Innovation, Employment and Income Inequality

Prepared for the AK Young Economists Conference

by

Stella Zilian

Research Institute Economics of Inequality (WU)
Today’s Presentation

• Introduction: history of technological progress
• Literature Review
  • Technological progress and employment
  • Technological progress and income inequality
  • Empirical Evidence
• Outlook
## Four stages of industrial revolution

<table>
<thead>
<tr>
<th>1ˢᵗ industrial revolution</th>
<th>2ⁿᵈ industrial revolution</th>
<th>3ʳᵈ industrial revolution</th>
<th>4ᵗʰ industrial revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanisation</td>
<td>Electrification</td>
<td>Automatisation</td>
<td>Digitalisation</td>
</tr>
<tr>
<td>○ Late 18ᵗʰ century</td>
<td>○ Beginning of the 20ᵗʰ century</td>
<td>○ Started in 1970s</td>
<td>○ 21ˢᵗ century</td>
</tr>
<tr>
<td>○ Steam and hydro power</td>
<td>○ Mass production based on division of labour and electric energy</td>
<td>○ ICT and electronics usage</td>
<td>○ Cyber-physical-systems</td>
</tr>
<tr>
<td>○ Wage labour and separation of home and work</td>
<td>○ Emergence of a broad middle class</td>
<td>○ Automatization of production processes</td>
<td>○ Autonomous production, „Smart Factories“</td>
</tr>
<tr>
<td>➢ Transformation from an agricultural to an industrial stage</td>
<td>➢ Transition from industrial to information society</td>
<td>➢ Rather an advancement of previous developments than an actual revolution</td>
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</tbody>
</table>
Historical context

• Widespread fear of technological unemployment whenever rapid technological progress
• So far worries have not been fulfilled
  • While old jobs became obsolete, new jobs were created
  • Some industries disappeared, others emerged
  • Living standards rose significantly in the long run
  • But transition was painful

➤ Relationship of technological progress, employment and the income distribution is affected through several channels
Technology, employment and income inequality

Labour Demand

Labour productivity

Process Innovation

Knowledge intensity

Output

Knowledge intensity (KBC, ICT)

Product Innovation

Digitalisation

4th Industrial Revolution

…via (1) decrease in prices
…via (2) decrease in real wages
…via (3) increase in machineries
…via (4) increase in income
…via (5) new products

Compensation...

Scale and Network Effects

“Winner-Takes-all-Markets”

Creative Destruction

Risk

Risk Premium

Market Rents

SBTC/RBTC

Wages unskilled/skilled

Return on Capital/Wage Share

Income Distribution
Compensation theory

**Substitution**
- Machines substitute for human labour in production process
- Reduces labour requirement to produce same amount of output

**Compensation**
- Market mechanisms that may offset technological unemployment due to substitution
- Work through different channels and are sensitive to assumptions
## Employment effects of innovation

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Effect</th>
<th>Transfer mechanism</th>
<th>Employment</th>
<th>Determinants</th>
</tr>
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<tbody>
<tr>
<td>Process Innovation</td>
<td>(0) Productivity Effect</td>
<td>Less labour input to produce same amount of output due to substitution by machines</td>
<td>-</td>
<td>Substitutability between factors in production</td>
</tr>
<tr>
<td></td>
<td>(1) Price effect</td>
<td>Cost reduction leads to price reduction</td>
<td>+</td>
<td>Price elasticity of demand, degree of competition</td>
</tr>
<tr>
<td></td>
<td>(2) Real wage effect</td>
<td>Technological unemployment is offset by a decrease of wages</td>
<td>+</td>
<td>Flexibility of wages</td>
</tr>
<tr>
<td></td>
<td>(3) Income effect</td>
<td>Extra-profits in incomplete markets increase wages through bargaining or raise income of shareholders</td>
<td>+</td>
<td>Bargaining power of worker, marginal propensity to consume/invest, efficiency of financial system</td>
</tr>
<tr>
<td></td>
<td>(4) New machineries</td>
<td>Demand for new machines increased labour demand in capital goods producing sectors</td>
<td>+</td>
<td>Labour intensity of production of capital goods</td>
</tr>
<tr>
<td>Product Innovation</td>
<td>(5) Direct demand effect</td>
<td>New product generates new demand</td>
<td>+</td>
<td>Competition, Synergy effects</td>
</tr>
<tr>
<td></td>
<td>(0) Indirect productivity effect</td>
<td>Productivity differentials between old and new products</td>
<td>-</td>
<td>Production technologies</td>
</tr>
<tr>
<td></td>
<td>(5) Indirect demand effect</td>
<td>Demand effect for existing products</td>
<td>+/-</td>
<td>Substitutability of old and new products</td>
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Technology, employment and income inequality

4th Industrial Revolution
- Process Innovation
- Knowledge intensity
- Product Innovation
- Digitalisation (KBC, ICT)

MARKET STRUCTURE
- Scale and Network Effects
- Creative Destruction
- „Winner-Takes-all-Markets“
- Risk
- Market Rents
- Risk Premium

Labour productivity

Labour Demand

(0) Substitution

Output

SBTC/RBTC

Wages unskilled/skilled

Return on Capital/Wage Share

Income Distribution

...via (1) decrease in prices
...via (2) decrease in real wages
...via (3) increase in machineries
...via (4) increase in income
...via (5) new products

Compensation...

