The impact of industrial robots on EU employment and wages: A local market approach

14th joint ECB/CEPR Labour Market Workshop
LABOUR MARKETS IN THE DIGITAL ERA

Georgios Petropoulos (Bruegel)

Joint work with Francesco Chiacchio (ECB) and David Pichler (Bruegel)
Research support by Enrico Bergamini is gratefully acknowledged.

The threat of technological unemployment

- Production processes have become increasingly automated.
- Workers can be replaced by more machines (displacement effect).
- How can we estimate the impact of automation?
- First branch of empirical studies: how feasible it is to automate existing jobs given current and presumed technological advances?
  - Frey and Osborne (2013, 2017): 47 percent of US workers are at risk of automation.
  - Bowles (2014): 54 percent of European jobs are at risk.
  - Chui, Manyika and Miremadi (2015): 45% of work activities at risk.
  - Arntz, Gregory, and Zierahn (2016, 2017): Within an occupation, many workers specialize in tasks that cannot be automated easily (Brynjolffson, Mitchell and Rock, 2018), and that once this is taken into account, only about 9% of jobs in the OECD are at risk.

What about the productivity gains?

- Acemoglu and Restrepo (2018): technological innovations can affect employment in two main ways.
  - Displacement effect.
  - Productivity effect:
    - increase in the demand for labour in non automated tasks
    - new jobs that arise as a result of technological progress

National Geographic: Horses vs. Horsepower

The impact of industrial robots on employment

- Graetz and Michaels (2018): Using a sample of 17 countries from 1993-2007 and a panel data model on robot adoption (at the industry-country level) they find that
  - Increased labor productivity by 0.36 p.p.
  - No significant impact on total employment.
  - But, reduction in the employment of low skilled workers
- Accemoglu and Restrepo (AR, 2018): Different empirical strategy and focus on US
  - Equilibrium impact of robots on local labor markets (micro data with controls such as demographics and compositional variables)
  - Older estimate: Reduction of employment rate between 1993 and 2007 by 0.38 p.p.: One additional robot replaces 6.2 workers
  - New estimate: Reduction by approximately 0.2 p.p. in the employment rate
- Dauth et al. (2018): Focusing on local labor markets in Germany between 1994 and 2014
  - No significant impact on employment (industry shift away manufacturing)

What we do

- Study how the change in employment rate and real wages between 1995-2007 (also 1995-2015) are impacted by the introduction of industrial robots in EU industries.
- 6 EU countries: Finland, France, Germany, Italy, Spain and Sweden (more than 85.5% of the Europe's robots market) between 1995 and 2007 (+ Denmark, Ireland, United Kingdom).
- Local markets approach:
  - 116 NUTS2 regions (140 NUTS2 regions)
  - exploit the heterogeneity in both local labour distributions across industries and countries' change in the use of robots.
  - better control for demographic and compositional effects.
- Displacement or productivity effect dominates?

What we find

- 1995-2007:
  - Displacement effect dominates, one additional robot per thousand workers reduces the employment rate by 0.16-0.20 percentage points.
  - Impact less severe from the one found by AR for US labour markets (almost the half in magnitude)
  - Young and middle-educated people mostly affected.
- 1995-2015 The two effects cancel out.
  - But, negative impact of robots on the employment rate in manufacturing, mining and utilities.
- No robust significant impact of robots on wages.

Industrial robots: One automated technology

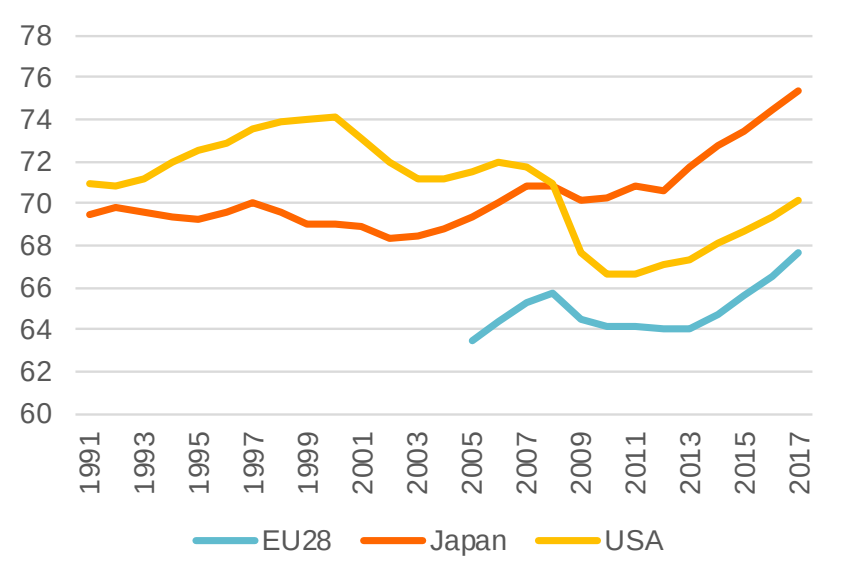
- IFR (2016):

  "an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications".

- This definition excludes other types of capital that may also replace labor such as ICT and other machines.
- But, it enables an internationally and temporally comparable measurement of a class of technologies that are capable of replacing human labor in a range of tasks.

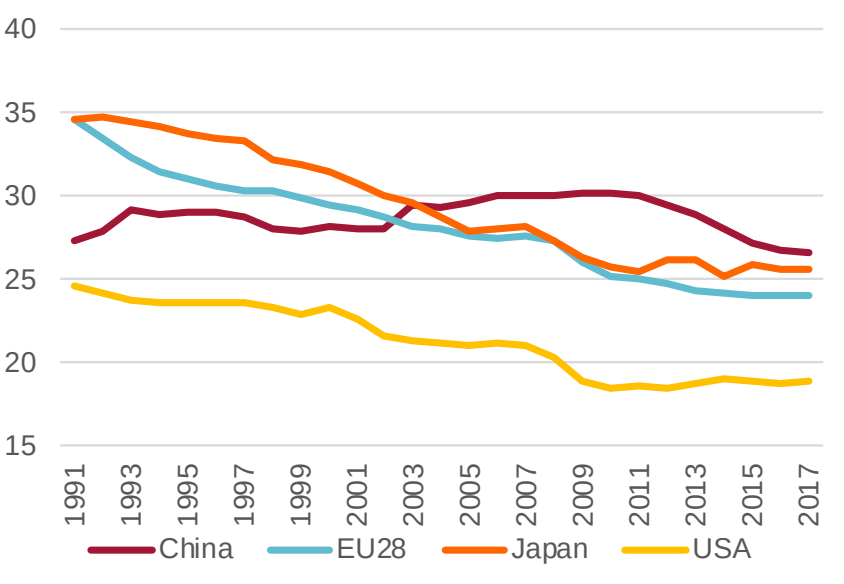
Trends in employment

Employment rate, % of working population



Source: OECD

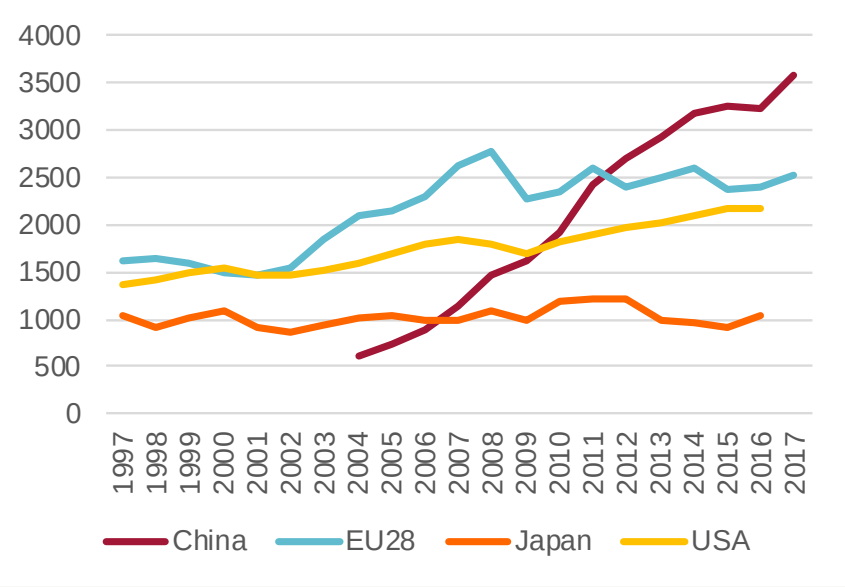
Employment in industry, % of total employment



