Technequality

Understanding the relation between technological innovations and social inequality

Automation and Adjustment in Europe: A Comparative Study of the Robot Revolution

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Outline

- Project background
- Data
- Empirical strategy
- Results
- Conclusions

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Project Background

- How does the robot adoption affect local labour market?
  - Untangle the effects of exposure to robots and trade
  - To what extent how employment adjusted
  - Effects by industry and demographic groups

- Empirical literature
  - EU region NUTS2 level: Chiacchio et al (2018), Antón et al (2020)
  - Individual country: US (Acemoglu & Restrepo, 2020), Germany (Dauth et al, 2018), Italy (Dottori, 2020)

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Data

Data sources

- Industrial Robots: IFR
- Industry employment: EU KLEMS
- International trade: UN Comtrade
- Census: IPUMS international
- National statistic offices
- Germany firm level data: IAB

Sample

- Local labour market: NUTS3 or lower
- Cut-off year: 2007

Country	Long Diff.	Spatial unit	N. of obs.
Denmark	1994-2007	Municipality 2007	99
Finland	1993-2007	Sub-region	70
France	1990-2006	NUTS2	22
Germany	1995-2007	District	402
Italy	1991-2011	Province 2009	110
Norway	1995-2007	Economic region	74
Spain	1991-2011	Province	52
Sweden	1993-2007	Local labour markets 1998	100
U.K.	1991-2007	Local authority district, prior to 2015	352

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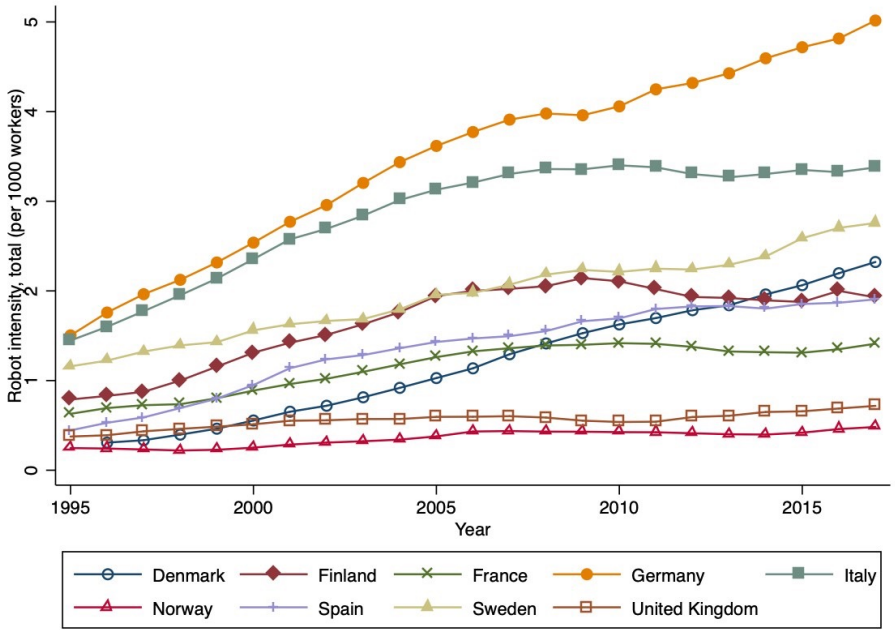
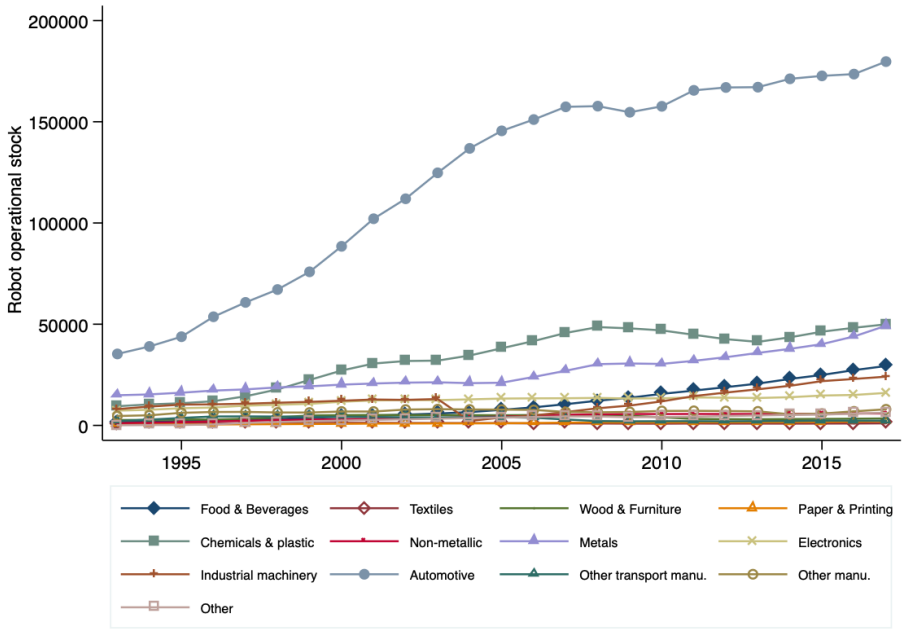
Robot adoption

