The Economics of Robotics

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1. The impact of robots on society

The kitchen of the future (1950s)

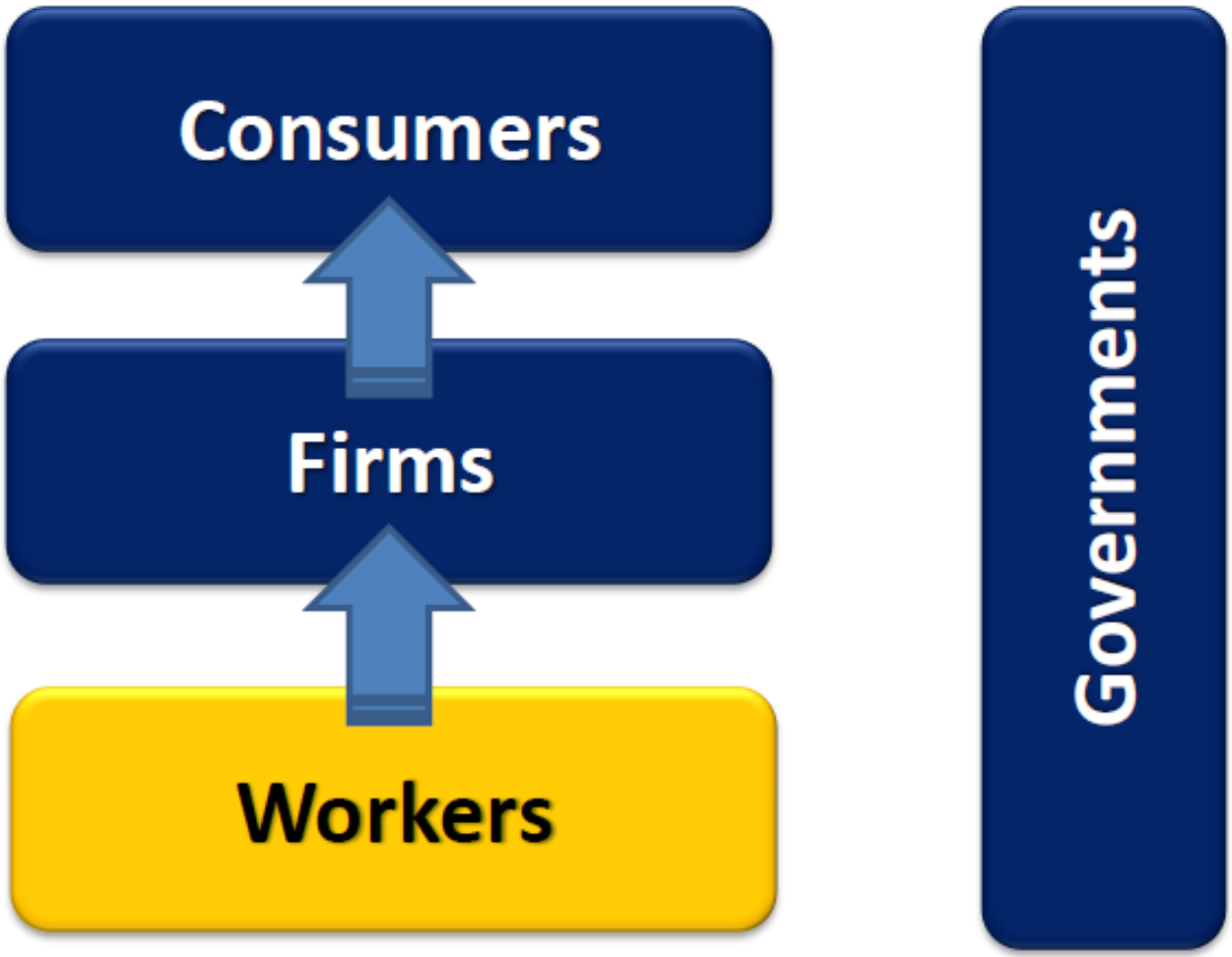
The kitchen of the future (1950s)

- This picture **illustrates innovation** in household kitchen appliances in the 1950s.
- Missing from the picture is the **societal impact of these innovations**.
- One of the "miracles" for economic growth in the 1960s: **women entering the labor market** en masse following the automation of household chores that freed up their time (together with an increase in the demand for their labor).

What is the impact of robots on society?