Source: World Bank

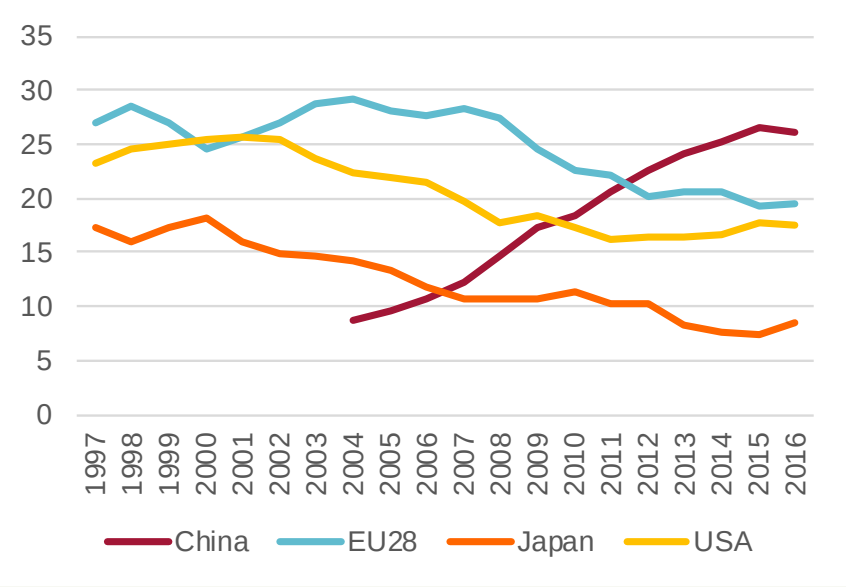
Trends in global manufacturing

Gross value added manufacturing (billion USD)



Source: OECD

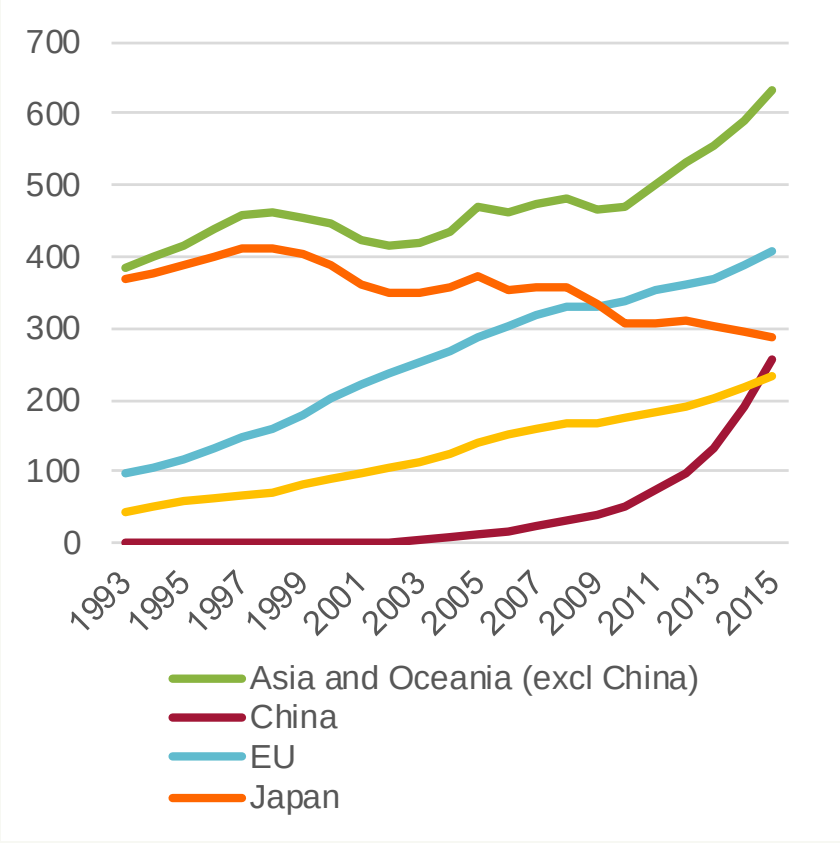
Gross value added manufacturing (% of global)



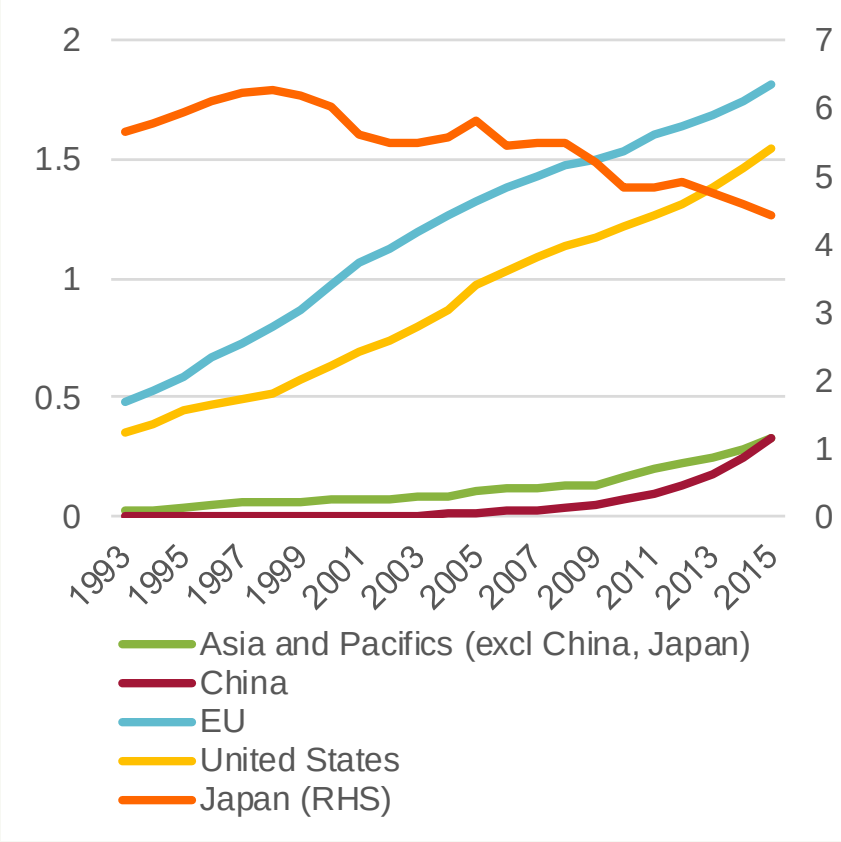
Source: World Bank

Technology trends: robots' penetration

Industrial robots by region (in thousands)