Robot intensity by country



Robot operational stock by industry



- Growing robot intensity across countries with various adoption rate
- Automotive is the leading industry in robot installation

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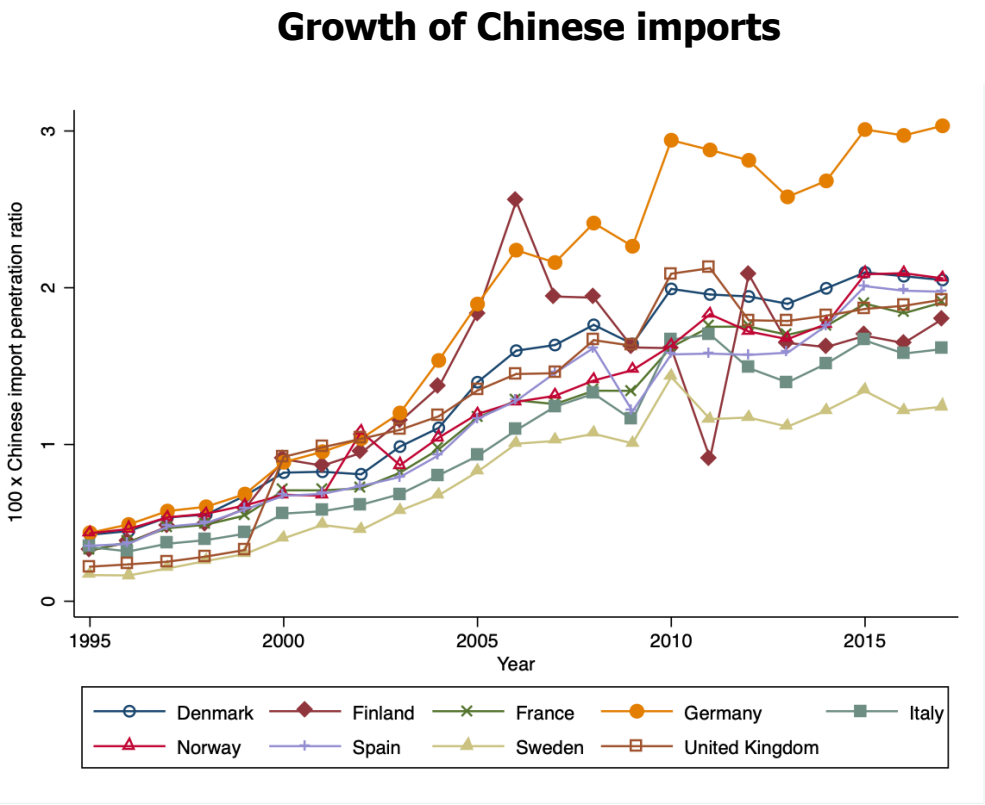
Trade penetration



