Effects of automation on public finances: Does automation erode governments' tax basis?

An empirical assessment of tax revenues in Europe

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Background

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Really?

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Today: Technology has changed

Many of the tasks executed by humans at work can now be done by machines.

In this paper, we ask:

What happens to taxes when automation technologies diffuse?

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Opinions of others

Robots replace jobs and undermine the tax basis

Should mass workplaces for humans disappear in the future, from a tax perspective a double negative effect could occur. On the one hand, significant tax and social security revenues would be lost, while on the other hand, the need would increase for additional state revenue to support the growing number of unemployed human workers.

Xavier Oberson 2017: "How Taxing Robots Could Help Bridge Future Revenue Gaps"

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> *"Help!" they cry, "Robots are coming for our jobs!" [...] The biggest mistake "robophobes" make when they predict higher unemployment is to omit second-order effects*

Robert Atkinson 2019: **"The Case Against Taxing Robots"**

They claim: Concerns about undermined tax basis for no reason.

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Our research aim

Check the empirical validity of these claims!

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What happens to the economy when automation diffuses?

Replacement

- Replacement of human labor by machines:
  - Negative effect on labor demand in industries where AT diffuses.
  - Ambiguous effect on wages: Negative if substituting, positive if complementing.

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- Creation of new tasks/ occupations in (1) AT-adopting and (2) other industries triggered by efficiency gains :
  - Reallocation of labor within and across industries.
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Real-income

- Composite effect arising from changing price levels and factor incomes:
  - Productivity $\uparrow \quad \rightarrow$ prices for final goods $\downarrow$ s.t. market competition.
  - Aggregate factor revenues from capital and labor change.
  - Aggregate demand increases if positive real-income effect.

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3 research questions:

1. *What is the effect of AT diffusion on aggregate tax revenues at the country level in absolute terms and in relation to GDP?*
2. *What is the effect of AT diffusion on the composition of taxes by source distinguishing between taxes on labor, capital and goods?*
3. *How can these effects be traced back to the three effects through which AT impacts the structure and level of production?*

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The empirical reality of taxation

Composition of taxation in Europe in 2016

- Taxes raised from different sources:
  - Labor (31.6%),
  - capital (35.1%),
  - sales (32.5%).[1]
- Total tax revenue := 37.3% of GDP.

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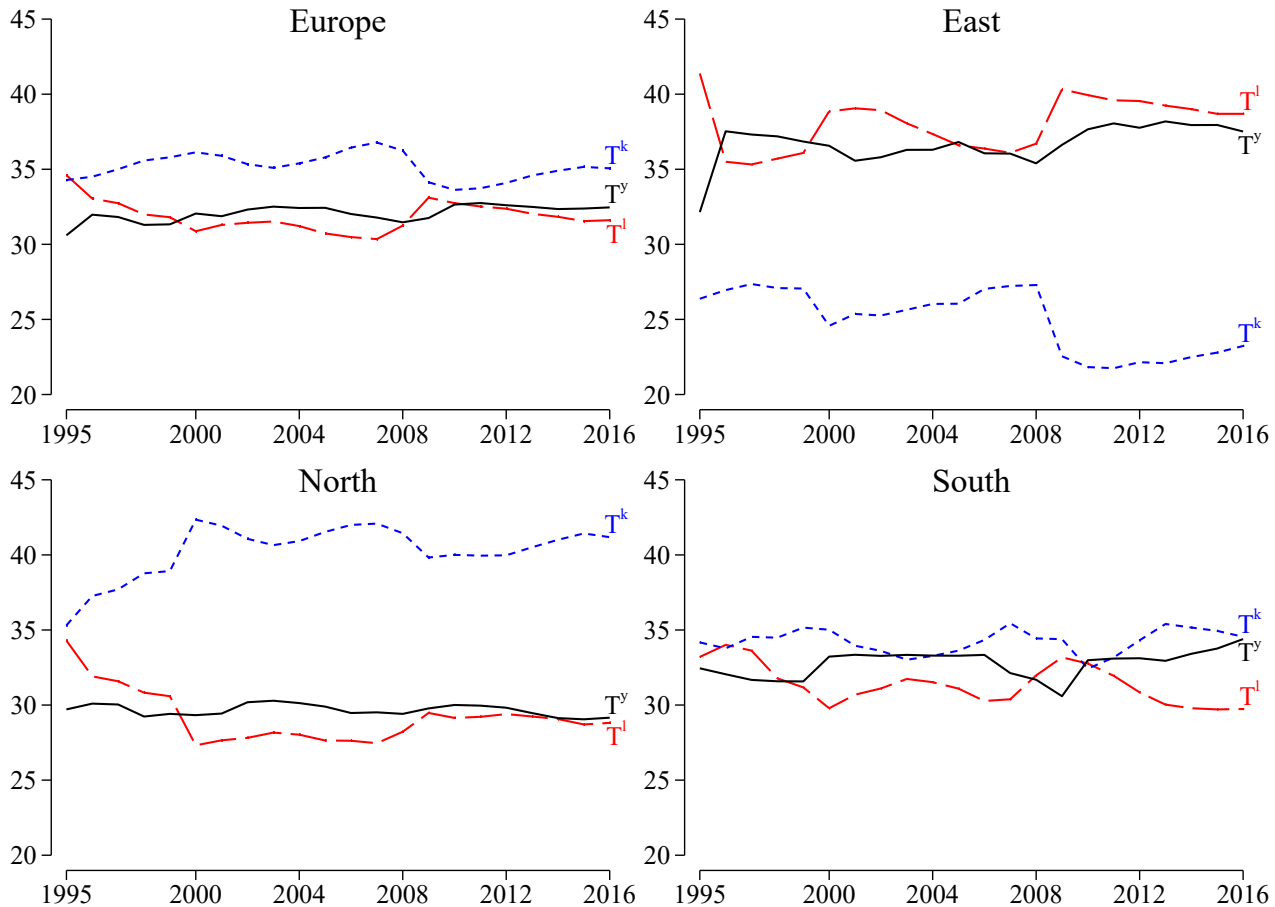
[1] Numbers indicate share in total taxation. Data for 19 EU countries in 2016.