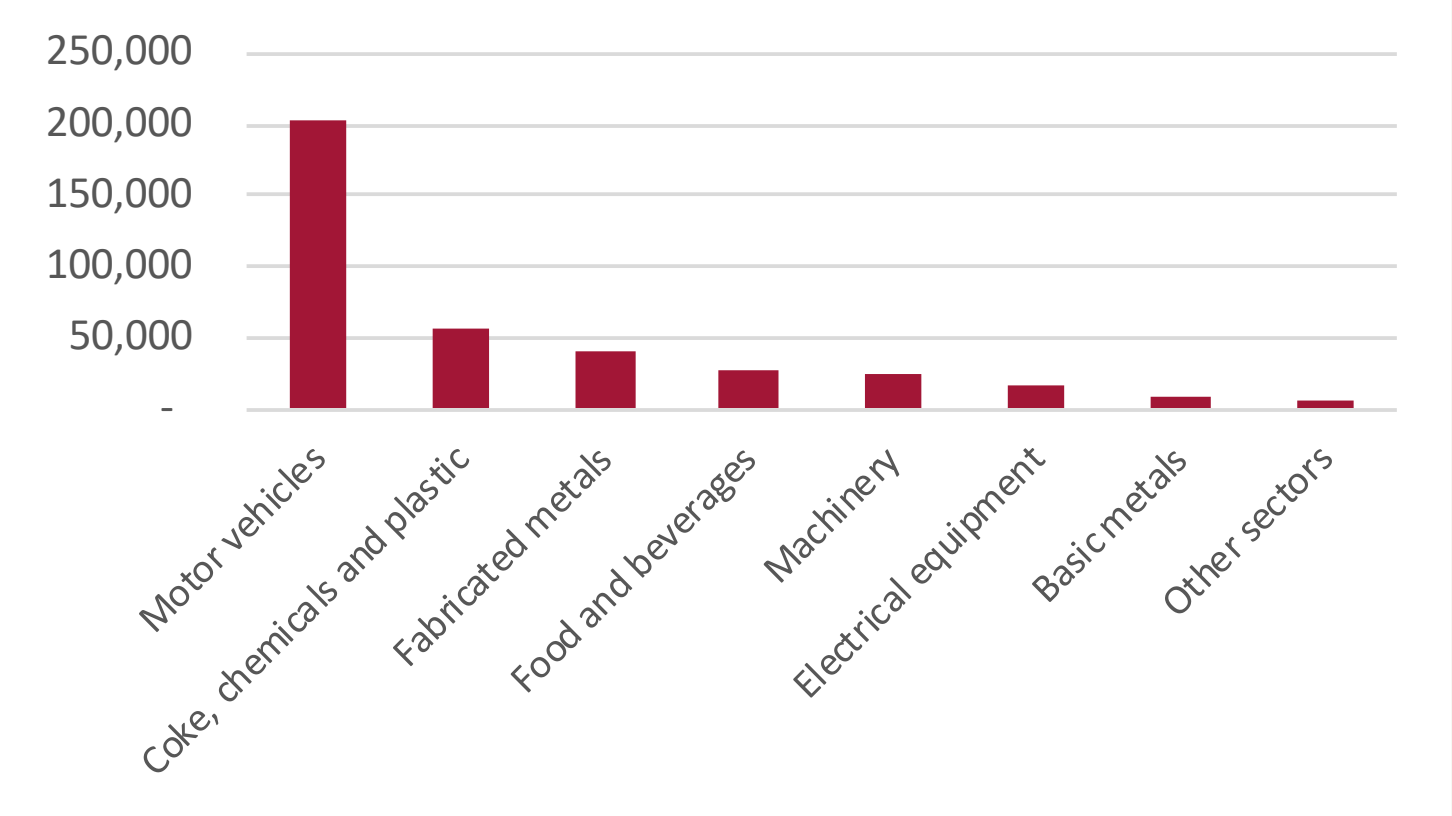
Industrial robots by region (per thousand workers)



Source: IFR, ILO

Technology trends: robots' distribution

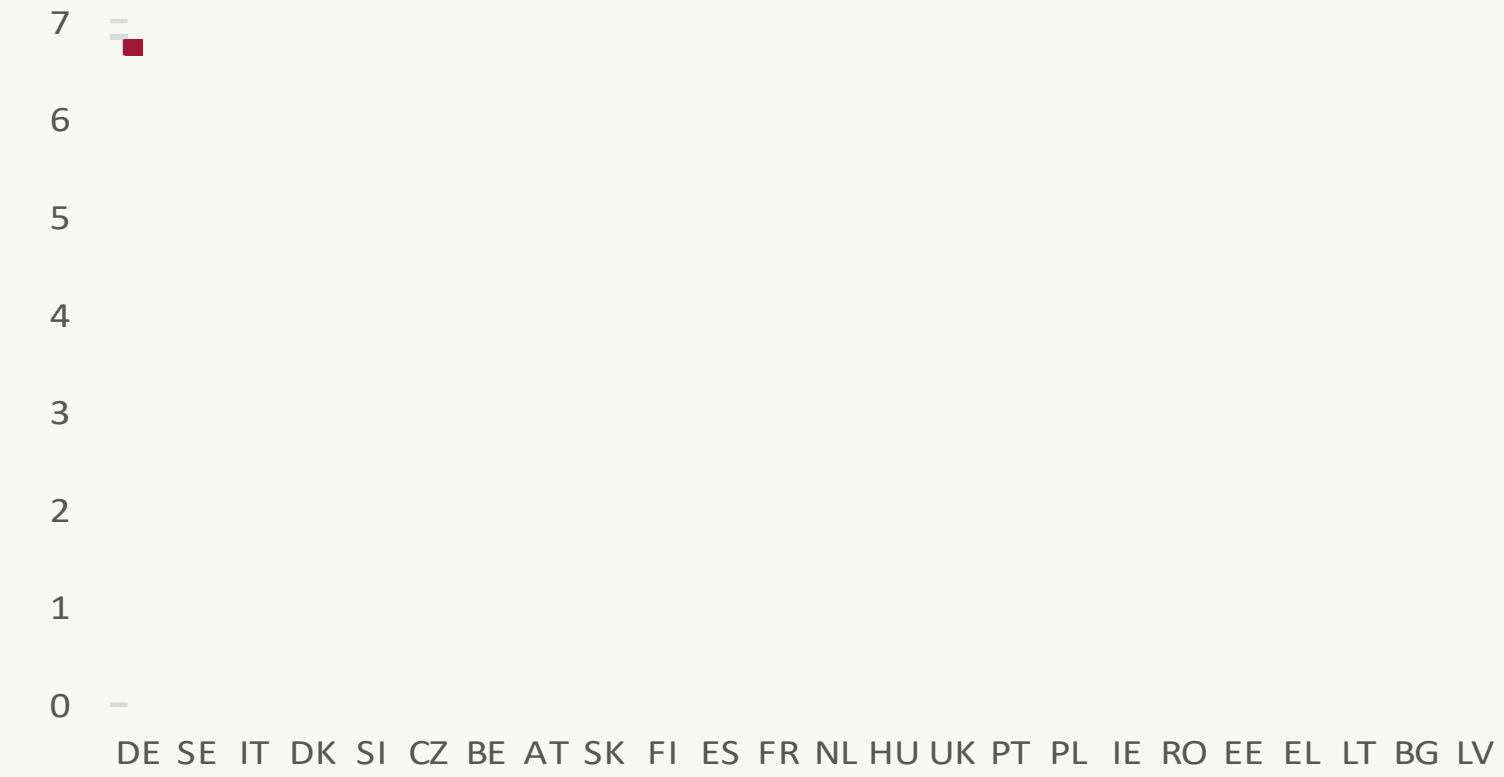
Number of industrial robots in EU, by sector



Source: IFR (2017)