- The growth of Chinese imports has accelerated since China joined World Trade Organization (WTO) in 2001

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Exposure to robots

- Exposure to robots
  - Variation in industry-level robot adoption and local industrial employment shares (Acemoglu & Restrepo, 2020)
  - Concerns about local industry and labour demand shocks: use industry-level adoption of robots in other European countries as well as historical industrial specialization across local labour markets

$$ER^{c}_{d,(t_0,t_1)} = \sum_{i \in I} l^{t_0}_{d,i} \cdot APR^{c}_{i,(t_0,t_1)}$$

$$APR^{c}_{i,(t_0,t_1)} = \frac{R^{c}_{i,t_1} - R^{c}_{i,t_0}}{L^{c}_{i,1990}} - g^{c}_{i,(t_0,t_1)} \frac{R^{c}_{i,t_0}}{L^{c}_{i,1990}}$$

c: Country, *t*: Year, *i*: Industry, *l*: Share of local market's industry employment, *d*: Local market
L: per 1000 workers
R: Operational stock of industrial robots
g: Real gross output growth between t_0 and t_1

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Exposure to Chinese imports

- Exposure to Chinese imports
  - The variation: concentration of manufacturing employment and specialisation in import-intensive industries within local labour market (Autor et al, 2015)
  - Concerns about unobserved product demand shocks: use historical industry composition and growth of Chinese imports in four other high-income countries: Australia, Japan, New Zealand and Switzerland

$$ECI_{d,(t_0,t_1)}^{China-c} = \sum_{i \in I} \frac{L_{i,d,t_0}^{c}}{L_{i,t_0}^{c}} \frac{M_{i,(t_0,t_1)}^{China-c}}{L_{d,t_0}^{c}}$$

c: Country, *t*: Year, *i*: Industry, *d*: Local market
L: Total employed
M: Change in imports from China to country *c*

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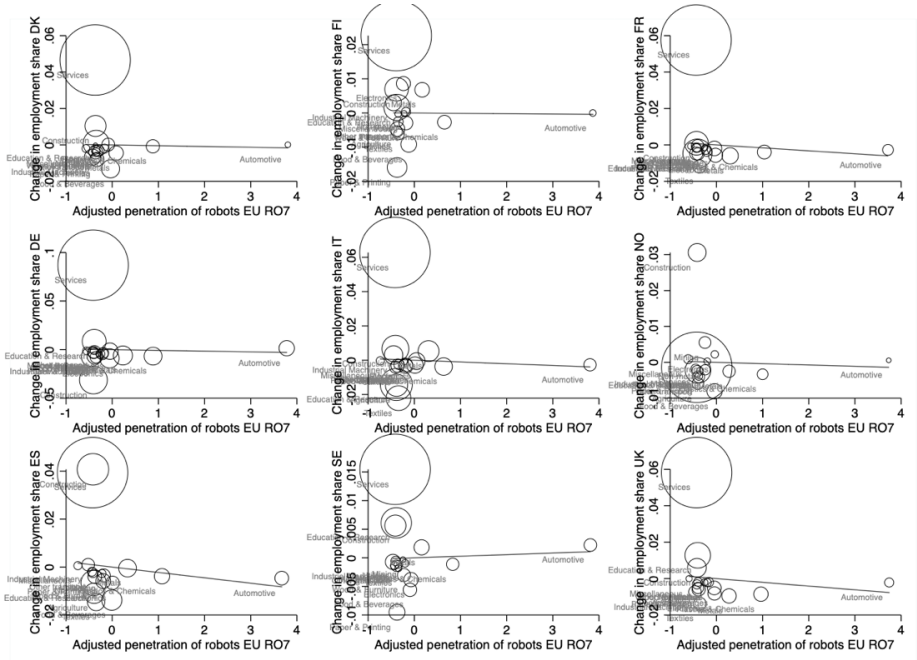
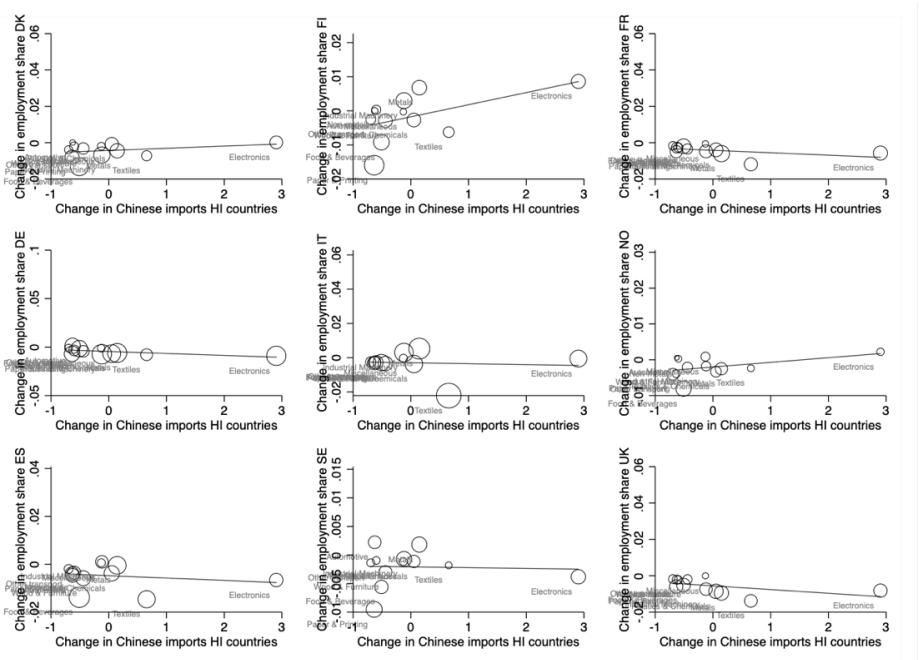
Correlations in industry level