- Can we expect an equally large **impact on society from today's development in industrial and service robotics**?
- Economists answer this question by analyzing its impact on:
  - Workers
  - Firms
  - Consumers
  - Governments

The economic impact of robots



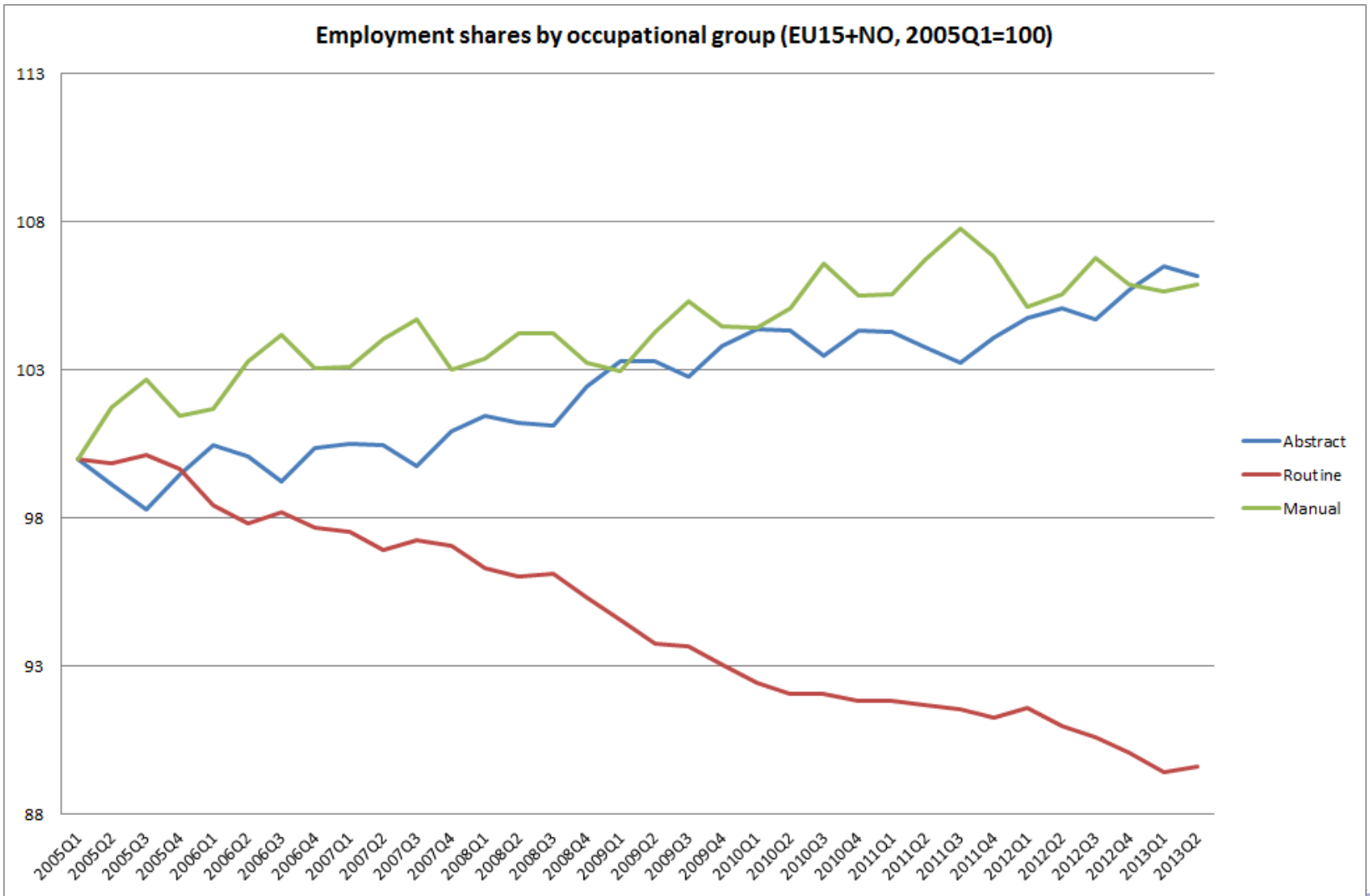
The impact of robots on workers

1. How many jobs can be automated by robots?
2. How are robots changing the quality of jobs?
3. What tasks can robots do?

How many jobs can be automated by robots?

