Robots and the origin of their labour-saving impact

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Outline

1 Context and motivation

2 Data and analysis

3 Results

4 Topic modelling and technological taxonomy

5 Discussion
Motivation

- The impact of automation upon employment has become a major topic of discussion both in policy and academic debate.

**Brynjolfsson and McAfee (2011, 2014)** The root of current unemployment is not the Great Recession, but rather a ‘Great Restructuring’ characterised by an exponential growth in computers’ processing power having an ever-bigger impact on jobs, skills, and the whole economy (“This time is different”)

**Frey and Osborne (2017)** 47% of the occupational categories are at high risk of being automated, including services and highly cognitive jobs.
“Automated systems, such as robotic systems, are used in a variety of industries to reduce labor costs and/or increase productivity. Additionally, the use of human operators can involve increased cost relative to automated systems.” [US20170178485A1]

“The use of [robotic] technology results in improved management of information, services, and data, increased efficiency, significant reduction of time, decreased manpower requirements, and substantial cost savings.” [US20100223134A1]
Our contribution

- we use natural language processing and probabilistic topic modelling techniques on the universe of 2009–2018 patent applications at USPTO, matched with ORBIS (BvD)
- we investigate the presence of explicit labour-saving heuristics among robotic patents
- we include not only patents entailing robotic artefacts as a *product* but also as *process* and complementary technology
- we analyse innovative actors engaged in robotic technology and their economic environment (identity, location, industry)
- we identify the technological fields that are particularly exposed to labour-saving innovations
- we pinpoint the technological bottlenecks underlying the search efforts inspiring robotics inventors
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Original data

- **universe** of USPTO patent applications from 1st January 2009 to 31st December 2018
- 3,557,435 full-text applications (hereafter, patents)

![Bar chart showing the number of patents by year from 2009 to 2018]

**Figure:** # of patents by year
Robotic patents

- Identification of robotics-[related] patents
  1. via CPC codes
     - USPTO concordance table with USPC class 901
     - purely robotic technology
     - 10,929 ‘CPC’ patents
  2. via keyword search
     - multiple occurrence (×10) of morphological root ‘robot’
     - process implementation and complementary technology
     - 18,860 ‘K10’ patents (once those already in 1 have been discarded)

- 29,789 total robotic patents
Robotic patents (cont’d)

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Text preprocessing

**tokenisation**
- each patent textual body is divided into *sentences* by means of a punctuation regexp
- patent text $\rightarrow$ list of sentences
- sentence $\rightarrow$ list of words

**stemming**
- each word in each sentence is reduced to its morphological root with the Porter2 stemming algorithm (an improved version of the original Porter (1980) algorithm)
- patent text $\rightarrow$ list of lists of stemmed words

- identification of labour-saving (LS) patents by means of a *word*-level text query per sentence
Labour-saving patents

- 336 combinations of triplets (not trigrams, as we do not require adjacency)
- a patent is flagged as potentially LS if contains at least one triplet within a sentence
- 1,666 potentially LS patents
all matched sentences are manually examined and flagged as explicitly LS if appropriate
1,276 explicitly LS patents (≈ 77% of potentially LS; ≈ 4.3% of robotic patents)
of which 461 (≈ 36.1%) are CPC and 815 (≈ 63.9%) are K10

Figure: Fraction of explicitly LS patents over robotic patents by year
Firm level match

- LS patents are matched to their assignee via ORBIS (BvD)
- number reduces to 1,136 (≈ 89%) due to truncation on 31st July 2018 (140 discarded)
- of these, 903 (≈ 79%) are matched to at least one firm (233 find no match)
- there are 408 LS firms in total
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LS patents by country – absolute value

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LS patents by country – as % of robotic patents

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LS patents by industry

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Probabilistic topic model

1. we estimate a topic model with $K = 20$ topics on the whole collection of robotic patents $D$
   - each topic $k \in K$ is identified as a list of keywords ranked by frequency
   - each patent $d \in D$ is assigned a distribution $\theta_{d,k}$ over the $K$ topics

2. we assign a significance measure of CPC codes ($c \in C$) originally attributed to patents to each topic $k$ by leveraging on the \textit{latent semantic structure} of the whole collection of patents, through relevance distributions $\theta_{d,k}$ obtained in 1
   \[
   \phi_{c,k} = \sum_{d \in D} 1\{c \in d\} \cdot \theta_{d,k} \quad \forall k = 1, \ldots, K; \quad \forall c \in C
   \]
   - this brings useful information for labelling the topics

3. we compare the relevance of the $K$ topics for robotic patents and the subset of LS patents

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Topic relevance for robotic and LS patents

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<table>
<thead>
<tr>
<th>Topic #</th>
<th>LS relev.</th>
<th>Words</th>
<th>CPC</th>
<th>Weight</th>
<th>Description</th>
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<tbody>
<tr>
<td>6</td>
<td>+132.2%</td>
<td>carrier, conveyor</td>
<td>B65</td>
<td>24.4%</td>
<td>Conveying; packing; storing; handling thin or filamentary material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>item, gripper,</td>
<td>H01</td>
<td>6.8%</td>
<td>Basic electric elements</td>
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<td></td>
<td></td>
<td>tape</td>
<td>G11</td>
<td>6.0%</td>
<td>Information storage</td>
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<td></td>
<td></td>
<td></td>
<td>Y02</td>
<td>4.6%</td>
<td>Technologies or applications for mitigation or adaptation against climate change</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>B23</td>
<td>4.3%</td>
<td>Machine tools; metal-working not otherwise provided for</td>
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</tr>
<tr>
<td>9</td>
<td>−75.2%</td>
<td>heater, hydrocarbon, pipe, drill, gas</td>
<td>H01</td>
<td>8.6%</td>
<td>Basic electric elements</td>
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<td>Y10T29</td>
<td>4.4%</td>
<td>Metal working</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Y02</td>
<td>4.4%</td>
<td>Technologies or applications for mitigation or adaptation against climate change</td>
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</tbody>
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Main findings

- LS firms are not only robots producers, but mainly adopters (archetypical cases are Boeing, Amazon, and UPS)
- The overall number of robotic patents is rapidly expanding (3-fold increase in a decade)
- Conversely, LS patents do not exhibit a clear trend, supporting the idea that labour-saving is a rather established heuristic
- LS robotic patents emerge along the entire supply chain, signalling pervasiveness
- LS patents are concentrated in labour intensive industries (e.g. logistics, healthcare)
- Technological bottlenecks identified by Frey and Osborne (2017) (occupations requiring social and cognitive intelligence, finger dexterity and manipulation) are under active research efforts by innovative firms
Thank you very much!

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this presentation available at www.staccioli.org/research