

Aging Society and Job Polarization

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Introduction

- Since 1980, both aging and job polarization occurred in U.S. and other countries
 - U.S. median age increased from 30 in 1980 to 38 in 2019
 - Occupation composition shifted from middle-skill (-17pp) to high-skill (+13pp) and low-skill (+4pp) (Acemoglu and Autor (2011))
- How important is population aging (and other changes between 1980 and 2019) in causing job polarization?
- We use an equilibrium model for measurement, focusing on two channels
 - Changing consumption basket over the life cycle
 - Lower interest rate makes middle-skill-substituting ICT capital cheaper

First Channel: Life-Cycle of Consumption Basket

- Households with different stages of life spend on different goods and services
- Older households spend more on services (e.g. healthcare)
- Population aging shifts economy-wide demand to services
 - Cravino et al. (2022) – aging and rising importance of service sector
 - Siliverstovs et al. (2011) – aging and employment shift across industries
- Service industries (healthcare) require more high- and low-skill occupations while non-services (manufacturing) require more middle-skill ones
- Shift of demand to service sectors could induce job polarization
 - Comin et al. (2020) – Income-elastic services and income growth

Second Channel: Middle-Skill-Substituting ICT Capital

- Acemoglu and Autor (2011): *“recent technological developments have enabled information and communication technologies (ICT) to either directly perform or permit the offshoring of a subset of the core job tasks previously performed by middle skill workers”*
- Assume that one type of capital can substitute middle-skill occupations
 - Capital-skill complementarity: Krusell et al. (2000)
 - Robots: Acemoglu and Restrepo (2022)
- When population aging raises savings and lowers real interest rate, ICT capital becomes cheaper, leading to job polarization
 - Aging and lower interest rate: Gagnon et al. (2021), Papetti (2021)

Plan

1. Data
2. Model
3. Two Experiments

Data: Consumption Basket (PCE) by Age in 1980 and 2019

Year & Age	1980	21-65	66-99	2019	21-65	66-99
PCE	100.0	100.0	100.0	100.0	100.0	100.0
Goods	45.7	49.5	28.6	31.4	32.5	27.7
Durable goods	12.9	14.5	6.0	10.5	11.3	8.1
Motor vehicles and parts	4.9	5.5	2.2	3.8	4.1	2.8
Furniture and household equipment	3.9	4.2	2.4	2.4	2.5	2.0
Recreational goods and vehicles	2.6	3.1	0.6	3.0	3.3	2.0
Other durable goods	1.6	1.7	0.8	1.4	1.4	1.4
Nondurable goods	32.7	35.0	22.6	20.8	21.2	19.6
Food and beverages	13.7	14.4	10.5	7.5	7.9	6.4
Clothing and footwear	5.9	6.6	2.8	2.9	3.2	1.8
Gasoline and other energy goods	5.8	6.2	4.1	2.4	2.6	1.8
Other nondurable goods	7.3	7.8	5.1	8.0	7.5	9.7
Services	54.3	50.5	71.4	68.6	67.5	72.3
Housing and utilities	17.8	14.7	31.8	17.8	17.2	19.6
Healthcare	9.9	7.7	19.7	17.2	15.5	22.2
Transportation	3.2	3.4	2.0	3.4	3.6	2.8
Recreational services	2.3	2.5	1.3	4.1	4.0	4.5
Food services and accommodation	6.9	7.5	4.1	7.0	7.4	5.4
Financial services and insurance	5.3	5.1	6.1	7.9	8.0	7.5
Other services	7.3	7.7	5.2	8.5	8.8	7.5

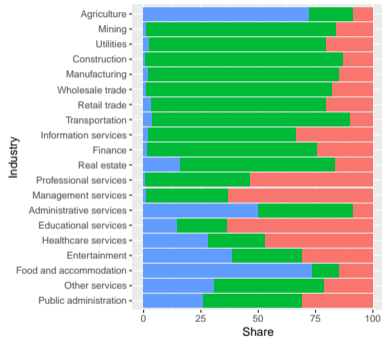
- Older households spend more on services (health and housing)
- Young spend more on goods
- Everybody spends more on services in 2019