- From 1811 to 1817, Luddites protested against newly developed labor-saving machinery (spinning frames, power looms in textiles). But in the long-run, employment and standards of living rose.
- A recent study conjectures that **47% of today's jobs will be done by robots** in 2035.
- Can we come up with **(beter) estimates** of how many jobs are susceptible to automation by robots and how many new jobs are created by robotics?

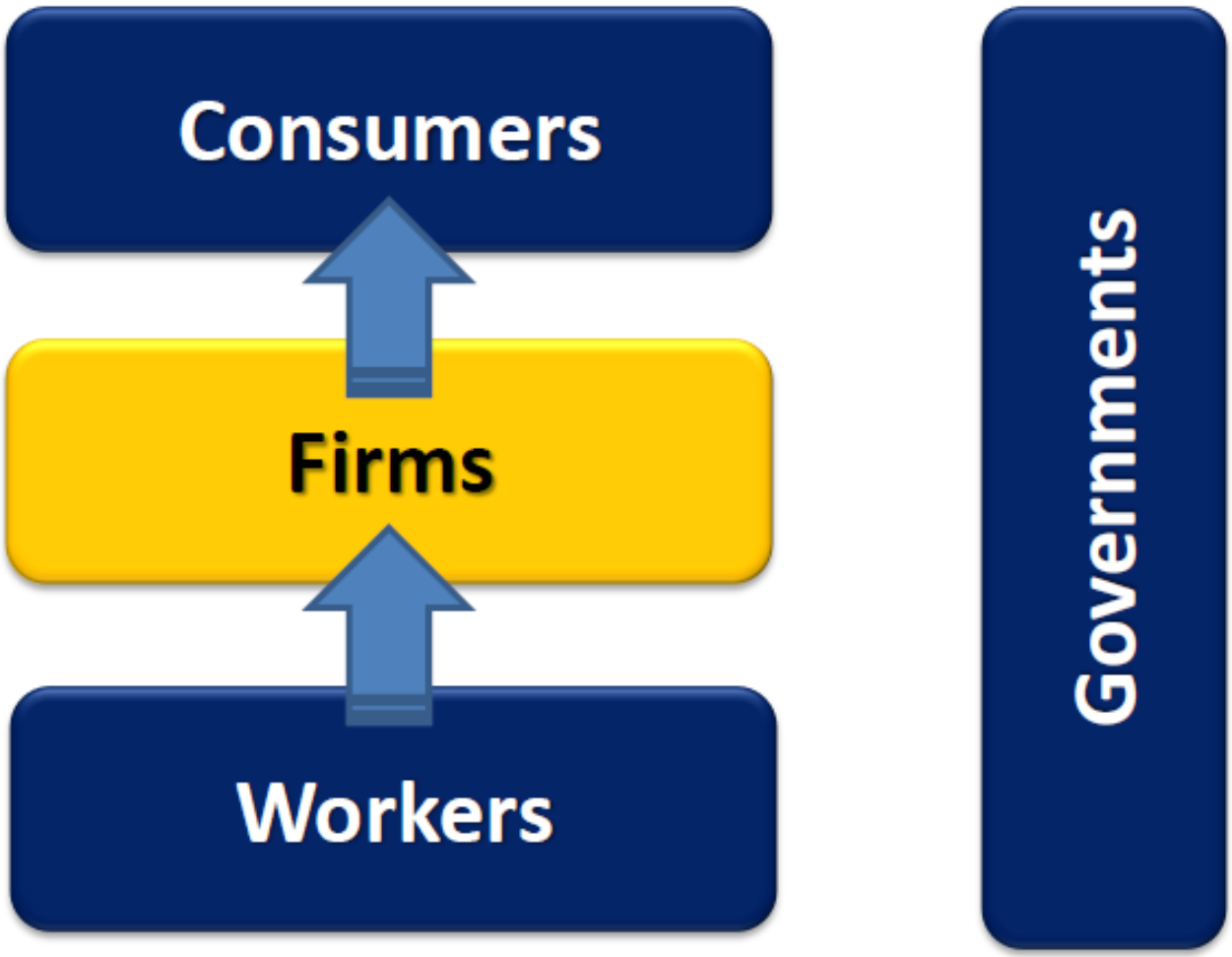
How are robots changing the quality of jobs?



What tasks can robots do?

