Robot, Employment, and Population:

Evidence from Articulated Robot in Japan's Local Labor Markets

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Automation technology and employment

- How does the automation affect our future work?
- Half of current occupations disappear due to the penetration of AI (Frey and Osborne, 2017)
- Penetration of robots reduced the local employment-population ratio in the US (Acemoglu and Restrepo, 2019)
- Penetration of robots reduced the local manufacturing employment but increased local service emplyment in Germany (Dauth et al., 2018)
- Impacts in Japan? - Most advanced robot technology, Declining population

Overview

- Regional analysis based on 300 commuting zones (CZs)
- Heterogeneous robot penetration across CZs depending on initial industrial structure and heterogeneous robot penetration across industries
- Instrumented by German penetration index
- Robot penetration increased local employment as well as local population
- In total, robot penetration reduced the employment-population ratio

Variety of robots

- Cartesian robot
- SCARA robot
- **Articulated robot**
- Parallel robot
- Cylindrical robot

Figure: Articulated robot

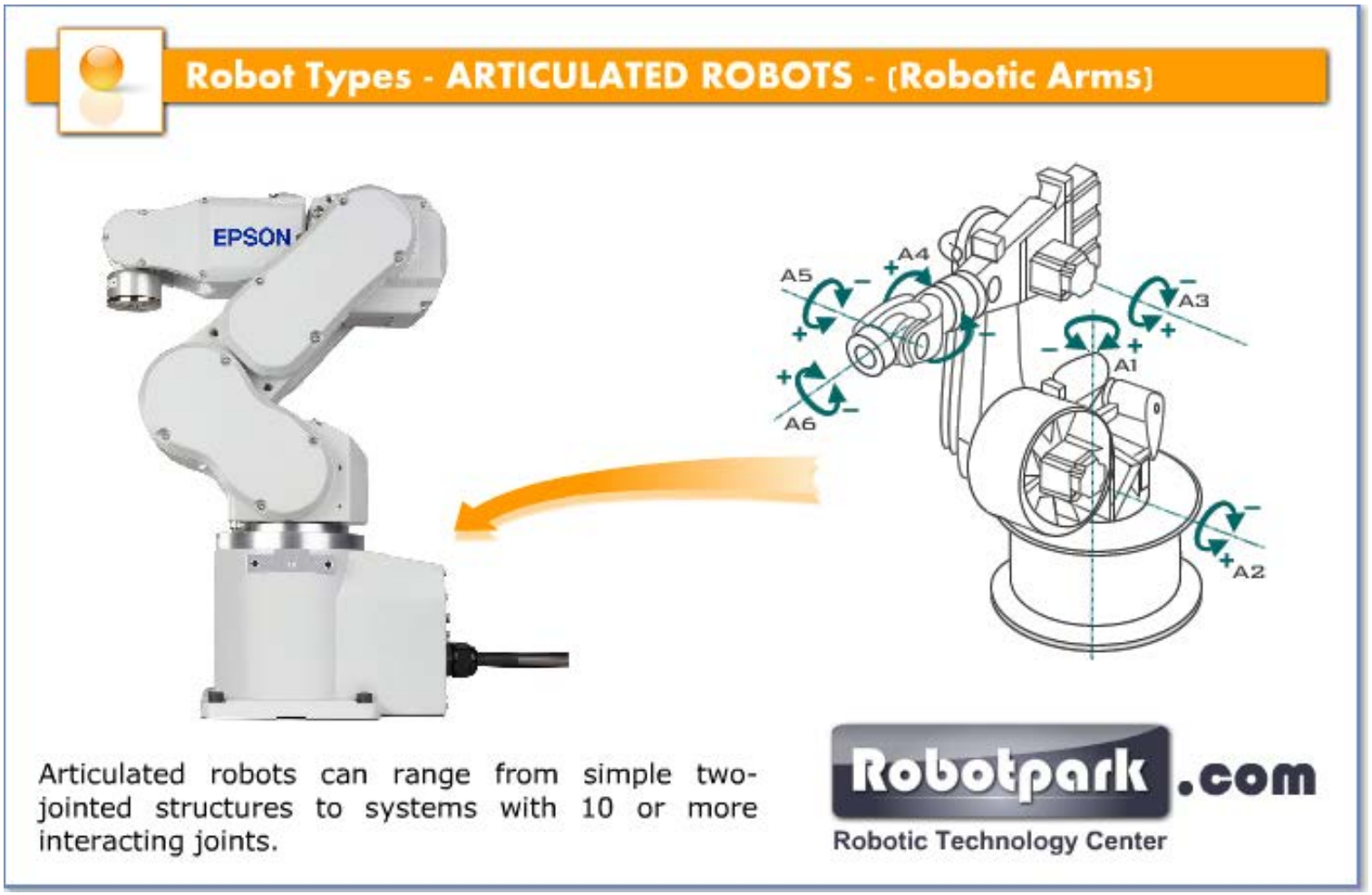
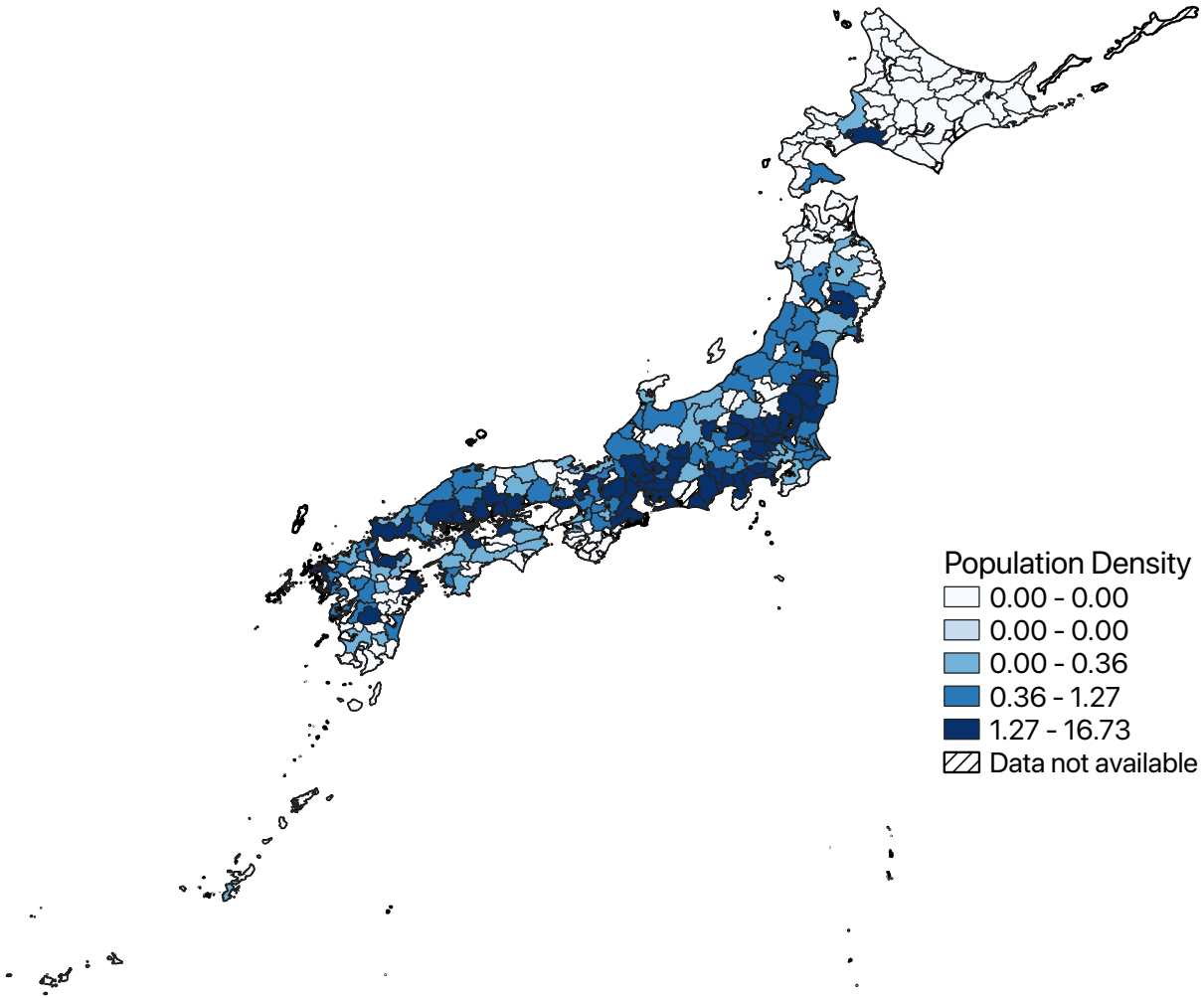


