

3. Presents empirical evidence on the link between the population age structure and the adoption of robots.

Outline of my discussion

1. Questions about the assumption and evidence on robot – age-of-worker substitutability.

2. Possible alternative explanation for the positive correlation between aging and robot adoption across countries.

3. Further thoughts on the potential of robots to solve aging problems.

Key Feature of Production

$$\widetilde{Y}(i) = \frac{\eta^{-\eta}}{1-\eta}[X(i)^{\alpha(i)} S(i)^{1-\alpha(i)}]^{\eta}[q(\theta(i), A(i))]^{1-\eta}$$

Gross output in industry i

Aggregate of production tasks used

"Senior" labor

Quantity of intermediate goods used

Task *s*

Middle-aged labor

robots

$$X(i,s) = \begin{cases} A(i)\gamma(i)l(i,s) + m(i,s) & \text{if } s \in [0, \theta(i)] \\ A(i)\gamma(i)l(i,s) & \text{if } s \in (\theta(i), 1], \end{cases}$$

Θ indexes whether robots can replace labor in task

Key Assumption and Implications

Assumption: Machines and middle-aged workers are "gross substitutes" while machines and senior workers are complements.

Implications:

- Demographic change that ↓ ratio of middle-aged to senior workers → ↑ adoption of robots.

  Effect increases with reliance on middle-aged workers ($\alpha(i)$) and with greater industry potential for automation ($\gamma(i)$) .

- Effects on aggregate productivity are ambiguous because of three competing forces.

Comparison to other production function complementarities

- Krusell, Ohanian, Rios-Rull, Violante (2000): explain increase in wage inequality in a model with capital-skill complementarity.

- Autor, Levy, Murnane (2003) – the tasks most likely to be replaced by machines are the ones that are routine or codifiable. "Computer capital" substitutes for workers in routine tasks and complements workers carrying out problem-solving tasks.

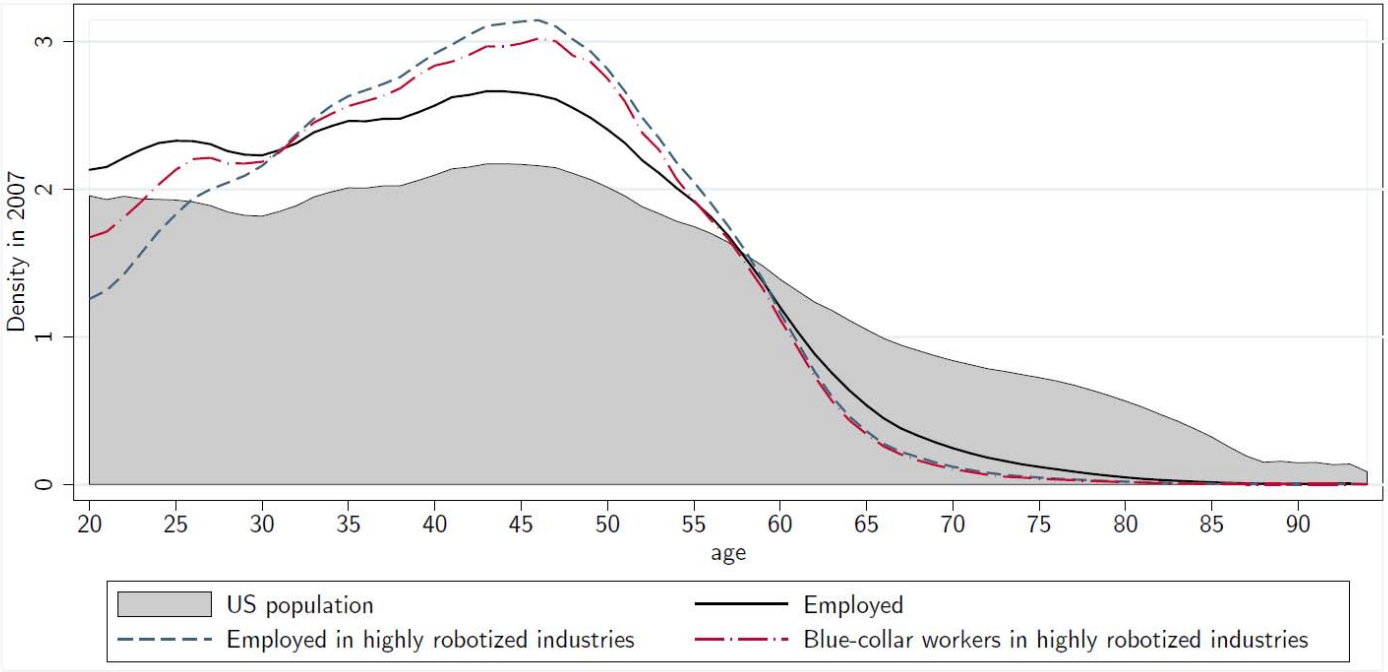
- Note that both papers cite microeconomic studies that support their assumptions. There are no studies I know of that support Acemoglu and Restrepo's assumption.