Structure of taxation in different EU countries



The structure of taxation is measured as taxes on different sources (labor T^l, capital T^k, goods T^y) as percentage share in total taxation. The subsets of Eastern, Northern and Southern European countries are defined as follows: East: CZ; LT; LV; SI; and SK. North: AT; BE; DE; DK; FI; FR; IE; NL; SE; and UK. South: ES; GR; IT; and PT.

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A stylized model of taxation

Total tax revenue in country c:

$$T_c = \underbrace{t_c^l \cdot w_c L_c}_{\substack{\text{Taxes on labor} \\ T_c^l}} + \underbrace{t_c^k \cdot r_c K_c}_{\substack{\text{Taxes on capital} \\ T_c^k}} + \underbrace{t_c^y \cdot p_c Q_c}_{\substack{\text{Taxes on goods} \\ T_c^y}} \tag{1}$$

with:

- $L_c = \sum_{i \in I_c} L_i$: aggr. labor as sum of labor in industries $i \in I_c$ in c,
- $K_c = \sum_{i \in I_c} K_i$: aggr. capital stock incl. AT tech (i.e. robots & ICT),
- $p_c Q_c = \sum_{i \in I_c} p_i Q_i$: aggr. demand,
- w_c, r_c and p_c: Wages, prices for capital and goods.

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Empirical strategy

Major challenge

- Complexity of taxation: Macro-level tax rates t^l, t^k, t^y do not exist.
- Non-linearities from thresholds and exemptions & heterogeneity of countries.

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Empirical strategy

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Solution

Step-wise procedure:

1. Establish link between aggregate tax data and production.
2. Test for the 3 effects of AT diffusion.
3. Explain aggregate observations wrt taxation along the 3 effects.

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Data & methods

We combine data from different sources:

- Tax data for labor, capital, and consumption (OECD).
- Economic data on employment, capital use, and output (EUKLEMS).
- 2 measures of automation:
  - Industrial robots.
  - ICT.

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Methods

- Regressions for the 3 effects + link between production & taxes.
- Industry- and country-level.
- 2 sub-periods (95-07 & 08-16); 4 Eur. regions.

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Key observations:

Replacement (industry level)

- Robots & depth of adoption: Labor $\downarrow$, wages $\uparrow$.
- ICT: No effect on wages or Labor.

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Reinstatement (country level)

- Robots: Wages ↓
- ICT & depth of automation: Wages ↑, Labor ↓

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Key observations:

Replacement (industry level)

- Robots & depth of adoption: Labor ↓, wages ↑.
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Reinstatement (country level)

- Robots: Wages ↓
- ICT & depth of automation: Wages ↑, Labor ↓

Real-income (country level)

- Robots: factor income (K,L,Q) & Prices ↓
- ICT: factor income (K,L,Q) no effect. Labor productivity ↑
- In total:
  - Labor replacing tech without efficiency gains: taxes & income ↓
  - Labor augmenting tech with efficiency gains: taxes ↓ but productivity↑

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3 questions - 3 answers

1. *What is the effect of AT diffusion on aggregate tax revenues at the country level in levels and in relation to GDP?*

- Dependent on income effects of AT: If negative $\rightarrow$ taxes $\downarrow$
- We observed: Negative impact of robots (esp. $\leq$ 2007), but not for ICT.
- Taxes in $\%GDP$ more stable, but negatively dep. on factor income share, i.e. $\downarrow$ for ICT.

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3 questions - 3 answers

2. *What is the effect of AT diffusion on the composition of tax revenues by source distinguishing between taxes on labor, capital and goods?*

- We observed:
  - Robots: Shift from taxes on capital to taxes on goods ($\leq$ 2007).
  - ICT: Before 2007: Shift from taxes on capital to taxes on labor & after 2008: Shift from goods to capital.
- When labor & capital income $\uparrow$, taxes on labor & capital tend to $\uparrow$ & taxes on goods $\downarrow$.

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3 questions - 3 answers

3. *How can these effects be traced back to the three effects through which AT affects the structure and level of production?*

- If replacement (at macro-level) dominates and/or wages $\downarrow$ sufficiently: Negative impact on taxes.
- We observed: Structure of taxation evolves proportionally to distribution of income across factors.
- Taxes on goods $\downarrow$ if factor shares are higher.

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Limitations and open issues

Limitations & (potential) ways forward:

- Tax burdens unequally distributed:
  - Poor households pay less taxes on labor and more on goods.
  - Heterogeneity among firms and profit shifting.

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Limitations and open issues

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- Tax burdens unequally distributed:
  - Poor households pay less taxes on labor and more on goods.
  - Heterogeneity among firms and profit shifting.
- A grain of salt: We observed extreme heterogeneity across countries and time periods.

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Conclusion

Thank you for attending.

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