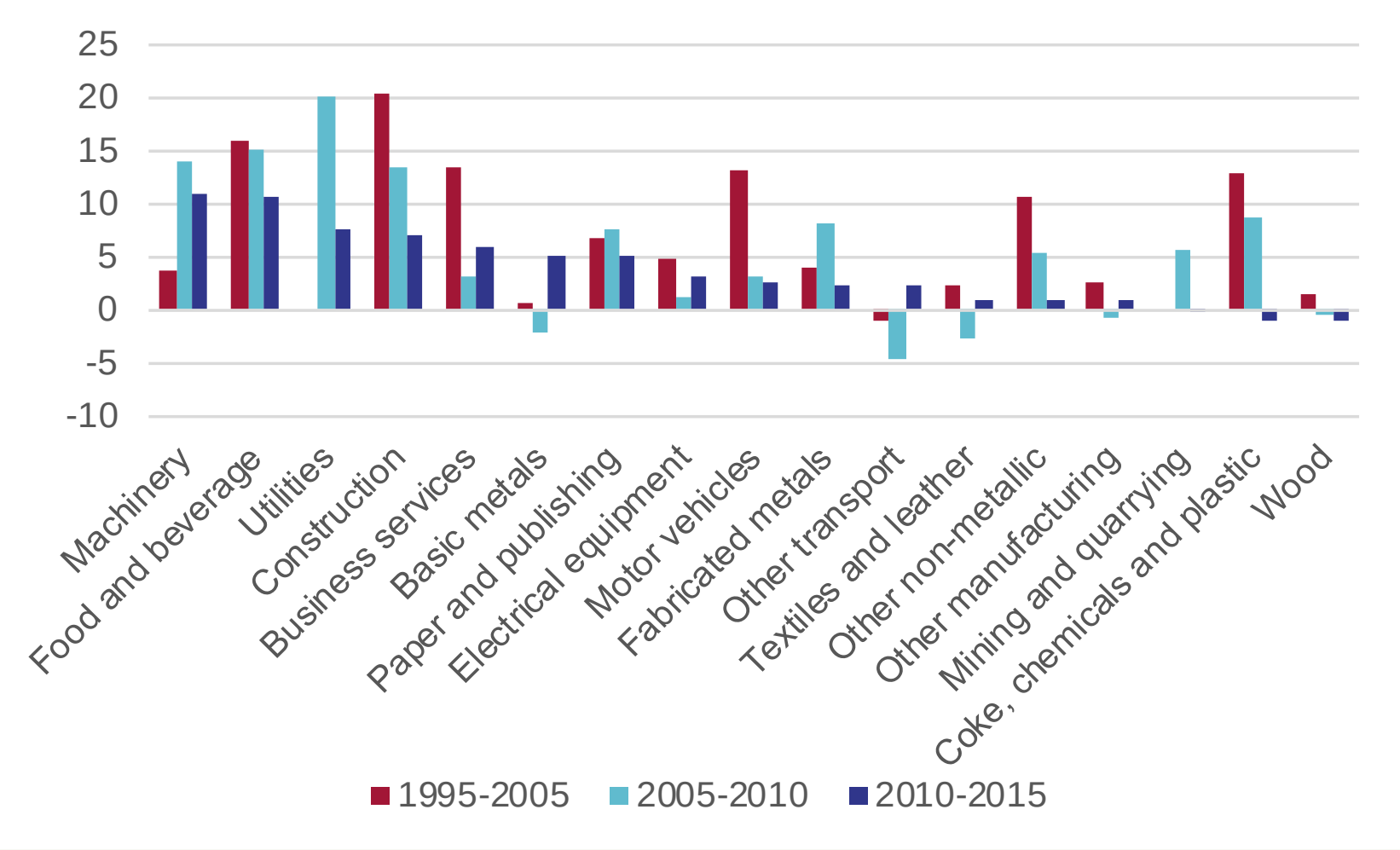
Technology trends: robots' distribution

Density of industrial robots in EU, by country



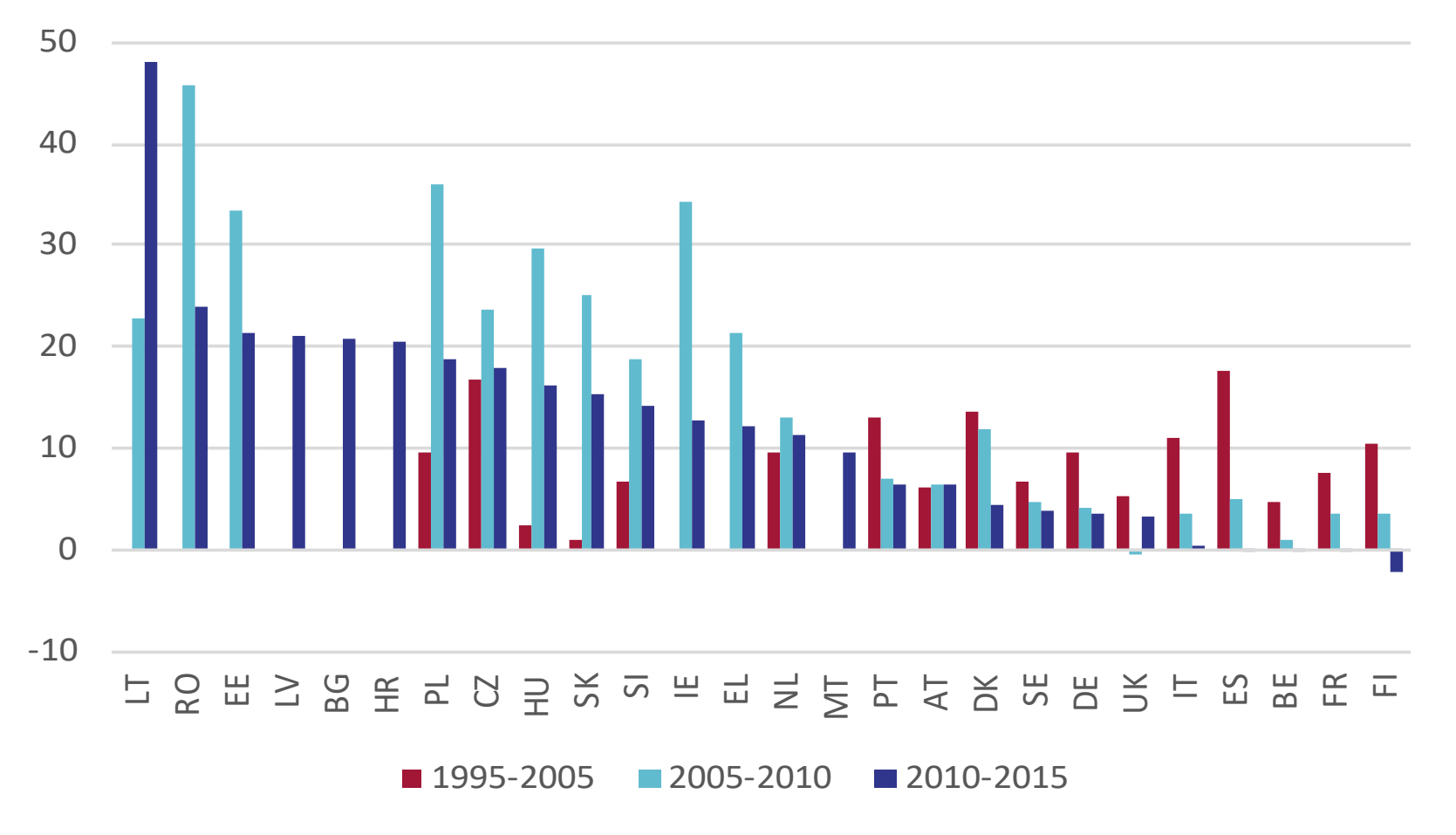
Source: IFR (2017)

Median growth rates in operational industrial robots by sector



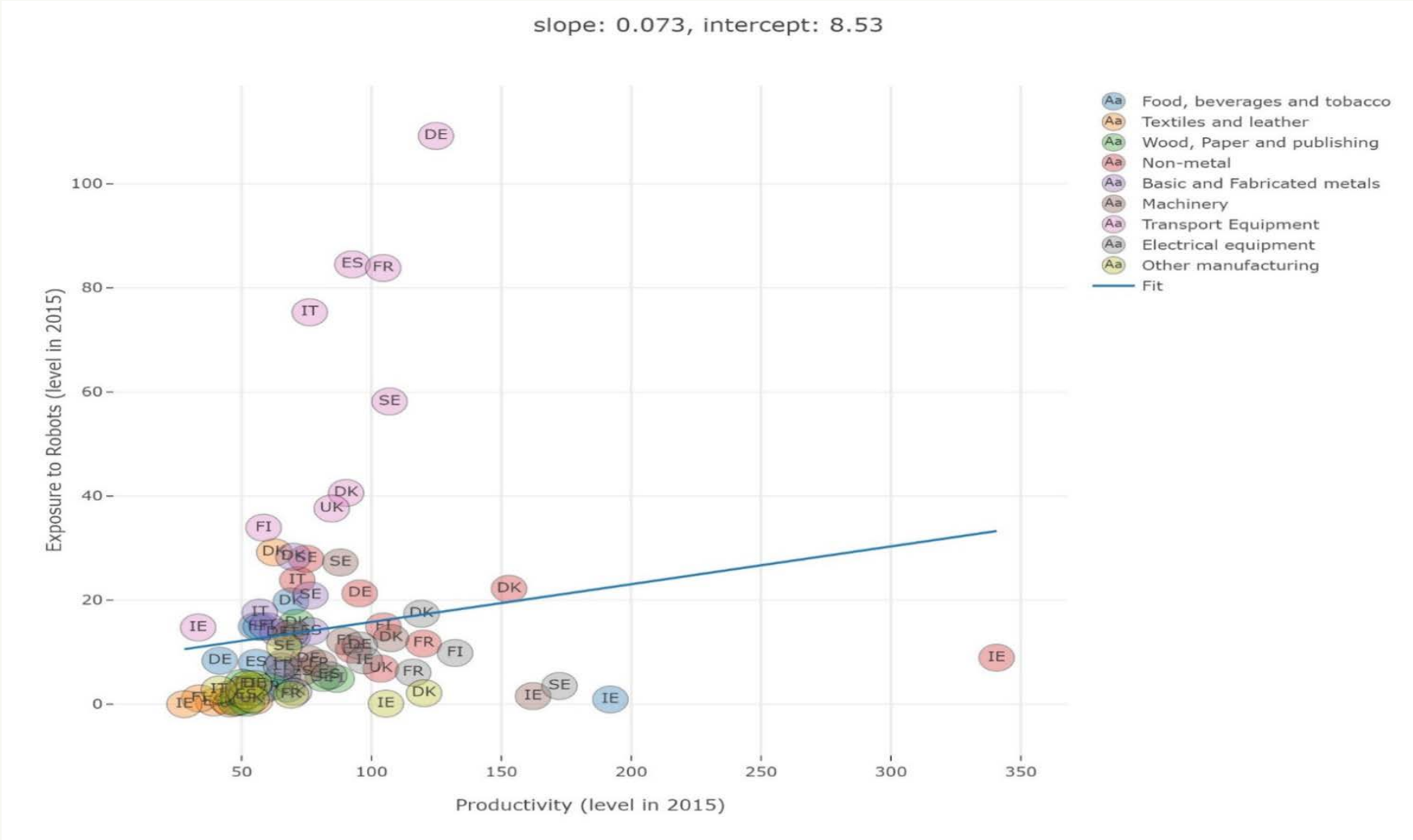
Source: Calculations based on IFR (2017)