Technology, employment and income inequality
Technological progress and the income distribution

Personal income distribution: Division of income between employees

• Standard explanation: SBTC
  • Technology complements high-skilled, substitutes low-skilled
• More recently: RBTC
  • Technology substitutes for routine tasks -> “hollowing out of the middle class”

Functional income distribution: Division of income of between factors of production

• Technological progress increases capital intensity
• Rising capital share
• Capital income is more unequally distributed than labour income
Technological progress and capital income

• Growing importance of knowledge-based capital (KBC)
  • Intangible goods
    • Computerised information: software, database
    • Innovative property: R&D, patents, trademarks
    • Economic competencies: brand-building, market research
  • Non-rivalrous nature of knowledge
    • Increasing returns to scale
    • Reinforced by network and reputation externalities
    • “Winner-takes-all” dynamics with dominating global players

➢ Monopoly/oligopoly rents and high capital returns
### Relating technology and income inequality

<table>
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<tr>
<th>Hypothesis</th>
<th>Effects on income inequality</th>
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</table>
| **SBTC**   | New technologies tend to complement high-skilled workers and substitute for low-skilled workers | • High-skilled workers’ productivity and wages increase compared to low-skill workers  
• Affects income distribution between skill groups |
| **RBTC**   | Routine-tasks can be carried out by new technologies while non-routine tasks require personal interaction and/or cognitive skills that are more difficult to be automatized | • Polarisation of employment because routine tasks are often found in middle-skill jobs  
• Aggravates skewed income distribution  
• Has likely contributed to the overall decline of the wage share |
| **Market structure** | Growing importance of KBC is associated with an increase in market concentration (“winner-takes-all” dynamics) and rent-seeking | • Higher capital share, declining labour share  
• Growing inequalities between firms may contribute to growing individual inequalities (global leaders) |
Empirical evidence: is technology destroying our jobs?

<table>
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<tr>
<th>Study</th>
<th>Countries</th>
<th>Main Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falk, M. (2014). “Employment effects of technological and organizational innovations”</td>
<td>Austria</td>
<td>Product-innovators experienced higher employment growth than non-innovators (1.7%) in the two subsequent years. Positive employment effects in shrinking as well as in growing firms.</td>
</tr>
<tr>
<td>Frey/Osborne (2013). “The future of employment: How susceptible are jobs to computerisation”</td>
<td>USA</td>
<td>47% of current American jobs are at risk (probability of more than 70%) to be automated over the next 10-20 years. Calculations are based on views of experts on the automatability of occupations.</td>
</tr>
<tr>
<td>Arntz et al. (2016). “The risk of automation for jobs in OECD countries: A comparative analysis”</td>
<td>OECD countries</td>
<td>Percentage of jobs at high risk of automation between 2% (Russia) and 12% (Austria, Germany, Spain). Calculations are based on task-contents of jobs using PIACC-data. Low-income groups are more heavily affected.</td>
</tr>
<tr>
<td>IAB (2015). “Industrie 4.0 und die Folgen für Arbeitsmarkt und Wirtschaft”</td>
<td>Germany</td>
<td>Scenario analysis to model the transition of Germany to Industry 4.0. Small net employment effects (-60k jobs) but large job dynamics (420k jobs disappear, 320k jobs are created).</td>
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Empirical evidence: Does innovation increase income inequality?

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<tbody>
<tr>
<td>Goos et al. (2014). “Explaining job polarization: Routine-biased technological change”</td>
<td>16 Western European countries</td>
<td>RBTC-induced job polarisation has taken place within and between industries in the period 1993-2010</td>
</tr>
<tr>
<td>Aghion et al. (2015). “Innovation and top income inequality”</td>
<td>USA (states)</td>
<td>From 1975-2010 the share of top 1% is significantly and positively correlated with innovativeness (patents/capita). Social mobility is also higher in more innovative US-states.</td>
</tr>
<tr>
<td>Breau et al. (2014). “On the relationship between innovation and wage inequality: New evidence from Canadian Cities”</td>
<td>Canada (cities)</td>
<td>Innovative cities (measured as patents/head and employment share in KBI services) have a more unequal distribution in terms of the Gini-coefficient and Theil-index</td>
</tr>
<tr>
<td>Karabarbounis/Neiman (2014). “The global decline of the labour share”</td>
<td>59 countries</td>
<td>Decreasing relative price of investment goods (attributed to advancements in ICT) can explain half of the observed decline of the labour share.</td>
</tr>
</tbody>
</table>
Summary of current views on the effects of the 4th industrial revolution

**Optimists**
- Short-run disruptions, but long-run benefits.
  - Continuation of historical trends
- Theory of comparative advantage
- Society will not run out of technological problems that need to be solved.

**Pessimists**
- New technologies and robots will become able to substitute for increasingly highly skilled labour.
- The “Great Decoupling” of productivity growth and employment growth
- The productivity gains will not be able to compensate for the displacement and there will be high technological unemployment.
- “Who owns the robots rules the world?” (R. Freeman, 2015)

Common Concern: **Rising Inequalities** and the need for political action to accompany the transition!
Outlook

• Project: „Innovation und Ungleichheit – eine Analyse der österreichischen Entwicklung im internationalen Kontext“
  • Comparative analysis
  • Income and employment development on a sectoral level
  • Technology-driven sectors vs. less technology-driven sectors

• Main hypotheses
  ➢ Income is more unequally distributed in technology-intensive sectors than in less technology-driven sectors.
  ➢ Market concentration is higher in technology-intensive sectors.
Data and indicators

• Technology-intensity indicators
  • R & D-data
  • Information from the Community Innovation Survey

• Distribution indicators (focus on the middle of the distribution)
  • Mean/Median ratio
  • IQR/Median ratio

• Market concentration
  • Herfindahl-Hirschmann-Index
Summary

• Innovation and employment
  • Mixed evidence
  • Firm, industry, whole economy
  • Technological potential vs. realisation

• Innovation and income inequality
  • SBTC/RBTC
  • Knowledge-intensity and changing market structures
  • Declining labour share
  • Empirical evidence indicates that there is a positive relationship between innovation and inequality
Thank you for your attention!