Acemoglu-Restrepo Evidence for Substitutability

In Section 4, AR present evidence in support of their assumption that robots are most highly substitutable for middle-aged workers (ages 35-55) and least substitutable for senior workers (ages 55+).

1. The evidence shown in Figure 8 and Table 2 suggests a positive correlation between the ratio of middle-aged to old workers and the investment in robots by industry.

AR evidence



"All three panels show that … workers in highly-robotized industries are more likely to be younger than 55 relative to both all employed workers and the full population. We interpret this evidence as supporting our presumption that industrial robots are more substitutable for the tasks performed by middle-aged workers than for the tasks performed by older (or younger) workers." (Acemoglu-Restrepo, p.22)

I’m not sure this evidence is very convincing

- If robots are substituting for middle-aged workers in these industries, why do they still have a higher density of middle-aged workers after wide-scale adoption of robots?

- Couldn’t we use the same evidence to suggest that robots are instead substitutes for older workers and complements for middle-aged workers?

- Job polarization literature suggests that what matters for complementarity is not *age* but whether the worker has *cognitive skills* that allow him/her to do non-routine tasks.

OECD PIAAC Numeracy Scores

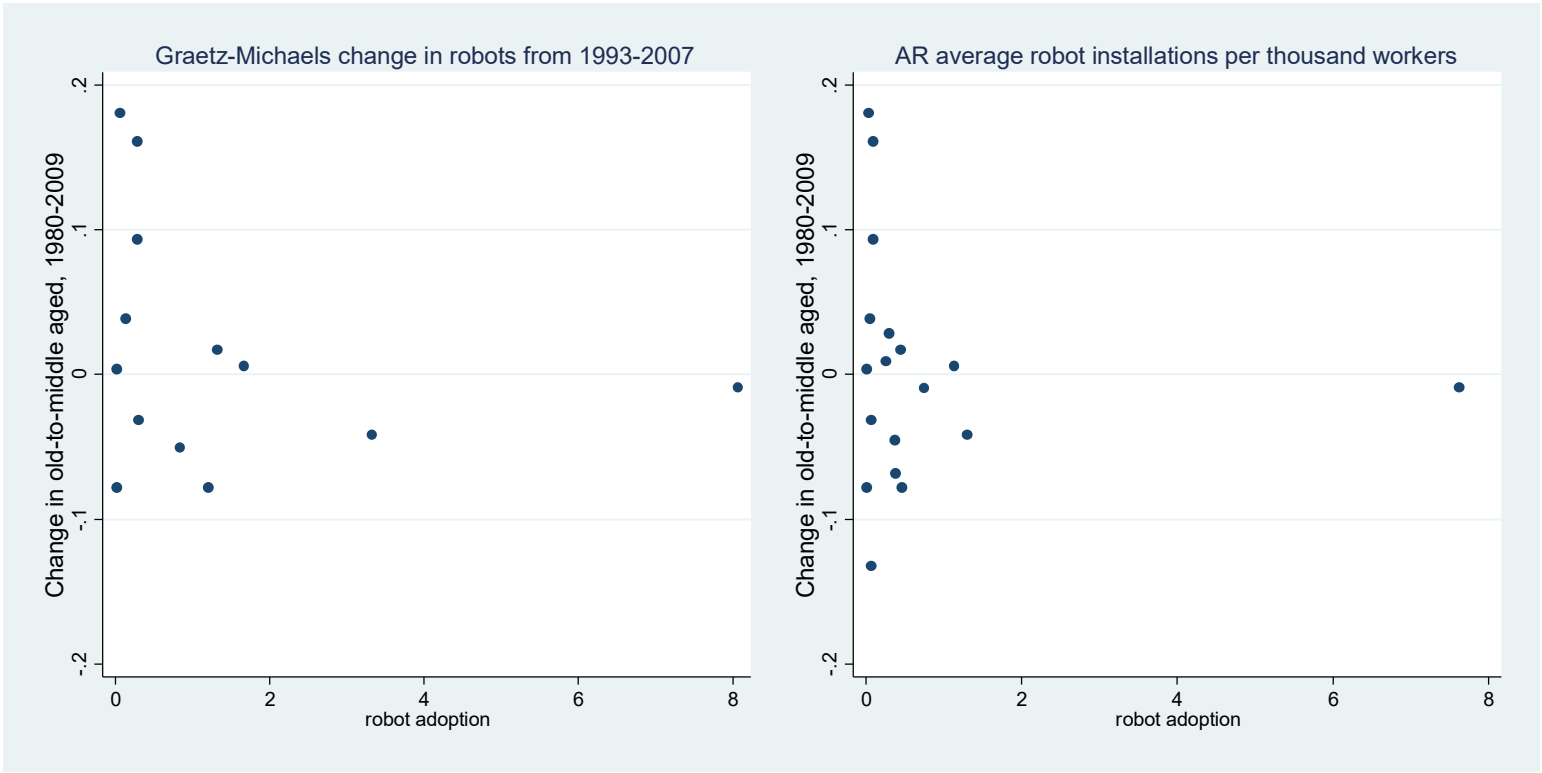