Data: Consumption Basket (VA) by Age in 1980 and 2019

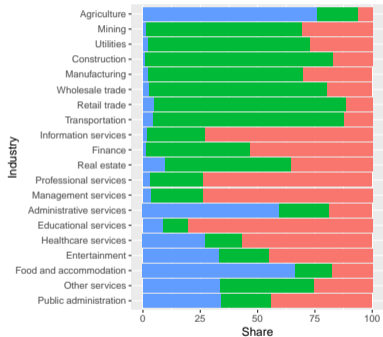
Line	Industry	1980	21-65	66-99	2019	21-65	66-99
1	Agriculture	2.4	2.5	1.8	1.3	1.3	1.1
2	Mining	2.0	2.1	1.5	1.1	1.1	1.0
3	Utilities	3.1	3.2	2.5	1.9	1.8	1.9
4	Construction	0.6	0.6	0.5	0.9	0.9	0.9
5	Manufacturing	15.4	16.4	10.7	11.4	11.6	10.6
6	Wholesale Trade	6.8	7.3	5.0	5.1	5.3	4.8
7	Retail Trade	9.8	10.5	6.4	6.5	6.8	5.6
8	Transportation	3.3	3.5	2.4	3.4	3.5	3.1
9	Information Services	3.7	3.9	2.6	4.3	4.3	4.2
10	Financial Services	7.4	7.1	8.4	9.4	9.5	9.2
11	Real Estate	15.5	12.7	27.8	17.0	16.6	18.4
12	Professional Services	5.0	5.1	4.4	5.6	5.6	5.6
13	Management Services	1.5	1.6	1.2	2.0	2.0	1.9
14	Administrative Services	2.7	2.8	2.4	3.1	3.1	3.1
15	Educational Services	0.8	1.0	0.2	1.4	1.6	0.6
16	Healthcare Services	6.2	5.1	11.3	10.8	9.7	14.2
17	Entertainment	0.8	0.9	0.5	1.4	1.4	1.4
18	Food and Accommodation	4.0	4.3	2.7	4.6	4.8	3.9
19	Other Services	4.7	4.9	3.7	3.7	3.7	3.7
20	Public Administration	4.5	4.6	4.3	5.3	5.5	4.9
21	Total	100.0	100.0	100.0	100.0	100.0	100.0
22	Services	56.8	54.0	69.4	68.5	67.7	71.0

- Older households spend more on services (healthcare and housing)
- Young spend more on non-services (manufacturing)
- Everybody spends more on services in 2019

Data: Employment Shares in 1980 and 2019



Employment Share in 1980



Employment Share in 2019

- Non-service industries (upper part) employ more middle-skill occupations
- Service industries (lower part) employ more low- and high-skill occupations
- All industries shift from middle-skill to high-skill occupations

Model: Overview

- Households
 - g (age) — stochastic aging from $g = 1$ (21-25) to $g = 16$ (96-100)
 - i (education) — 1 (college, fraction= m_1), 2 (non-college, fraction= m_2)
 - a (saving) — subject to non-borrowing constraint
 - z (productivity shocks) — three shocks for three occupations (high, middle, low)
- Final Goods Firms
 - $s = 1$ (non-service sector): consumption and investment
 - $s = 2$ (service sector): consumption
- Capital firms
 - $k = 1$: non-ICT capital
 - $k = 2$: ICT capital
- Government
 - Run the social security program
 - Collect all the bequests and distribute equally

Model: Household

$$\begin{aligned} V(g, i, a, z) = & \max_{\{c_s\}_{s=1}^S, a' \geq 0} \frac{\phi_g}{1 - \sigma} \left[\sum_{s=1}^S \alpha_{g,s} (c_s + \gamma_{g,s})^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon(1-\sigma)}{\epsilon-1}} \\ & + \beta \mathbb{E} \pi_{g,2} [\pi_{g,1} V(g, i, a', z') + (1 - \pi_{g,1}) V(g + 1, i, a', z')] \\ & + \beta \mathbb{E} (1 - \pi_{g,2}) \phi_b \frac{(\gamma_b + a')^{1-\sigma}}{1 - \sigma} \end{aligned} \quad (1)$$

$$\text{s.t.} \quad \sum_{s=1}^S p_s c_s + a' = e(g, i, z) + (1 + r)a + tr_b \quad (2)$$

$$e(g, i, z) = \begin{cases} \max_{j \in \{H, M, L\}} (1 - \tau) z_j \psi_g w_j & \text{if } g < G_R \\ \zeta \bar{e}_i & \text{if } g \geq G_R \end{cases} \quad (3)$$