- Economists have recently started modeling technology as **replacing or complementing workers in job tasks.**
- Robots can do **routine tasks** that are codifiable (e.g. industrial robots). But there are many **non-routine tasks** done by workers (e.g. managing a team, serving tables in a restaurant) that robots (as yet) cannot do.
- Can we better model and measure **what tasks robots can do,** what the **substitutability** is **with tasks done by workers** and how **robots and workers sort across tasks**?

The economic impact of robots



The impact of robots on firms

1. What is innovation in robots?
2. How do firms implement robots?
3. What is the impact of robots on sectors and regions?

What is innovation in robots?

- Investment in research and development of robots is through private, public or private-public networks.
- What is the process of **cooperation** and **knowledge accumulation** in these networks?
- How can **economic principles** be used to better **organize innovation in robotics**, e.g. in decentralized crowdsourcing environments with uncertainty about task difficulty.

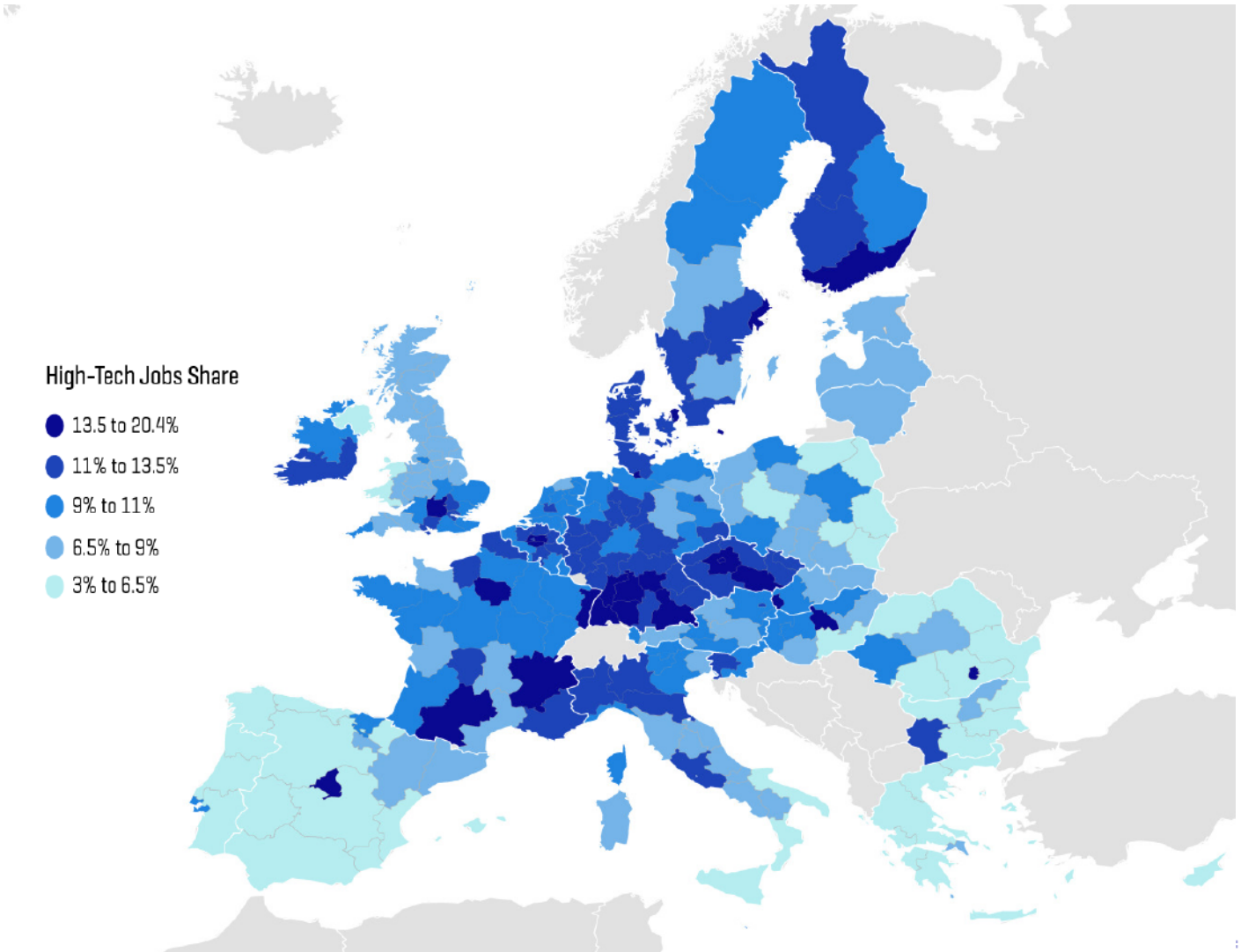
How do firms implement robots?