Difference between youngest (25-34) and oldest (55-65) adults

Country	Score dif.	Country	Score dif.	Country	Score dif.
Australia	8.2	France	12.2	Northern Ireland (UK)	2.4
Austria	18.6	Germany	24.1	Norway	15.5
Canada	9.4	Greece	-5.7	Poland	4.2
Chile	22.2	Ireland	5.5	Slovak Republic	-5.1
Czech Republic	12.0	Israel	13.2	Slovenia	17.8
Denmark	13.2	Italy	13.8	Spain	23.0
England (UK)	-2.4	Japan	9.8	Sweden	9.4
Estonia	13.3	Korea	18.3	Turkey	26.2
Finland	30.3	Netherlands	17.6	United States	5.4
Flanders (Belgium)	18.0	New Zealand	8.8	**OECD avg.**	**12.4**

The countries with the greatest adoption of robots are the ones in which the young have much higher skills than the old.

My simple test of their assumption

If robots are substituting for middle-aged workers, then the adoption of robots should raise the ratio of old to middle-aged workers in that industry.



There is no evidence here that the industries that are adopting robots are differentially shedding middle aged workers.

Acemoglu-Restrepo Evidence for Substitutability

2. Using commuting zones across the U.S., AR find that the negative effects of exposure to robots fall more heavily on the overall employment and earnings of middle-aged workers relative to older workers.

My comments:

- AR already showed us that these industries use higher shares of middle aged workers. Thus, even if robots were substituting for workers irrespective of age we would expect this result.

