The complexity of skills and the future of work

Morgan R. Frank
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Everybody Dance Now (arXiv:1808.07371)

Source Subject
*Challenging due to missed detections
Skill biased technological change

Surgeons & Robotics

Engineers & Drones

Bank Tellers & ATMs
A framework for skills, labor, and cities

- differential impact of automation
- skill & wealth disparity
- spatial career mobility

Local Labor Markets

Occupations & Employment
- Executive
- Programmer
- Bartender

Tasks & Skills
- Persuasion
- Stamina
- Mathematics
- Vision
- Computer Vision

- career trajectories
- viable retraining
- job polarization
- interaction with technology
- skill complementarity
- education

Frank et al., PNAS (2019)
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The structure of workplace skills

Occupations

j1

j2

j3

Skills

S1

S2

S3

Workers

j1

j2

j3

Skills

S1

S2

S3

S4

S5

S6

The Product Space

\[ \text{rca}(j, s) = \frac{\sum \text{onet}(j', s')}{\sum \text{onet}(j', s)} \]

\[ I(j, s) = \begin{cases} 1, & \text{if } \text{rca}(j, s) > 1 \cr 0, & \text{otherwise} \end{cases} \]

Science Advances (2018)
Unpacking the polarization of workplace skills

Science Advances (2018)
Skill polarization explains occupational polarization

Increasing annual wages

$$\text{cognitive}_j = \frac{\sum_{s \in C} \text{onet}(j, s)}{\sum_{s \in S} \text{onet}(j, s)}$$

Science Advances (2018)

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Skill polarization explains urban polarization

Increasing median household income (also population)

\[ \text{cognitive}_j = \frac{\sum_{s \in C} \text{onet}(j, s)}{\sum_{s \in S} \text{onet}(j, s)} \]

Science Advances (2018)
Explaining low- and high-skill employment

The “hollowing of the middle class”
Skill polarization and career mobility

- Waitstaff
- Bartender
- Mechanics Supervisor
- Mechanical Tool Setter
- Low Cognitive Skill
- Mid Cognitive Skill
- High Cognitive Skill
- Sales Engineer
- Retail Supervisor

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Occupations & Employment

Tasks & Skills

Executive

Persuasion

Stamina

Vision

Programmer

Bartender

Mathematics

Computer Vision

di
dferential impact of automation

skill & wealth disparity

spatial ca
cer mobility

different occupations & employment

tasks & skills

differential impact of automation skill & wealth disparity spatial career mobility
The structure of occupations

\[
\text{onet}(j, s)/ \sum_{s' \in S} \text{onet}(j, s')
\]

\[
rca(j, s) = \frac{\sum_{j' \in J} \text{onet}(j', s)/ \sum_{j' \in J, s' \in S} \text{onet}(j', s')}{\sum_{s' \in S} \text{onet}(j, s')/ \sum_{s' \in S} \text{onet}(j, s')}
\]

\[
I(j, s) = \begin{cases} 
1, & \text{if } rca(j, s) > 1 \\
0, & \text{otherwise}
\end{cases}
\]
Skill similarity predicts worker mobility

\[
\text{skillsim}(j, j') = \frac{\sum_{s \in S} I(j, s) \cdot I(j', s)}{\sum_{s \in S} \left( I(j, s) + I(j', s) - I(j, s) \cdot I(j', s) \right)}
\]
The polarized structure of occupations

Example Job Titles:

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lawyer</td>
<td>Bus Driver</td>
</tr>
<tr>
<td>Mathematician</td>
<td>Bartender</td>
</tr>
<tr>
<td>Software</td>
<td>Dancer</td>
</tr>
<tr>
<td>Developer</td>
<td>Carpenter</td>
</tr>
<tr>
<td>Surgeon</td>
<td>Car Mechanic</td>
</tr>
<tr>
<td>Microbiologist</td>
<td>Security Guard</td>
</tr>
<tr>
<td>Chief Executive</td>
<td>Janitor</td>
</tr>
<tr>
<td>Statistician</td>
<td></td>
</tr>
</tbody>
</table>

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Frank et al., PNAS (2019)
Projecting cities onto the job network

Boston, MA (N=311)

Houston, TX (N=317)

Overlap Network
(N=125)

Madera, CA (N=103)

Seattle, WA (N=330)

(N=23)
Skills determine spatial mobility

tightness(c, c') = \sum_{j,j' \in J^2} \frac{\text{skillsim}(j, j') \cdot (I(c, j) + I(c', j))}{2 \cdot \sum_{i,i' \in J^2} \text{skillsim}(i, i')}
Structural economic resilience

- Densely-Connected Labor Force
- Sparsely-Connected Labor Force

Current Employment
Tipping Point

Low Employment

Occupations & Employment
- Executive
- Programmer
- Bartender

Tasks & Skills
- Persuasion
- Vision
- Computer Vision
- Machine Vision

Annual Wage Percentile
B
C

Skills & Wealth Disparity
Spatial Career Mobility

Differential Impact of Automation

Career Trajectories
Viable Retraining
Job Polarization

Interaction with Technology
Skill Complementarity
Education
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MEASURING SKILL DEMAND
- structured representative survey (e.g. per job title, O*NET)
- microscopic skill perturbations (e.g. patent data)
- unstructured real-time skills data (e.g. per worker or employer, online job postings and resumes)

REGIONAL / URBAN LABOR DEPENDENCIES
- employment distribution
- location-specific career data
- longitudinal employment trends

Frank et al., PNAS (2019)
• Can retraining programs be more efficient?
• Which workplace activities will be automated?
• What creates economic resilience in cities?
• How can firms maximize returns on investment in technology?