- The implementation of technology requires a **rethinking** of the firm's overall **organizational design** due to **system-wide complementarities**.
- For example, modern technology requires **high-performance work practices** (e.g. problem solving teams, job rotation, information sharing, incentive pay).
- What are the system-wide complementarities when introducing robots to the firm?

What is the impact of robots on sectors and regions?

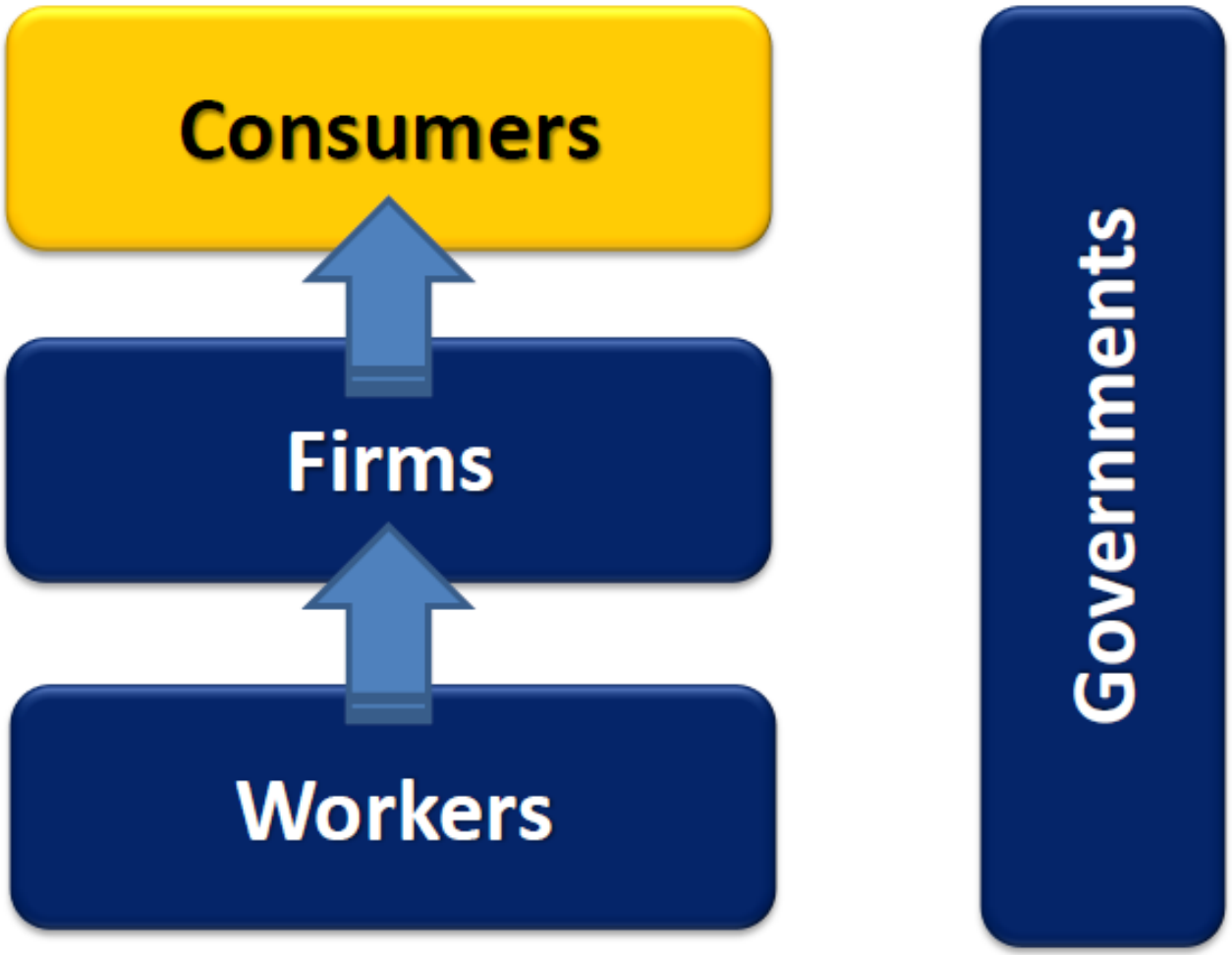
- Different **sectors** use robots to different degrees (e.g. education versus manufacturing).
- **Regions** in Europe differ in their high-tech intensity with traditional high-tech hubs.
- What is the impact of sectoral differences in innovation (e.g. do we see Baumol's cost disease?) and is there convergence in high-tech growth across regions in the EU (as we saw for manufacturing)?