Relationship between robot penetration and employment share



Relationship between Chinese imports and employment share



- Most countries have negative effect of robots in the industry level

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Empirical strategy

- Long difference: early 1990s to 2007
- Use IV to address endogeneity: unobserved industry trends and local labour demand shocks

$$Y^{c}_{d,(t_0,t_1)} = \alpha + \beta_1 \, ER^{c}_{d,(t_0,t_1)} + \beta_2 \, ECI^{China-c}_{d,(t_0,t_1)} + \mathrm{X}_{d,t_0} \, \mathrm{B} + \delta_r + \varepsilon_d$$

$$Y^{IV}_{d,(t_0,t_1)} = \alpha + \beta_1 \, ER^{IV}_{d,(t_0,t_1)} + \beta_2 \, ECI^{China-HI}_{d,(t_0,t_1)} + \mathrm{X}_{d,t_0} \mathrm{B} + \delta_r + \varepsilon_d$$

$Y^{c}_{d,(t_0,t_1)}$: Total/manufacturing/non-manufacturing employment to population ratio

X_{d,t_0} : start-of-period demographic and industry variables

δ_r : regional dummies

ε : error term

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Main Results

	Long Difference, Total employment								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Denmark	Finland	France	Germany	Italy	Norway	Spain	Sweden	U.K.
	Panel A. OLS								
Exposure to robots	0.564	-0.641	-0.713	-0.037	-0.306*	-0.525	0.042	-0.736*	-0.333
	(0.968)	(0.400)	(0.729)	(0.045)	(0.150)	(1.081)	(0.072)	(0.407)	(0.479)
Exposure to Chinese imports	-0.432	0.345***	0.875	-0.105**	-0.277	-0.650	0.309	0.953	-0.482**
	(0.518)	(0.098)	(1.946)	(0.043)	(0.602)	(0.640)	(0.250)	(0.765)	(0.211)
Observations	99	70	20	357	110	74	49	100	352
	Panel B. 2SLS								
Exposure to robots	1.064	0.068	-0.295	-0.076	-0.422***	-3.220*	0.030	-0.586	-0.937*
	(1.262)	(0.527)	(0.567)	(0.046)	(0.138)	(1.529)	(0.075)	(0.512)	(0.529)
Exposure to Chinese imports	-0.282	0.243	0.196	-0.166***	0.280	-0.203	0.326	0.132	-0.816***
	(0.850)	(0.152)	(1.892)	(0.054)	(0.857)	(0.682)	(0.271)	(1.374)	(0.313)
C-D Wald F statistic	26.90	23.17	1.85	434.54	140.07	48.22	470.31	37.25	140.76
Observations	99	70	19	319	110	74	49	100	352
Regional FE & Covariates	✓	✓	✓	✓	✓	✓	✓	✓	✓