Median growth rates in operational industrial robots by country



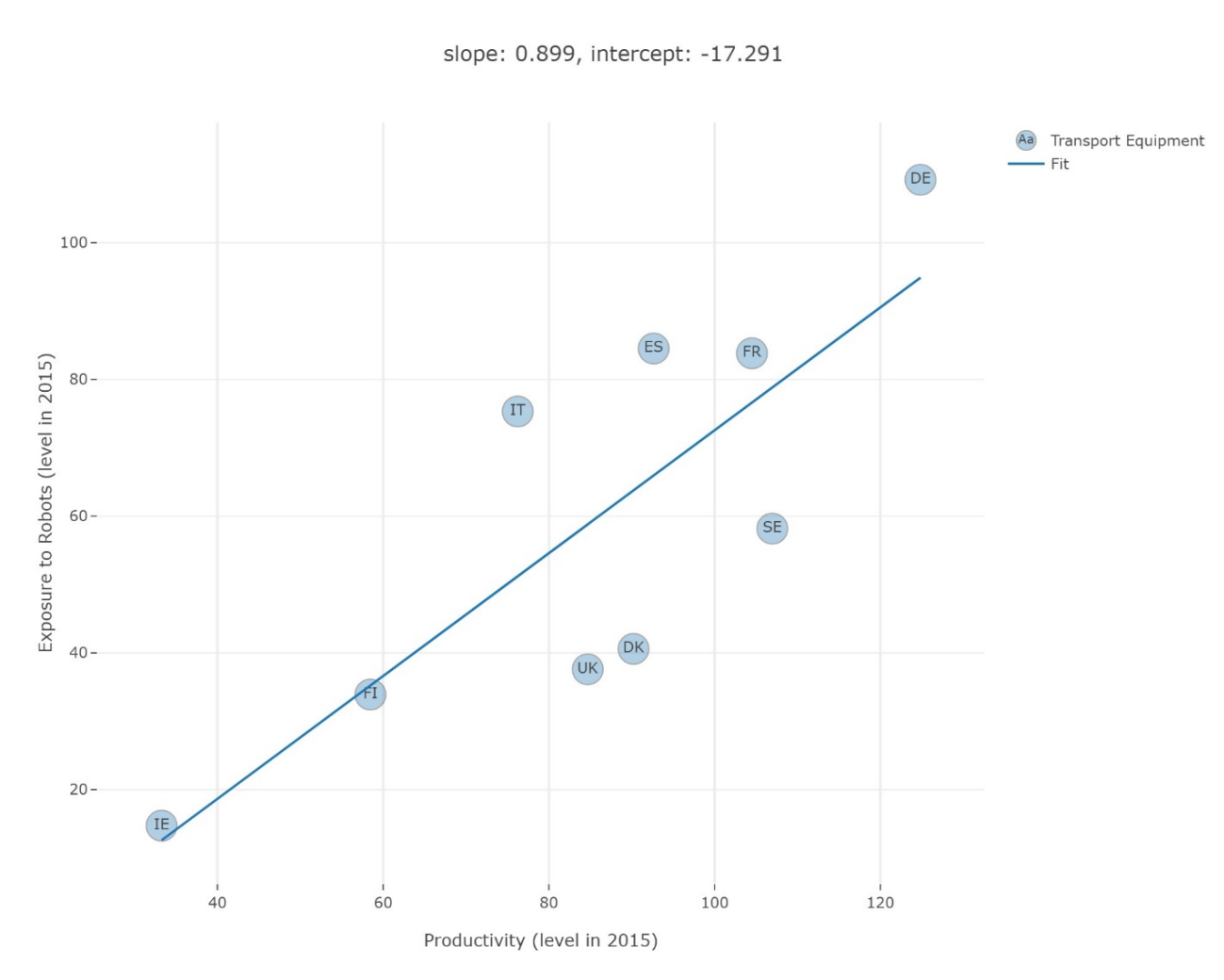
Source: Calculations based on IFR (2017)

Do robots increase productivity?