Table: Per-thousand-worker Penetration of Robot, Articulated Robot, 2002-17

Industry	Penetration of Robot
Transport machinery	19.033
Chemical products	0.326
Food / Beverage / Tobacco	0.275
General machinery	-5.863
Precision and optics	-7.481
Non-ferrous metal	-12.253

Figure: Density of automobile industry as of 2002



Construction of robot exposure

Robot growth in industry i:

$$PR^{s}_{i,(2002,2017)} \equiv \frac{R^{s}_{i2017} - R^{s}_{i2002}}{L_{i2002}}, \tag{1}$$

where $R^{s}_{i,t}$ is industry-i, structure-s, year-t stock of robot.

Robot exposure in CZ c:

$$ER^{s}_{c,(2002,2017)} \equiv \sum_{i} l_{ci2002} PR^{s}_{i,(2002,2017)}, \tag{2}$$

where $l_{ci2002} \equiv \frac{L_{ci2002}}{\sum_{k} L_{ck2002}}$ is the industry-i share of employment in CZ c and year 2002.

Empirical strategy

Estimation equation:

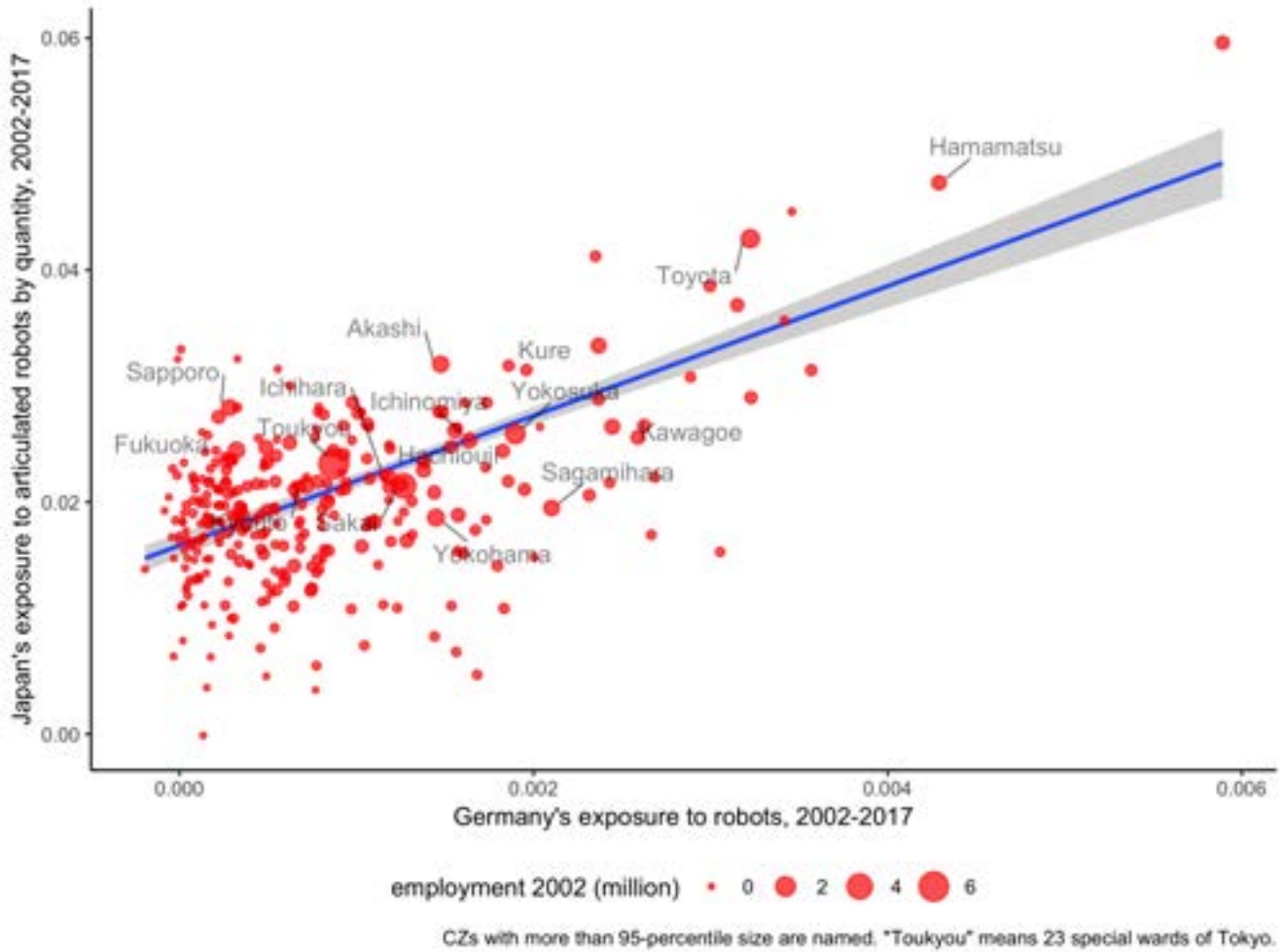
$$y_c^g = \alpha^{gs} + \beta^{gs} ER_c^s + X_c' \gamma^{gs} + \varepsilon_c^{gs}, \tag{3}$$