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

- The impact of robots on total employment in local labour markets is ambiguous

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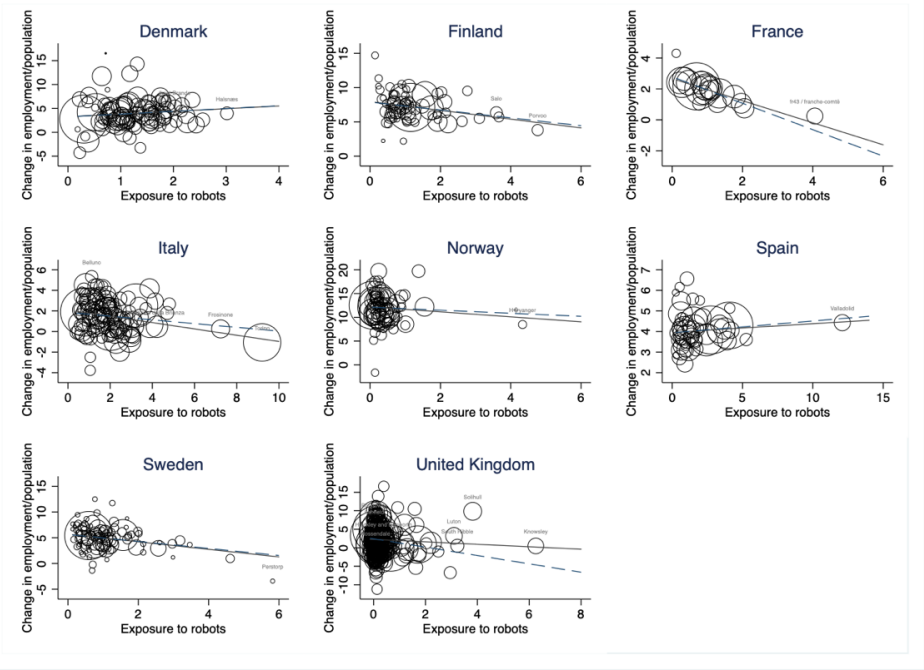
Variation of Exposure to robots across local labour markets



- Only a handful local markets are exposed greatly to robots: many of them are specialized in automotive or plastic/chemical industry
- Countries with relatively more local labour markets exposed to robots could face larger displacement effect than others

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Composition effects

	Long Difference, 2SLS								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Denmark	Finland	France	Germany	Italy	Norway	Spain	Sweden	U.K.
	Panel A. Manufacturing employment								
Exposure to robots	-0.244	-0.291	-0.357	-0.042	-0.210***	-0.838	-0.157***	-0.362	-0.599**
	(0.955)	(0.420)	(0.318)	(0.037)	(0.067)	(0.707)	(0.042)	(0.365)	(0.246)
Exposure to Chinese imports	-0.592	0.287**	-0.146	-0.027	-0.968**	0.167	-0.889***	0.794	-0.763***
	(0.334)	(0.102)	(1.054)	(0.034)	(0.458)	(0.213)	(0.146)	(1.221)	(0.132)
	Panel B. Non-manufacturing employment								
Exposure to robots	1.292	0.445	0.048	-0.035**	-0.212*	-2.325*	0.183*	-0.255	-0.310
	(1.218)	(0.310)	(0.518)	(0.017)	(0.121)	(1.303)	(0.088)	(0.316)	(0.450)
Exposure to Chinese imports	0.323	-0.058	0.542	-0.145***	1.248	-0.356	1.195***	-0.527	-0.130
	(0.840)	(0.110)	(1.527)	(0.037)	(1.095)	(0.586)	(0.376)	(0.823)	(0.269)
Observations	99	70	19	319	110	74	49	100	352
Regional FE & Covariates	✓	✓	✓	✓	✓	✓	✓	✓	✓