High-tech employment in Europe



Source: Eurostat, EULFS; ONS, UKLFS; authors' calculations; data are for 2011

The impact of robots on consumers



The impact of robots on consumers

1. What explains consumer attitudes toward robots?
2. What is the impact of robots on consumer utility?
3. How do robots interact with consumers?

What explains consumer attitudes toward robots?

- What explains **consumer attitude toward robots** (Eurobarometer, "Public Attitudes Towards Robots")?
- Use regression techniques to **explain these attitudes** (e.g. no desire for robots in education because of misinformation or because of consumer discrimination).
- Knowing this matters for **effective policy responses** (e.g. provide information if there is misinformation or legislate if there is consumer discrimination).

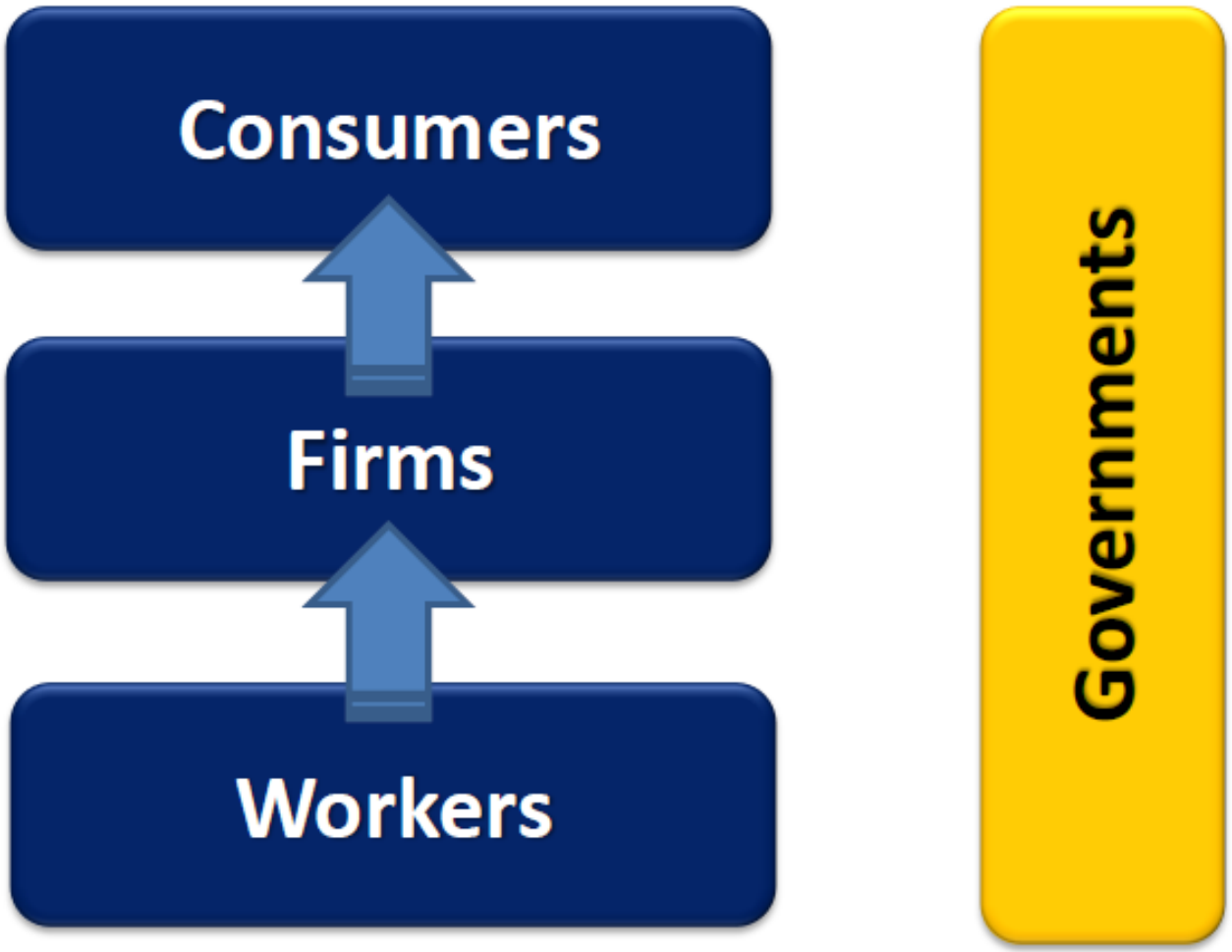
What is the impact of robots on consumer utility?