- These industries have special features (as I will discuss later) and one is that they have strong seniority rules for layoffs.

AR aggregate evidence on the link between demographics and robots

1. Evidence across 52 countries and by industry-country

   Countries with a greater projected ↑ ratio of old-to-young workers from 1990 to 2025 adopted more robots from 1993 to 2014.

2. Evidence across 722 US commuting zones

   Commuting zones with greater ↑ ratio of old-to-young workers from 1990 to 2015 have more robot integrators (proxy for robots).

Many robustness checks, IV used to deal with migration.

A possible alternative channel for the aging / robotization correlation.

- Firms adopt robots for two main reasons:

  - to save on labor costs

  - to ensure uniform quality (this is China's motive).

- Labor costs depend on wages as well as taxation, etc.

- Aging societies often have high labor costs because of taxes, etc. imposed to fund expensive pensions and health care for seniors.

Some indirect evidence on the role of wage costs in adoption.

- Adoption of robots is concentrated in only a few industries.

  "The automotive industry employs 39 percent of existing industrial robots, followed by the electronics industry (19 percent), metal products (9 percent), and the plastic and chemicals industry (9 percent)." (AR – "Robots and Jobs" paper)

- These are industries that have historically had high wage premia (i.e. residual wage after accounting for worker observables).

- Borjas-Ramey (2000) and Shim-Yang (2017) have shown that industries with high historical wage premia have lower than average subsequent employment growth but higher productivity growth and capital investment.

Interindustry wage differentials are highly correlated across countries and across time