where y_c^g is one of CZ c-demographic group g outcome variables, X_c is the (column) vector of control variables of CZ c, and ε_c^{gs} is the error term.

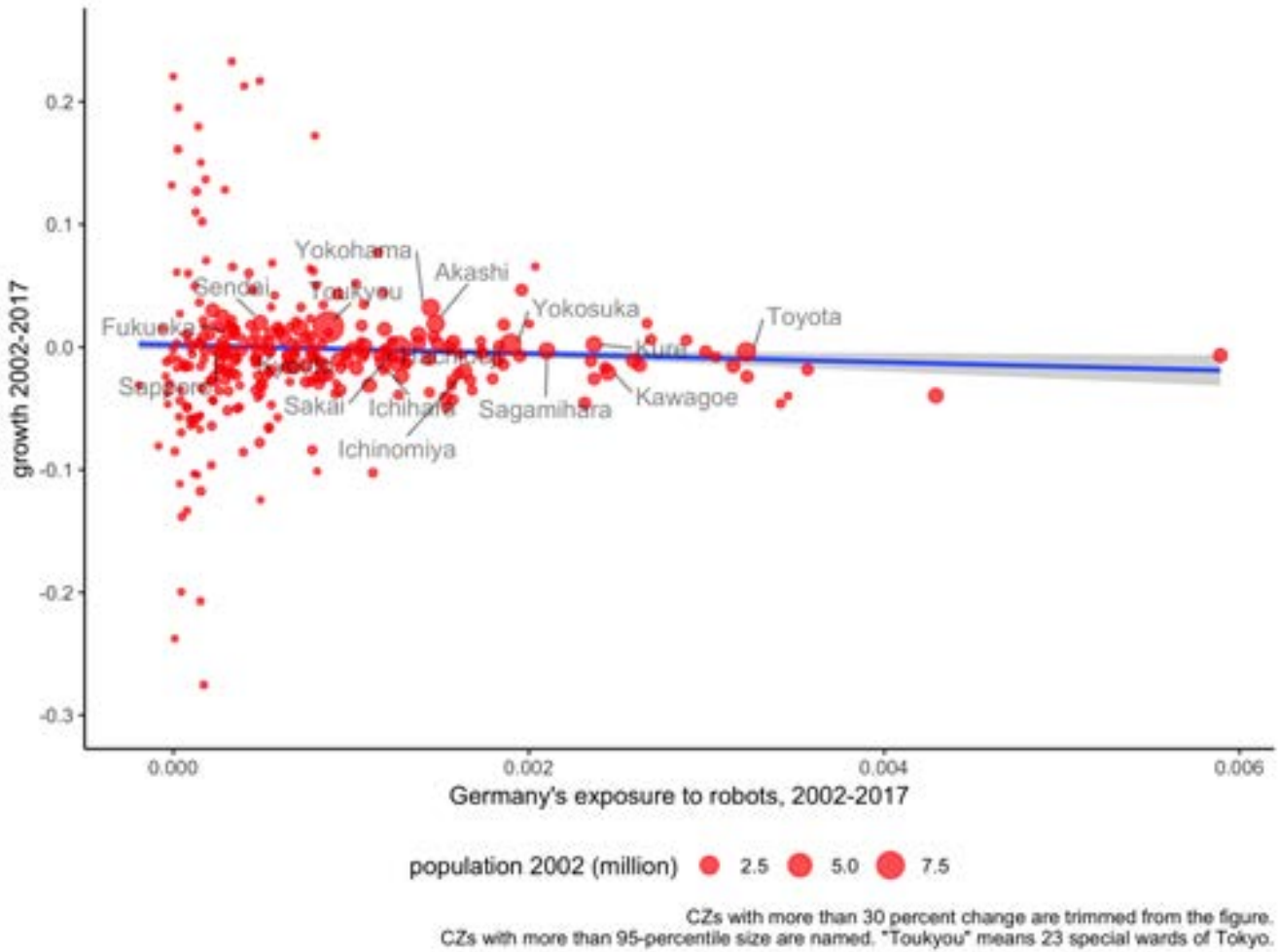
Instrumental variable:

$$ER_{c,(t_0,t_1)}^{DEU} \equiv \sum_i l_{cit-1} PR_{i,(t_0,t_1)}^{DEU}, \tag{4}$$

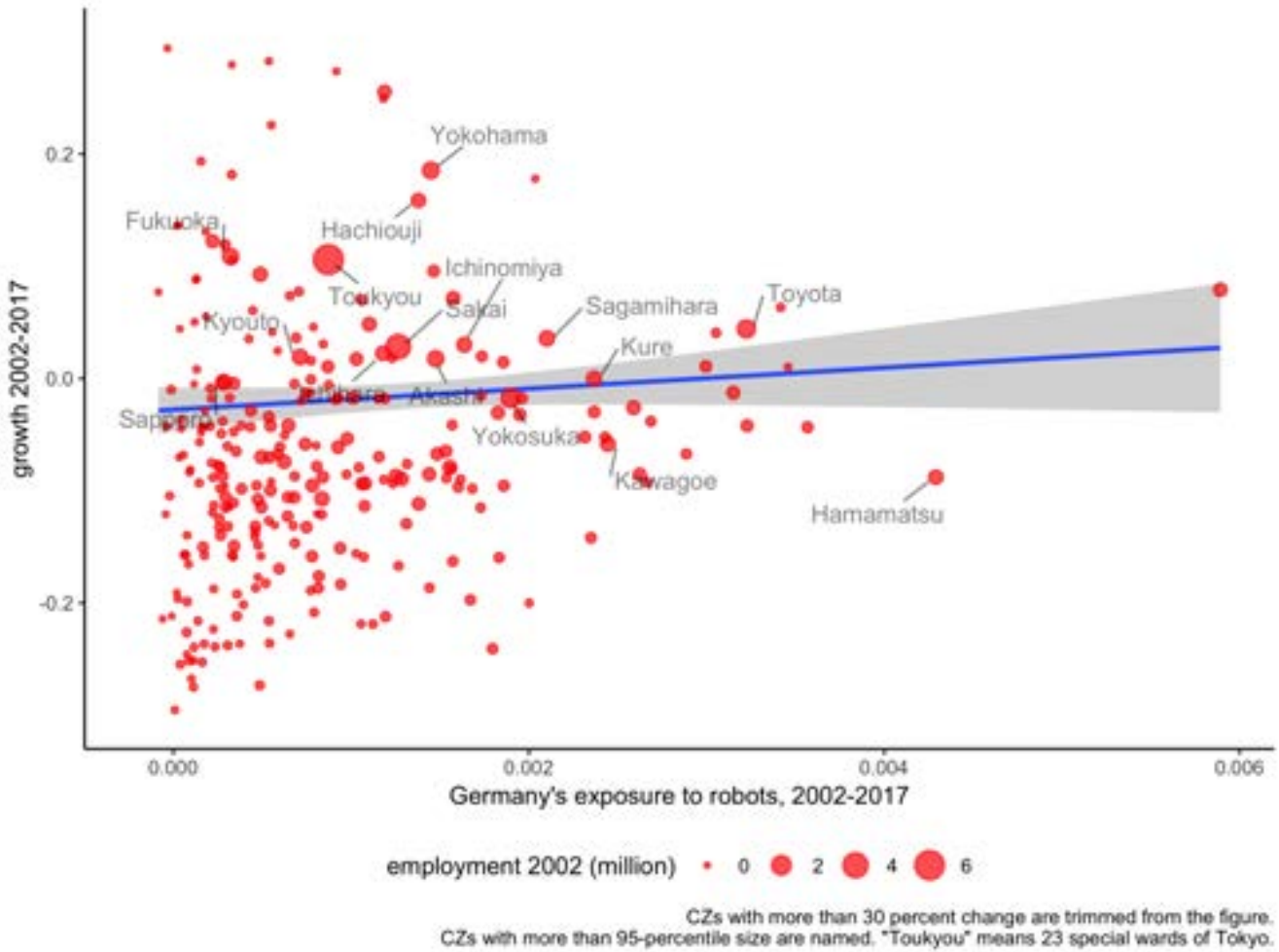
First stage


Japan's exposure to articulated robots by quantity, 2002-2017
0.06
0.04
0.02
0.00
0.000
0.002
0.004
0.006
Germany's exposure to robots, 2002-2017
Hamamatsu
Toyota
Akashi
Kure
Sapporo
Ichihara
Ichinomiya
Yokosuka
Fukuoka
Toukyou
Kawagoe
Sagamihara
Yokohama
employment 2002 (million)
0
2
4
6
CZs with more than 95-percentile size are named. "Toukyou" means 23 special wards of Tokyo.