- Advancements in robotics affect **consumer utility** through **decreasing prices** and the introduction of **new products**.
- How do these changes **affect the spending patterns** of consumers? How substitutable are the different goods in the consumption basket and what are their income elasticities?
- What is the impact of robots on **consumer surplus** (a measure of an economy's overall gain from robots as a consumption good).

How do robots interact with consumers?

- Economists assume that consumer behavior and interaction is predictable because consumers behave according to the **axioms of rational choice**.
- **Consumers** increasingly **interact with robots** (e.g. as robotic applications in personal services and health care are developed).
- How can we program the **decision making by robots** to improve the interaction between robots and their consumers?

The impact of robots on governments



The impact of robots on governments

Governments are impacted by robots:

1. Indirectly, developing **adequate policy responses** to the effects of robots on workers, firms and consumers.

2. Directly, using the latest **technologies for policy interventions.**

The indirect impact of robots on governments

Government policy responses concern:

- Redistributive policy to target **equity** concerns:
  - Rising wage and income inequality changes due to technological progress.
  - Education policy to deliver worker skills required by a changing job structure and work organization.
- Policy to increase the **efficiency of market outcomes** by e.g. stimulating high-tech innovation, informing consumers or regulating the market for domestic robots.

The direct impact of robots on governments

Potential for governments to **use technological advances**:

- "**Big data policies**" e.g. to help students choose a field of study; better match jobseekers to vacancies; inform consumers of their options and rights.
- Technology used in the **provision of public goods** (e.g. public safety) and in **enforcement** (e.g. monitoring whether online job search conditions for unemployment benefit eligibility are being met).

Legal, privacy and ethical concerns likely to be important here, and influence public opinion on governments using robots.

A note on economic methodology

Economists aim to identify **causal relationships in the social world**: since experimentation is typically not an option, we rely on the following methology:

- Formalizing agents' behavior in **theoretical models**, making explicit behavioral assumptions.
- **Estimating structural or reduced form equations** derived from such theoretical models, as well as applying **econometric techniques** to exploit exogenous variation in the data.

Summary

- Economists joint with robotics experts can better **map the societal impacts** of robotics and help **inform policy makers** and **public opinion.**

- Robotics experts can help economists to **open the black-box way economists have modeled technologies**: e.g. by providing valuable input on technological capabilities today and in the future; and assessing the validity of related assumptions made in economic models.

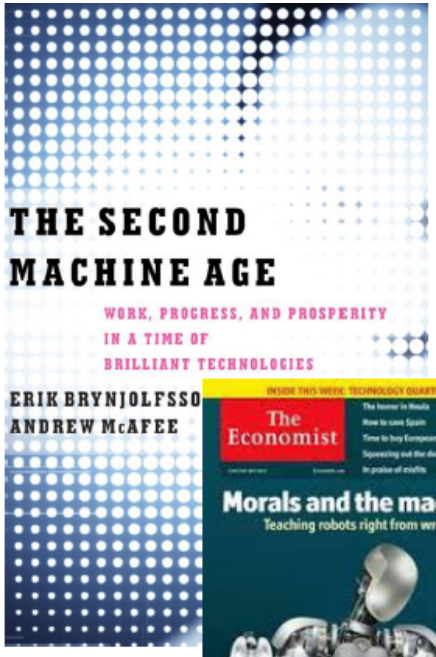
- Economists can help robotics experts to **better understand the effects of robots on workers, firms, consumers and policies** and can bring economic principles to robotics.