- $z_j \sim i.i.d.LN(\mu_{i,j}, \sigma_i^2)$
- $\gamma_{g,s} = 0$ for now (Buera et al. (2022) set $\gamma_{g,s} > 0$ for services)

Model: Consumption Goods Firm

- A type- s representative consumption goods firm decides labor inputs of three skill levels (H_s, M_s, L_s) and capital inputs ($K_{1,s}, K_{2,s}$) each period

$$\max_{H_s, M_s, L_s, K_{1,s}, K_{2,s}} p_s Y_s - w_H H_s - w_M M_s - w_L L_s - p_{K,1} K_{1,s} - p_{K,2} K_{2,s} \quad (4)$$

$$Y_s = A_s \left[\eta_{H,s} H_s^{\frac{\rho-1}{\rho}} + \eta_{M,s} D_s^{\frac{\rho-1}{\rho}} + \eta_{L,s} L_s^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho(1-\theta_s)}{\rho-1}} K_{1,s}^{\theta_s} \quad (5)$$

$$D_s = \left[(1 - \eta_{K,s}) M_s^{\frac{\kappa-1}{\kappa}} + \eta_{K,s} (A_K K_{2,s})^{\frac{\kappa-1}{\kappa}} \right]^{\frac{\kappa}{\kappa-1}} \quad (6)$$

- CES across high- (H_s), middle- (M_s), and low-skill (L_s) occupations
- Middle-skill occupations (M_s) can be substituted by ICT capital ($K_{2,s}$)
- A_K = Productivity of ICT capital

Calibration: Baseline 1980 Model

Statistic	1980 U.S.	1980 Model	2019 U.S.
Employment share: High	28.1	27.9	40.9
Employment share: Middle	59.9	60.0	42.7
Employment share: Low	12.0	12.1	16.4
Wage bill share: High	32.6	28.5	50.8
Wage bill share: Middle	59.0	63.6	37.8
Wage bill share: Low	8.4	7.9	11.4
Wage: High	1.20	1.02	1.25
Wage: Middle	0.98	1.06	0.88
Wage: Low	0.67	0.65	0.68
College premium	1.25	1.26	1.51
Service exp share	56.8	56.1	68.5
Total Capital/Y	2.93	2.92	2.92
ICT Capital/Y	0.05	0.05	0.08
Real interest rate	5.72	5.94	3.72

- The 1980 model mostly captures the 1980 data
- Except for high-skill wage not being high enough

Results: Overview of Population Aging Experiment

Model	20s	30s	40s	50s	60s	70s	80s+
CE in 1980 (%)	20.8	20.7	15.0	16.0	13.9	9.8	3.2
CE in 2019 (%)	12.9	17.9	16.8	18.4	17.3	10.7	6.0
1980 Model (%)	18.5	18.2	17.7	16.4	13.9	9.8	5.4
2019 Mortality (%)	17.1	16.9	16.5	15.7	14.1	11.3	8.5
2019 + Baby boomer (%)	14.4	14.2	13.9	17.5	19.8	13.0	7.2

Three changes to the 1980 model:

- Mortality rate in 2019
- Baby boomers (raise share of 56-75 years old in 2019)
- Flatter family-size profile (ϕ_g) in 2019