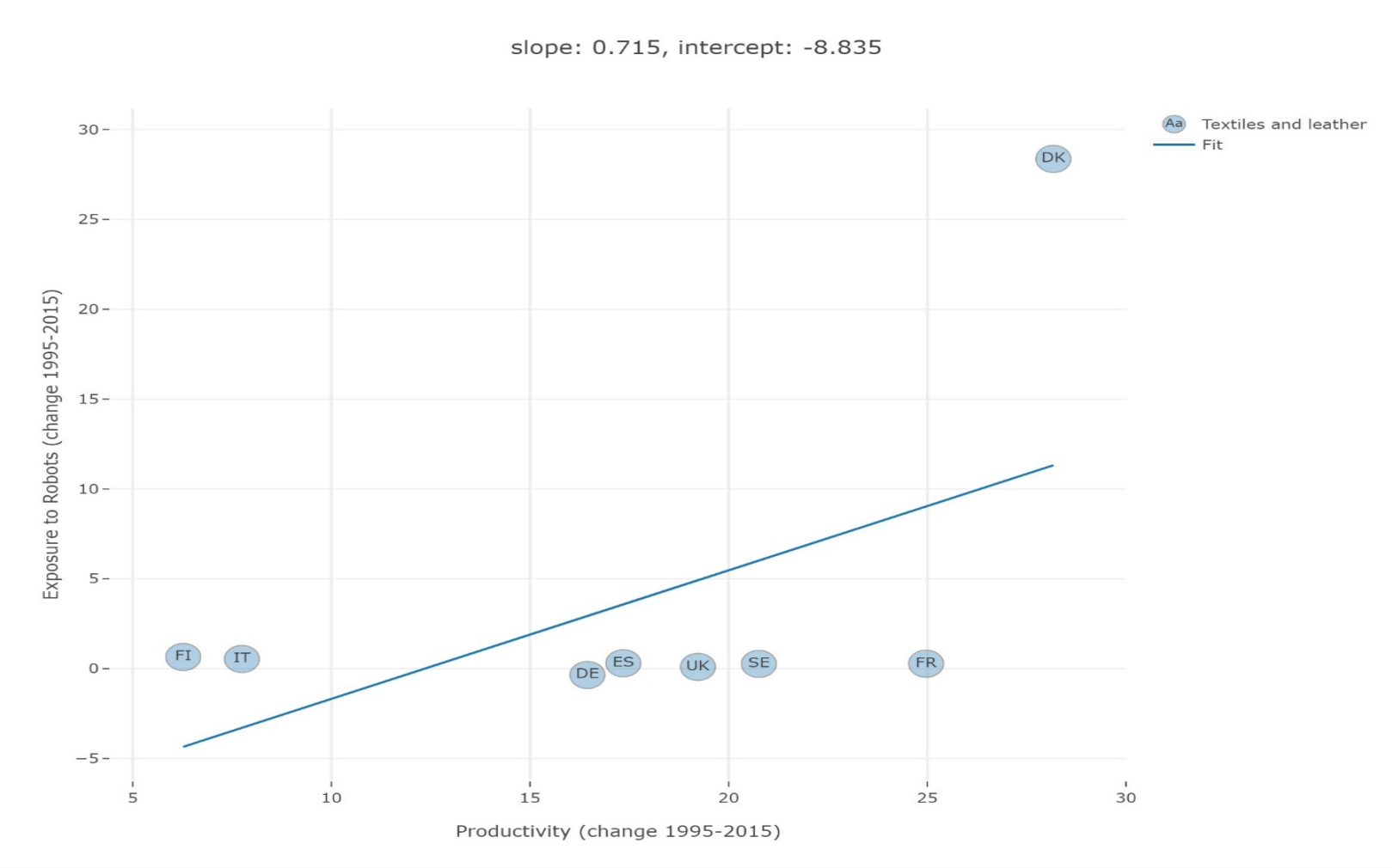
Source: Bruegel based on IFR, EU-KLEMS

In specific sectors yes



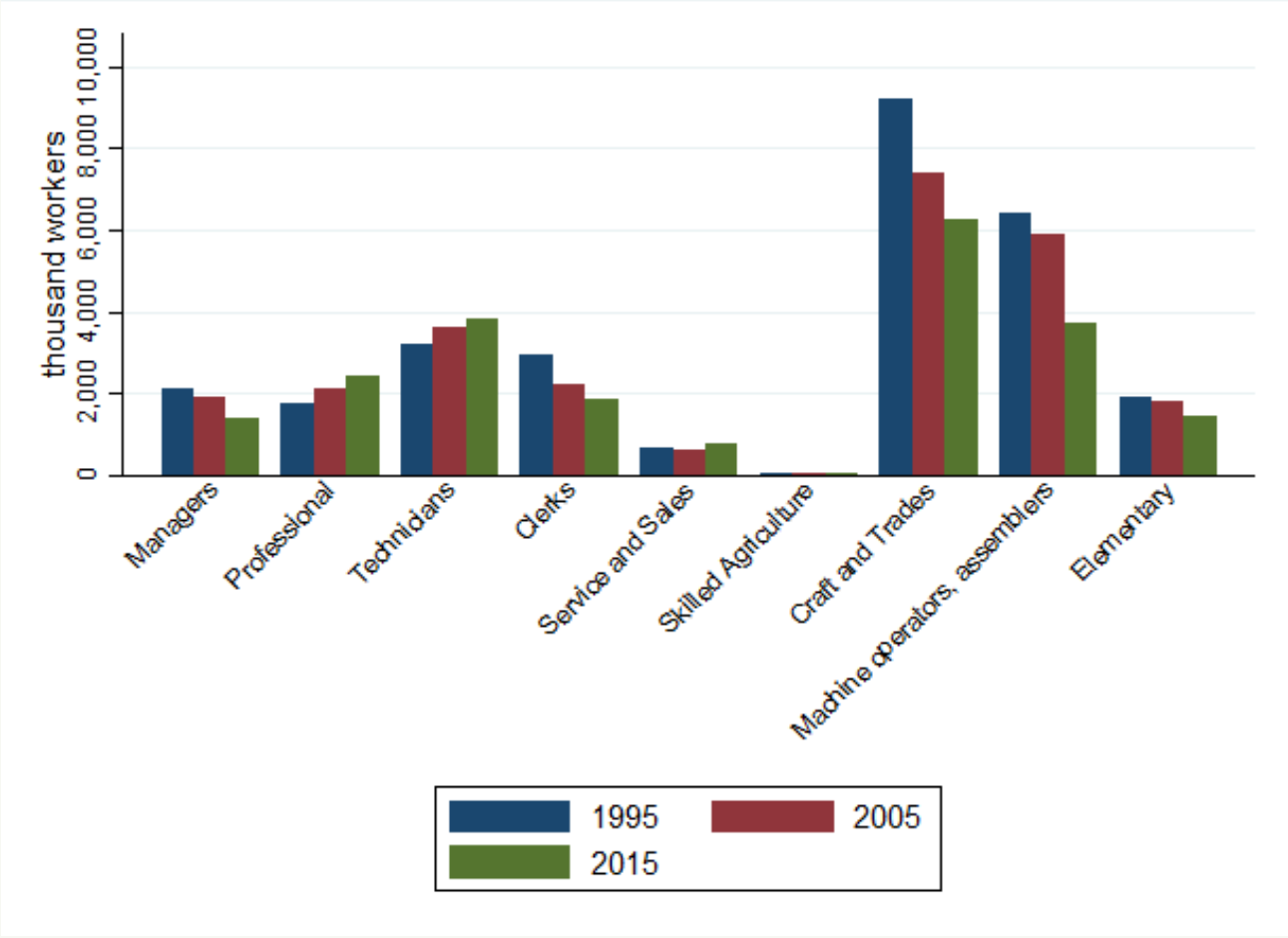
Source: Bruegel based on IFR, EU-KLEMS

In others not necessarily



Source: Bruegel based on IFR, EU-KLEMS

Trends in occupations



Source: Bruegel calculations based on Labour Force Survey
Note: Sample includes DE, DK, ES, FI, FR, IE, IT, SE, UK

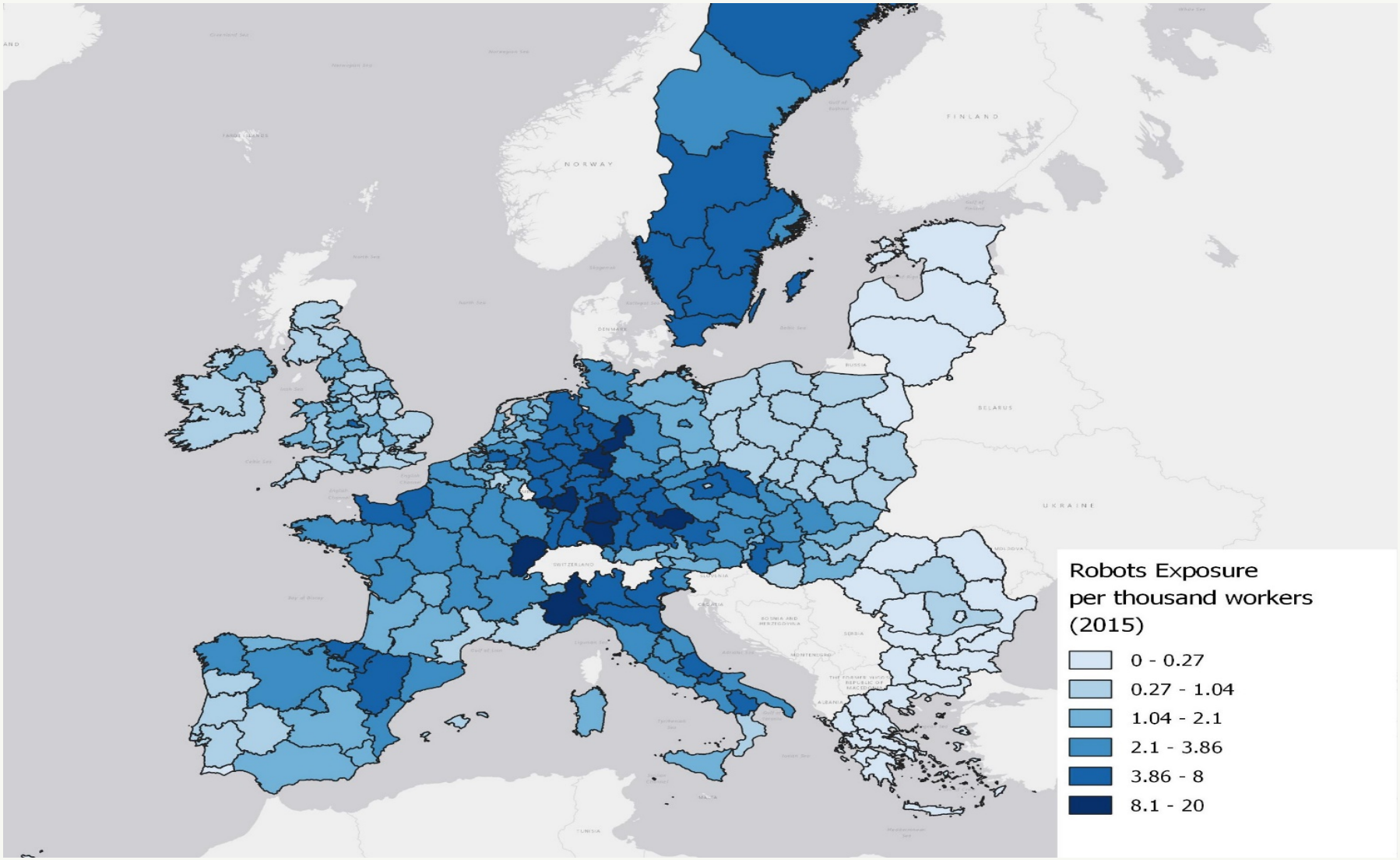
Robot exposure

- Aggregate changes in employment and wages depend on average robots' adoption, measured by the change in a measure of exposure to robots, across NUTS2 regions.
- Sum over industries of the penetration of robots in each industry times the baseline employment share of that industry in the labour market:

$$\Delta robot\ exposure_{r,1995-2007} = \sum_{j \in J} \frac{emp_{rj,1995}}{emp_{r,1995}} \times \left(\frac{robots_{j,2007}}{emp_{j,1990}} - \frac{robots_{j,1995}}{emp_{j,1990}} \right)$$

where r labels each NUTS2 region and j each industry.