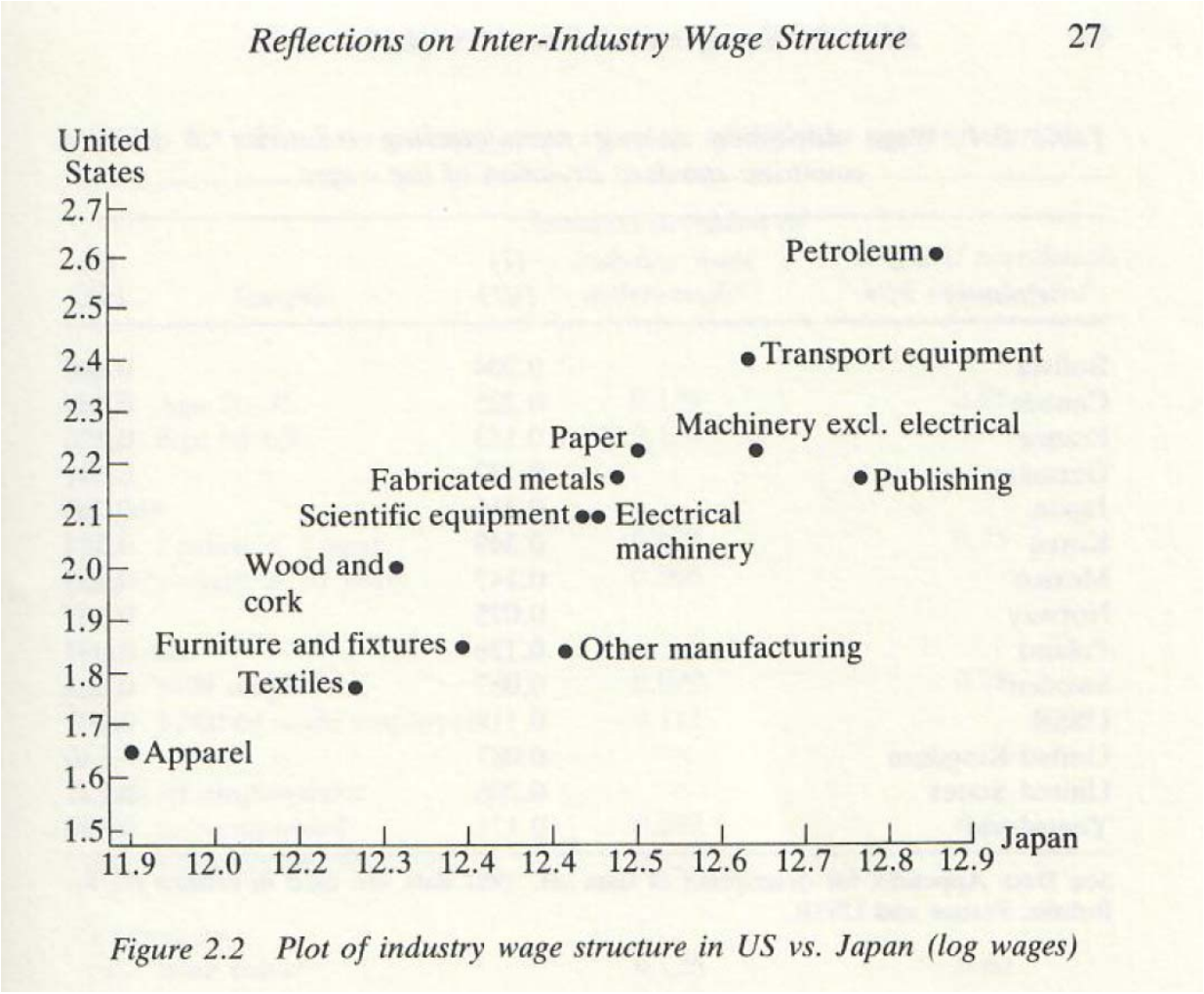


Figure 2.2 Plot of industry wage structure in US vs. Japan (log wages)

From Krueger-Summers (1987)

Myunkyu Shim & Hee-Seung Yang (2017)

They find that the Borjas-Ramey pattern (studied from 1960-1990) persists from 1980 to the present and is concentrated in routine workers.