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

- Robots seem to reduce employment in the manufacturing sector
- We find a reallocation of employment form manufacturing to non-manufacturing employment in Spain due to positive employment spillovers

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Effects by industry

	Long Difference, Total employment 2SLS								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Denmark	Finland	France	Germany	Italy	Norway	Spain	Sweden	U.K.
Exposure to robots in automotive	-0.198	5.948	0.212	-0.050	-0.455**	0.096	0.060	-0.589	-0.612
	(1.843)	(4.307)	(0.879)	(0.038)	(0.172)	(1.091)	(0.065)	(0.518)	(0.452)
Exposure to robots in other industries	-1.078	-0.900**	-7.403	-0.872***	-0.928*	-12.833***	-1.414	-0.436	-15.975**
	(1.545)	(0.316)	(6.748)	(0.208)	(0.536)	(3.145)	(0.841)	(1.022)	(7.485)
Observations	99	70	19	319	110	74	49	100	352
Regional FE & Covariates	✓	✓	✓	✓	✓	✓	✓	✓	✓

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- The displacement effect of robots is not solely driven by the automotive industry

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Impacts by demographic groups

	Long Difference, Total employment								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Denmark	Finland	France	Germany	Italy	Norway	Spain	Sweden	U.K.
					Panel A. Gender				
Female	1.244**	-0.061	0.068	-0.023	0.030	-0.379	0.044	-0.251	-0.183
	(0.539)	(0.214)	(0.311)	(0.015)	(0.027)	(0.362)	(0.064)	(0.205)	(0.297)
Male	-0.078	-0.386	-0.545	-0.026	-0.032*	-0.007	-0.014	-0.429	-0.388
	(0.728)	(0.267)	(0.398)	(0.034)	(0.017)	(0.405)	(0.053)	(0.258)	(0.301)
					Panel B. Age				
Age 24 and below	-0.047	-0.072	-0.355	-0.023**	0.162***	-0.328	-0.037	-0.067	-0.043
	(0.231)	(0.085)	(0.460)	(0.009)	(0.033)	(0.205)	(0.031)	(0.131)	(0.178)
Age 25-54	1.215	-0.017	-0.148	-0.037	-0.260*	-0.149	0.052	-0.528*	0.395
	(0.725)	(0.291)	(0.635)	(0.033)	(0.141)	(0.763)	(0.044)	(0.300)	(0.455)
Age 55 and above	0.209	0.646**	0.208	0.012*	0.041	-0.291	0.014	0.009	-0.060
	(0.233)	(0.260)	(0.275)	(0.006)	(0.046)	(0.216)	(0.023)	(0.144)	(0.145)
					Panel C. Skills				
Unskilled	0.904	0.748	-0.069	-0.036***		-0.661	-0.127		-0.547***
	(0.584)	(0.562)	(0.721)	(0.013)		(1.585)	(0.087)		(0.128)
Skilled	0.419	-0.200	-0.233	-0.012		-0.326	0.158***		-0.225
	(0.556)	(0.244)	(0.908)	(0.034)		(0.641)	(0.053)		(0.468)

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

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Conclusions

- Robots have reduced employment in the manufacturing sector, while the impacts on local labour markets, which also take into account indirect employment effects, are more ambiguous
- Robots, unlike other computer technologies, have no significant impact on the demand for skilled workers
- Different demographic groups have fared differently from the robot revolution: in most countries, male and young workers have experienced most of the adverse impacts of robots in employment terms
- To what extent robots reduce employment plausibly depends on both labour market conditions and institutions

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Thank you!
Questions and comments?

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