Robots exposure of EU regions



Source: Bruegel based on IFR, Eurostat

Specifications

- Aggregate changes in employment and wages depend on average robots' adoption, measured by the change in a measure of exposure to robots, across NUTS2 regions:

$$\Delta employment\ rate_{rg,1995-2007} = \beta_1 + \beta_2 \Delta robot\ exposure_{r,1995-2007} + u_{rg}$$

$$\Delta wage_{rg,1995-2007} = \beta_1 + \beta_2 \Delta robot\ exposure_{r,1995-2007} + u_{rg}$$

where r labels NUTS2 regions and g the demographic group.

- Controls: share of employment in manufacturing, exposure to Chinese and United States imports, extent of routine jobs, offshoring, ICT capital, demographic characteristics, dummy for northern countries (or country dummies).

Data on main variables

- Detailed information on regional employment is derived from micro-data based on the European Union Labor Force Survey (LFS).
- Wage developments are derived from micro-data based on the European Community Household Panel (ECHP), the European Union Statistics on Income and Living Conditions (EU-SILC).
- Data for industrial robots comes from IFR: yearly survey that covers around 90 per cent of all robots sold globally since 1993.

Endogeneity concerns

- Potential unobserved trends, which might affect both robot exposure and labour market outcomes in a region
- Possibility that changes in employment and wage levels also affect the take up of robots.
- Instrumental variable approach:
  - Capture the trend in sectoral adoption of robots in similar advanced economies (as in AR), namely: The United Kingdom and Denmark.
  - Country-specific intensity of Employment Protection Legislation (for all standard contracts, EPL), as collected by the OECD, in its baseline 1990 level or its change between 1985 and 2007.
  - In 1995-2015 sample: Average exposure to robots in all the regions apart from the one considered (+Norway)

Main results on employment

Impact on employment for Total Economy

	(1) Employment rate (2007)	(2) Employment rate (2007)	(3) Employment rate (2007)	(4) Employment rate (2015)	(5) Employment rate (2015)
Change in exposure to robots (1995-20**)	-0.0026***	-0.0016*** [-0.0018, -0.0011]	-0.0020* [-0.0104, -0.0002]	-0.0100 [-0.0433,0.0232]	-0.0126 [-0.0458, 0.0207]
North dummy	V	V	V	V	V
Demographics	V	V	V	V	V
Broad manufacturing share	V	V	V	V	V
Routinization, offshoring, import exposure	V	V	V	V	V
Change in exposure to IT capital (1995-2007)	V	V	V	V	V
Instruments	-	UK and DK robot exposure, EPL in 1990	UK and DK robot exposure, ΔEPL 1985-2007	average sample and NO robots exposure	average sample robots exposure
Observations	1,129	1,129	1,129	1634	1634
R-squared	0.2008	0.1999	0.2005	0.8297	0.8295

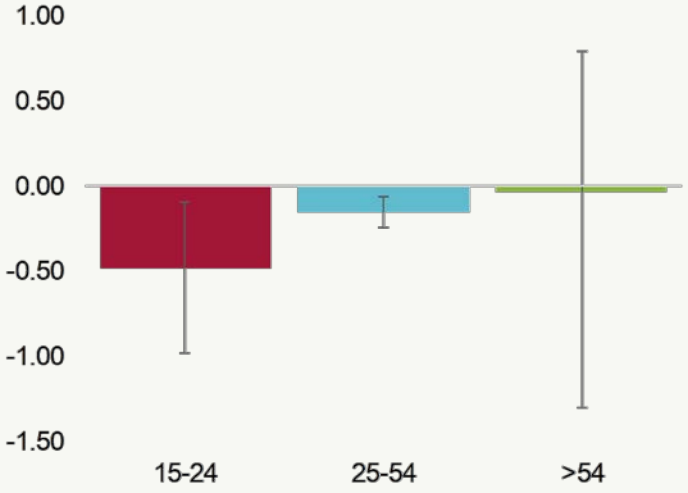
Wild cluster bootstrapped standard errors in parentheses; WRE 90% confidence intervals in square brackets. Data in demografic cells.

*** p<0.01, ** p<0.05, * p<0.10

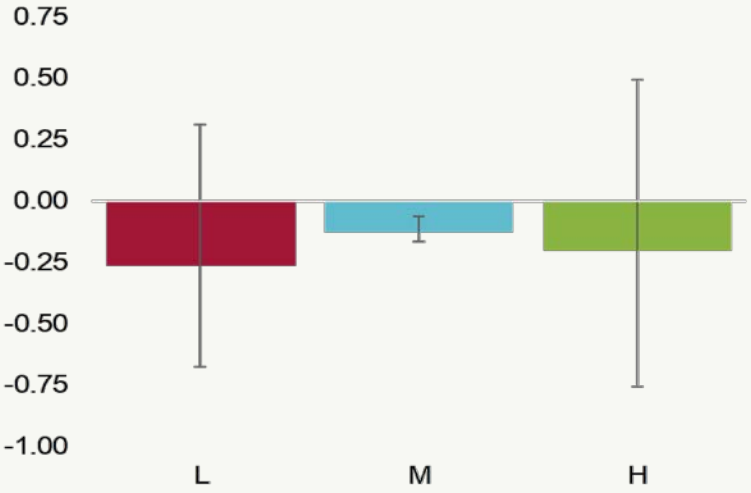
1) Exposure to robots defined as regional exposure to sectoral robot intensity.

Results: Different groups

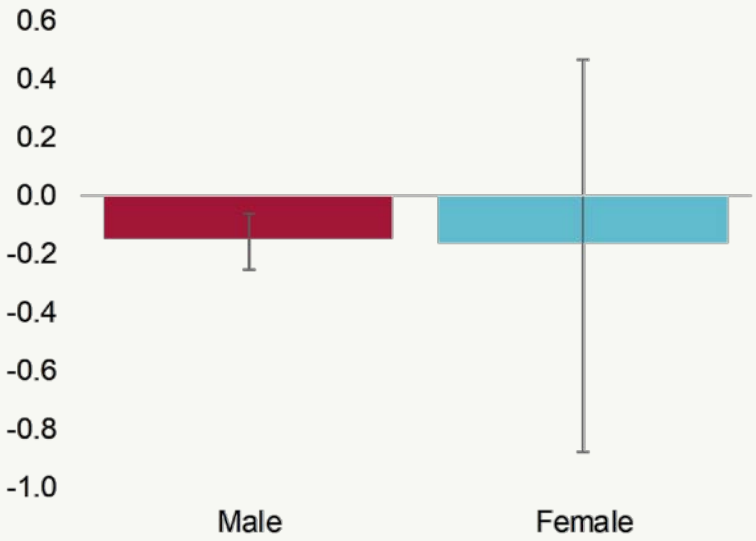
Results by age group
(p.p.)



Results by education group
(p.p.)