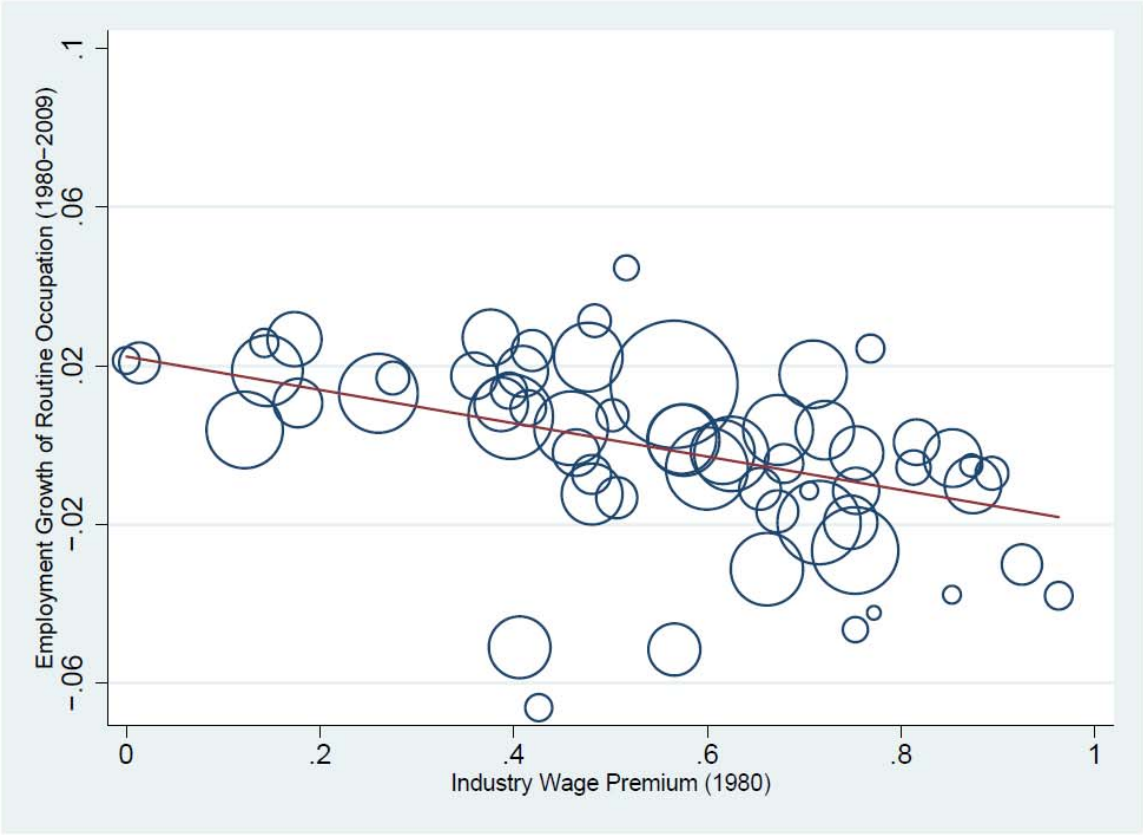


Figure 5.2: Dynamic Responses of Industries to Industry Wage Premia–Routine Occupations

Myunkyu Shim & Hee-Seung Yang (2017)

- Industries with higher initial wage premia experienced subsequently experienced both lower employment growth and higher investment in ICT capital per worker.

Table 5.6: Estimates of Capital, Productivity, and Employment Growth (1980−2007)

	IV		
	Capital/Worker	ICT Capital/Worker	Non-ICT Capital/Worker
Industry Wage Premium	0.0136	0.0397	0.0034
	(0.0133)	(0.0171)**	(0.0139)
	Output	Labor Productivity	Employment
	−0.057	0.0255	−0.0313
	(0.0084)	(0.0086)***	(0.0071)***

My evidence using the robot data

I regressed the measures of industry robot adoption reported in tables in Graetz and Michaels (2017) and Acemoglu-Restrepo (2017) on Shim and Yang's estimated industry wage premia in 1980.

Regression of Robot Adoption on Industry Wage Premium in 1980

	Graetz-Michaels Δ robots since 1990s.	Acemoglu-Restrepo robot installations
coefficient	3.15	2.11
Standard error	(1.6)	(1.2)
Observations	13	18

Idea behind alternative explanation

Germany, which is aging more quickly than the U.S., is adopting robots more quickly because (i) the cost of supporting older people raises labor costs; and (ii) they specialize in industries in which interindustry wage premia are higher and it is easier to replace workers with robots.

Further thoughts on robots

- We should keep in mind that robotization of manufacturing can only help so much – manufacturing employment is only 7.7% of total employment.

- If robots are going to save us from aging, we need much more innovation in the use of robots outside of manufacturing.

  In particular, it seems that the robots will help with aging if robots can substitute for labor in the production of goods and services demanded by the elderly.

Henrik Christensen, Executive Director of the UCSD Institute for Robotics and Intelligent Machines

Worked on the 2009 National Robotics Roadmap and its 2013 revision.

Henrik Christensen's points:

- Comment on the 2013 revision of the Roadmap:

"From an R&D point of view it was interesting to see that driverless vehicles and UAVs had progress faster than expected as applications. Supply chain use of robotics was also growing faster than expected. Machine learning is a technology that has gained tremendous popularity. Safe actuation, gripper technology, long-term autonomy and effective human-robot interaction are examples of areas that have progressed slower than expected."

- Some of the biggest challenges are operation of robots in "cluttered spaces," shared autonomy with humans, and a lack of necessary legal infrastrucutre.

This is what we really need to deal with aging

Health sector employment is projected to be 13.6% by 2025.

Surgical robots!

Nurse robots!

Concluding thoughts

- Very nice, thought-provoking paper.
- Acemoglu & Restrepo present a very intriguing hypothesis and correlations that deserve further research attention.
- The next step should be more direct evidence supporting the production function assumption.