Results: Aging Society

Statistic	1980 U.S.	2019 U.S.	U.S.Δ	1980 Model	Aging	ModelΔ
Employment share: High	28.1	40.9	12.8	27.9	28.2	0.2
Employment share: Middle	59.9	42.7	-17.2	60.0	59.6	-0.4
Employment share: Low	12.0	16.4	4.4	12.1	12.3	0.2
Wage bill share: High	32.6	50.8	18.2	28.5	28.8	0.3
Wage bill share: Middle	59.0	37.8	-21.3	63.6	63.1	-0.5
Wage bill share: Low	8.4	11.4	3.1	7.9	8.1	0.1
Wage: High	1.20	1.25	5.8	1.02	1.02	0.2
Wage: Middle	0.98	0.88	-9.7	1.06	1.06	0.0
Wage: Low	0.67	0.68	1.2	0.65	0.66	0.3
College premium	1.25	1.51	25.4	1.26	1.27	0.8
Service exp share	56.8	68.5	11.8	56.1	57.2	1.1
Real interest rate	5.72	3.72	-2.0	5.94	5.18	-0.76

- Aging induces job polarization, but only 2-4% of observed changes
- According to Cravino et al. (2022), aging can account for 1.9pp increase in the service share out of 8.5pp increase between 1982 and 2016
- Eqm interest rate does not decline as much as in Gagnon et al. (2021) (1.25pp)

Results: Overview of the 2019 Model

The 2019 Model is different from the 1980 Model in the following five ways:

1. Aging society
 - Higher life expectancy + baby boomers + smaller family size
2. More college graduates (19% \rightarrow 36%)
 - College graduates have comparative advantage with high-skill occupations
3. Shift of preferences towards services — Recalibrate $\alpha_{2,g}$
 - Capturing income-elastic services + higher income (Comin et al. (2020))
4. Skill-biased structural change (SBSC) — Recalibrate $\eta_{j,s}$
 - Both non-service and service sectors use less middle-skill labor inputs
5. Productivity growth of ICT capital ($A_K \uparrow$)

Results: Decomposition of the 2019 Model

$\Delta 1980 \rightarrow 2019$ in pp	U.S. Δ	Model Δ	Aging	College	Service	SBSC	ICT K
Employment share: High	12.8	13.5	0.2	2.6	2.5	7.9	0.1
Employment share: Middle	-17.2	-14.8	-0.4	-1.8	-4.4	-8.1	-0.1
Employment share: Low	4.4	1.3	0.2	-0.8	1.8	0.2	0.0
Wage bill share: High	18.2	19.1	0.3	2.3	3.8	11.2	0.1
Wage bill share: Middle	-21.3	-20.1	-0.5	-1.7	-5.5	-11.4	-0.1
Wage bill share: Low	3.1	1.0	0.1	-0.6	1.7	0.2	0.0
Wage: High	5.8	12.6	0.2	-1.1	4.0	8.7	0.0
Wage: Middle	-9.7	-9.6	0.0	0.3	-1.5	-5.3	0.0
Wage: Low	1.2	1.4	0.3	-0.9	3.4	0.3	0.1
College premium	25.4	11.3	0.8	-24.4	9.8	28.7	0.1
Service exp share	11.8	13.1	1.1	-1.2	14.2	-0.6	0.0
Real interest rate	-2.00	-0.70	-0.76	0.0	0.07	0.03	-0.05

- More than half of polarization (high- and middle-skill) is accounted for by SBSC
- Most of the rest are accounted for by shift in consumer demand to services and rising number of college graduates
- SBSC significantly raises college premium (Buera et al. (2022))

Concluding Remarks

- We document:
 - Older households spend more on services, while younger ones spend more on goods
 - Service industries employ more high- and low-skill occupations while non-service industries employ more middle-skill
 - All industries employ more high-skill occupations in 2019
- According to our overlapping-generations general-equilibrium model:
 - Population aging generates job polarization, but the channel is quantitatively weak
 - Skill-biased structural change, increasing number college graduates, and general shift of demand to services account for most of job polarization
- Next steps:
 - Interactions between aging and income inequality — higher inequality among the old
 - Changes in relative prices of services, non-services, and capital
 - Broader definition of worker-replacing capital — Robots (Acemoglu and Restrepo (2022))
 - Redefine “services” and “non-services”
 - Population aging continues — look at 2050 or 2100, or Japan

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