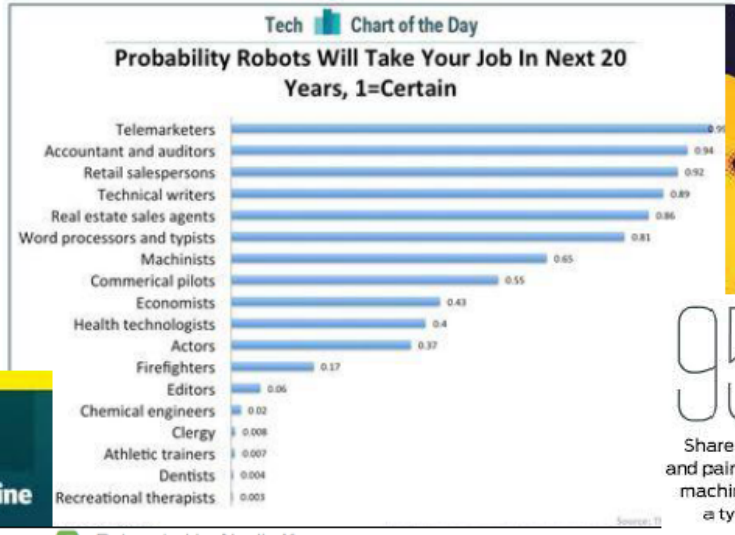
2. Network

Sample of scientific network

- David Autor, MIT (workers, consumers, government)
- David Dorn, CEMFI (workers, consumers, government)
- Matias Cortes, University of Manchester (workers)
- Nir Jaimovich, Duke University (workers)
- Brian Kovak, Carnegie Mellon University (workers)
- Alan Manning, LSE (workers, consumers, government)
- Stephen Redding, Princeton (workers, consumers)
- Anna Salomons, Utrecht University (workers, consumers, government)
- Alexandra Spitz-Oener, Humboldt University (workers)
- Kathryn Shaw, Stanford (firms)
- John Van Reenen, LSE (workers, firms)

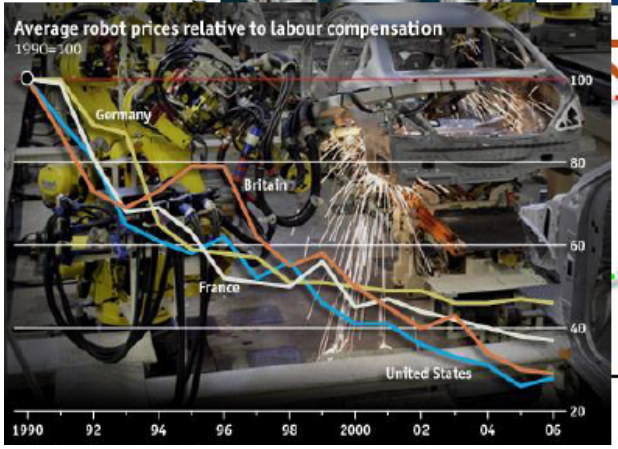
Large public interest in the societal impact of robotics

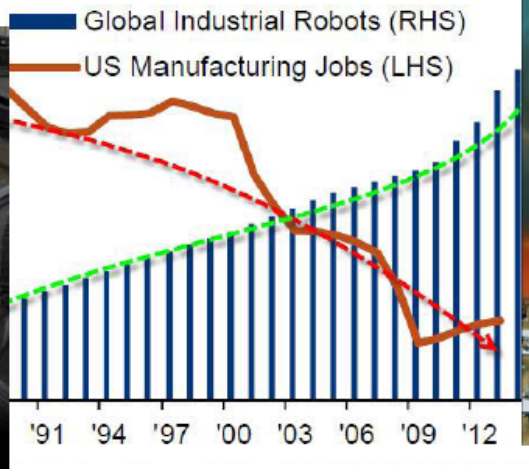




95%
Share of welding and painting done by machines to build a typical car

1,091
Number of robots for every 10,000 humans employed in the U.S. automotive industry





Popular media network

Contributed to items for:

- Associated Press
- The Economist
- The Financial Times
- The Huffington Post
- Belgian press (De Financieel Economische Tijd, De Standaard, Het Laatste Nieuws, Dag Allemaal, Radio 1)
- Dutch press (Het Financieele Dagblad, De Volkskrant, NRC Handelsblad, De Telegraaf, Radio 1, BNR News Radio)

3. Conferences and journals

Conferences and journals

- Large **general interest economics conferences** in the US (American Economic Association) and Europe (European Economic Association) have had sessions dedicated to the economic impacts of technological progress: for the former, these sessions can be proposed by a group of authors.
- Research on the economic impacts of technology has been published in **top economics journals** such as *the American Economic Review*, *the Review of Economics and Statistics*, *the Quarterly Journal of Economics*, and *the Journal of Labor Economics*, among others.