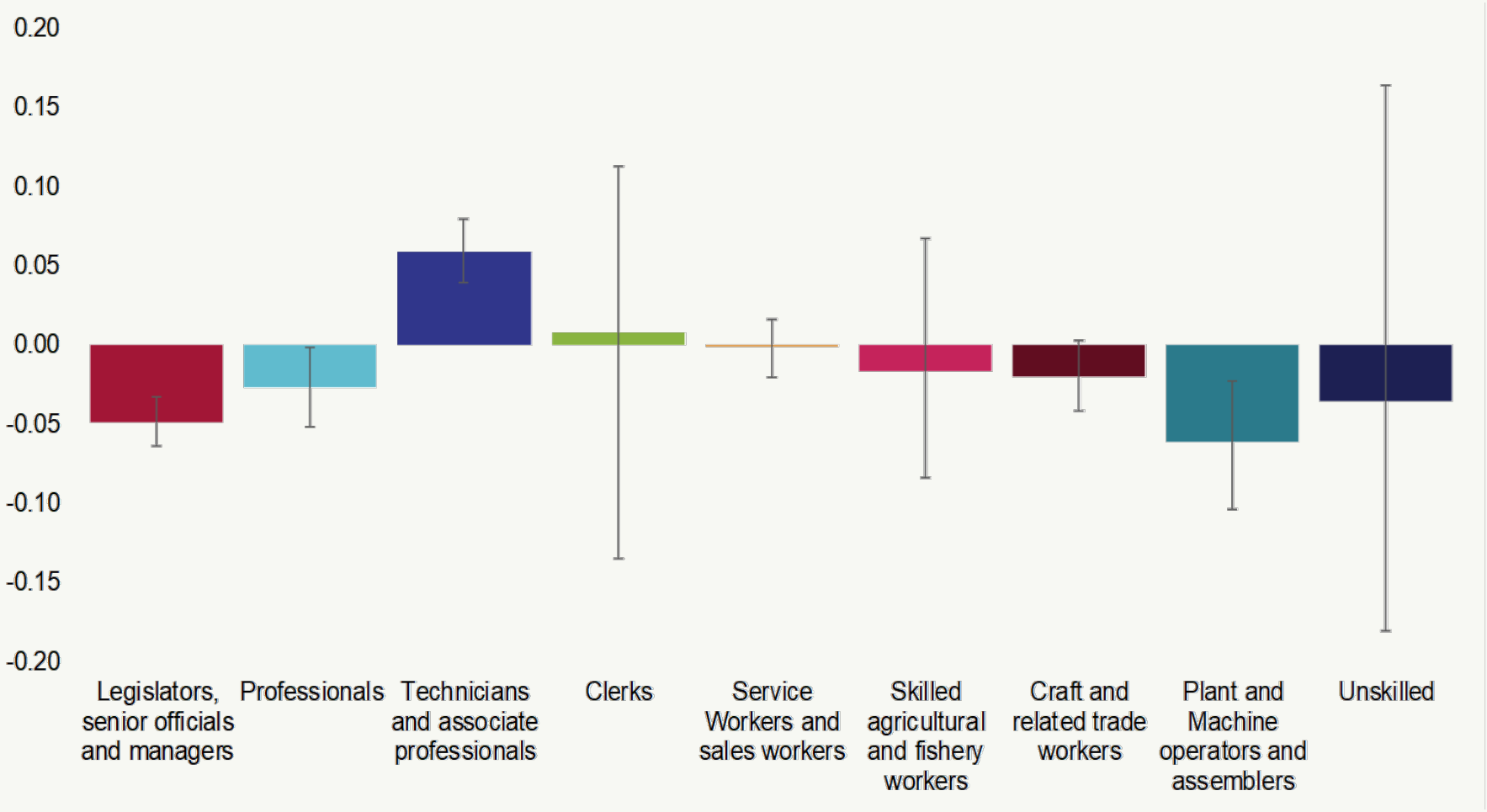


Results by gender
(p.p.)



Results in Industry (up to 2015)

Results: Occupations



Results on wages

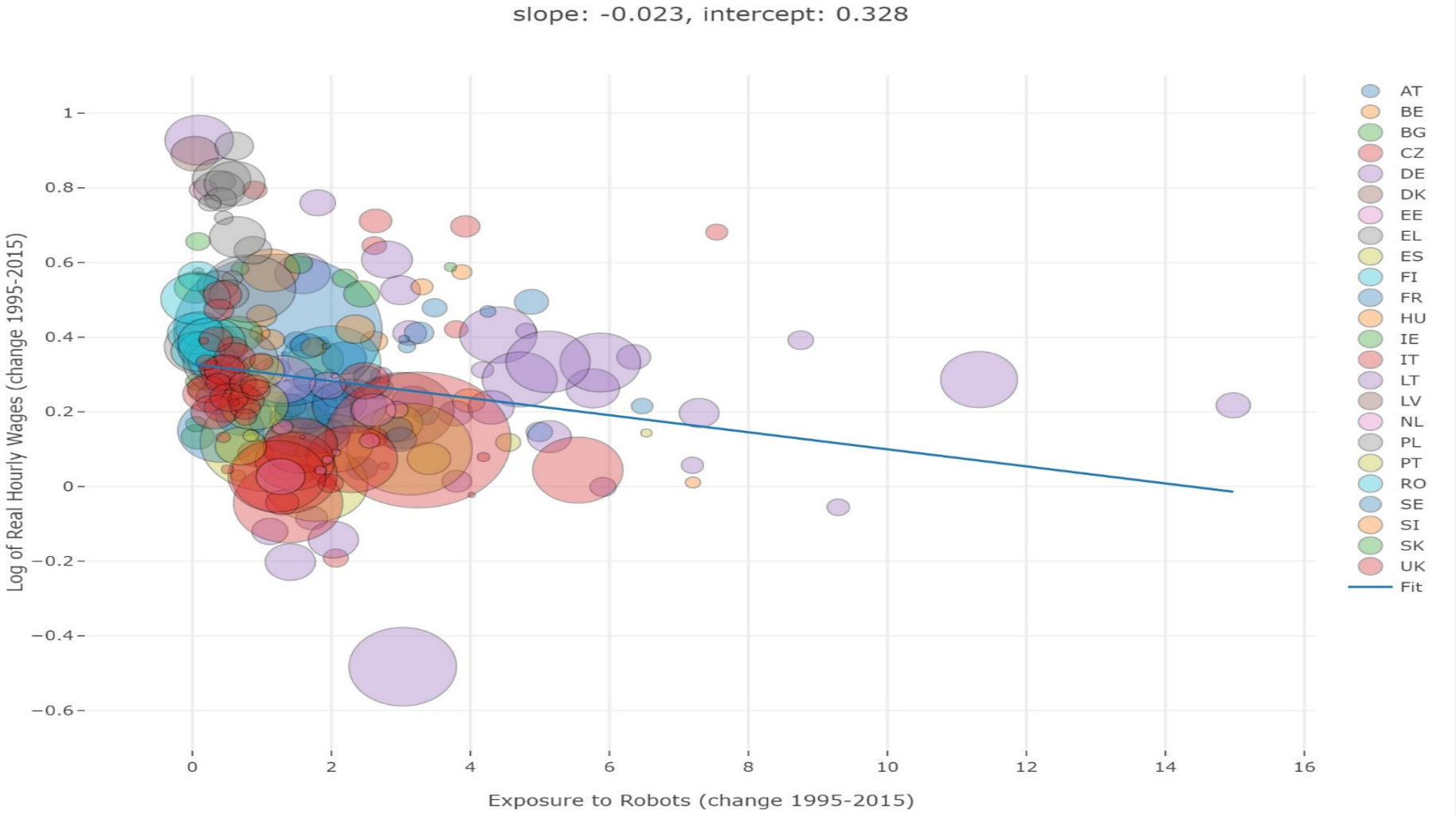
Impact on wages - Total Economy

	(1) Hourly wages	(2) Hourly wages	(3) Hourly wages	(4) Hourly wages	(5) Hourly wages	(6) Hourly wages	(7) Hourly wages	(8) Hourly wages
Change in exposure to robots (1995-2007)	-0.0275***	-0.0144**	-0.0091	-0.0100	-0.0044	-0.0048	-0.0063*	-0.0139
	(0.0089)	(0.0073)	(0.0153)	(0.0274)	(0.0065)	(0.0072)	[-0.0460, -0.0080]	[-0.1732, 0.0372]
North dummy		V	V	V	V	V	V	V
Demographics			V	V	V	V	V	V
Broad manufacturing share				V	V	V	V	V
Routinization, offshoring, import exposure					V	V	V	V
Growth in IT capital					V	V	V	V
Instruments	-	-	-	-	-	-	UK and DK robot exposure, EPL in 1990	UK and DK robot exposure, ΔEPL 1985-2007
Observations	1,337	1,337	1,266	1,251	1,135	1,135	1,135	1135
R-squared	0.0738	0.1589	0.1672	0.1748	0.2620	0.2757	0.2756	0.2708

Wild cluster bootstrapped standard errors in parentheses, WRE 90% confidence intervals in square brackets. Data in demografic cells.

*** p<0.01, ** p<0.05, * p<0.10

Correlations on wages



Source: Bruegel based on IFR, Eurostat

Discussion

- Different impact in EU and US?
  - Labour market policies
  - Welfare systems
- Impact of robots and ICT: Different automated technologies have different impact?
- Run all the estimation up to 2015
- How to control for the crisis?
- A more panel data approach?
- Regional vs country level specifications?