Reduced form, employment to population ratio



Reduced form, employment growth rate



Reduced form, population growth rate

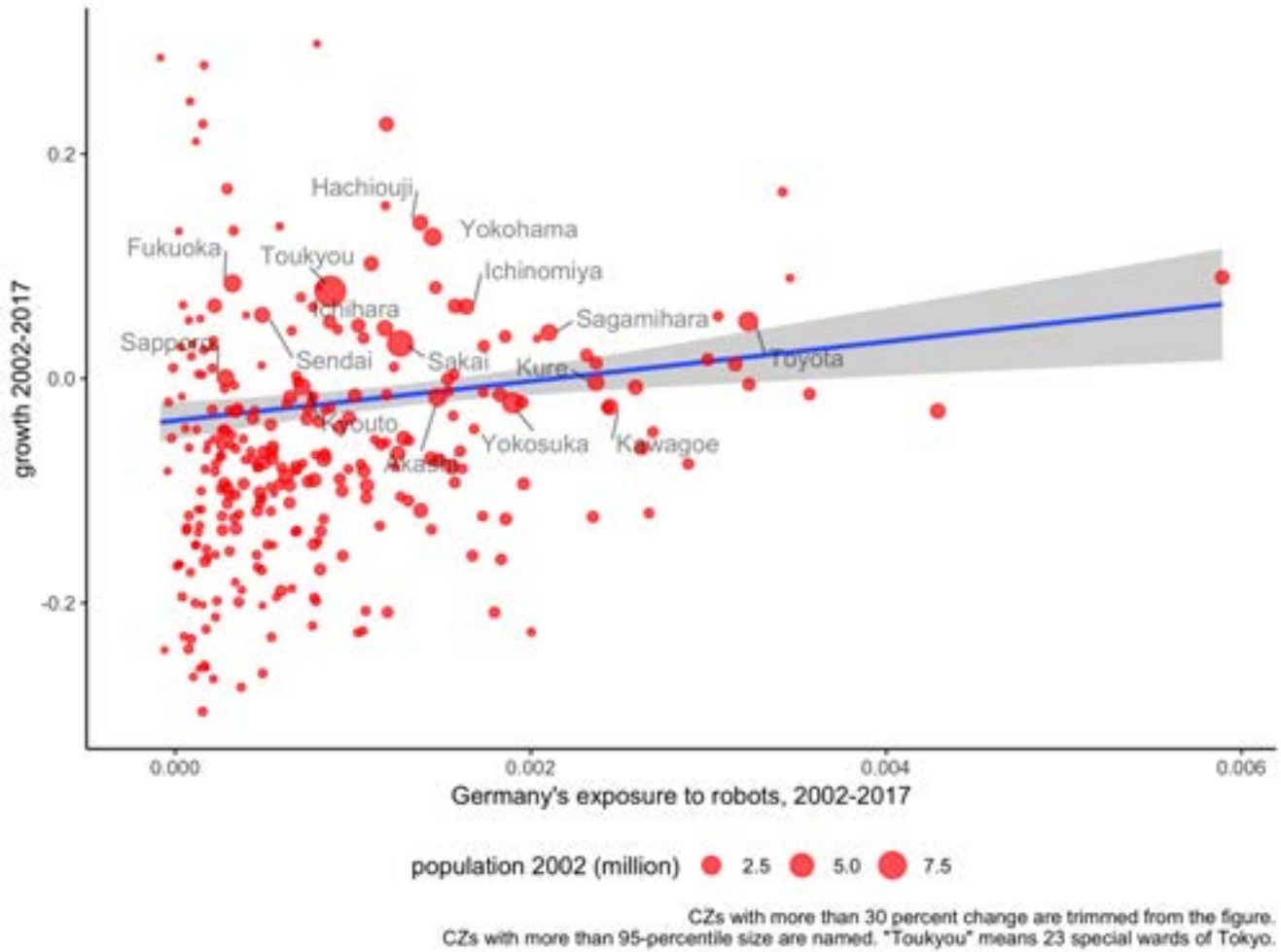


Table: IV First Stage and Reduced Form

	Dependent variable:			
	ER	$\Delta \frac{L}{P}$	g^L	g^P
	(1)	(2)	(3)	(4)
ER^{DEU}	0.220^{***}	-0.234^{*}	1.289^{**}	1.731^{***}
	(0.012)	(0.121)	(0.632)	(0.523)
Observations	302	302	302	302
R^2	0.514	0.012	0.014	0.035
Adjusted R^2	0.513	0.009	0.010	0.032

*p<0.1; **p<0.05; ***p<0.01. See the main text for the definition of each dependent and independent variables. All regressions are weighted by base-year populations in each CZ.

Table: IV regressions

	Dependent variable:		
	$\Delta \frac{L}{P}$	g^L	g^P
	(1)	(2)	(3)
ER	-1.067^{*}	5.868^{**}	7.883^{***}
	(0.553)	(2.892)	(2.418)
Observations	302	302	302

Notes: *p<0.1; **p<0.05; ***p<0.01. See the main text for the definition of each dependent and independent variables. All regressions are weighted by base-year populations in each CZ. ER is instrumented by ER^{DEU}.

Tentative conclusion

- Articulated robot penetration affected different regions heterogeneously.
- Penetration of articulated robot decreased employment/population ratio.
- Penetration of articulated robot increased both employment and population.
- The impact on population dominated the impact on employment.
- Automation technology help local area to sustain employment and population.

Acemoglu, Daron and Pascual Restrepo, "Automation and New Tasks: How Technology Displaces and Reinstates Labor," Technical Report, National Bureau of Economic Research 2019.

Dauth, Wolfgang, Sebastian Findeisen, Jens Suedekum, and Nicole Woessner, "Adjusting to Robots: Worker-Level Evidence," Technical Report Institute Working Paper 13 2018.

Frey, Carl Benedikt and Michael A. Osborne, "The future of employment: How susceptible are jobs to computerisation?," *Technological Forecasting and Social Change*, 2017, *114* (C), 254–280.