Robots and reshoring: Evidence from Mexican labor markets

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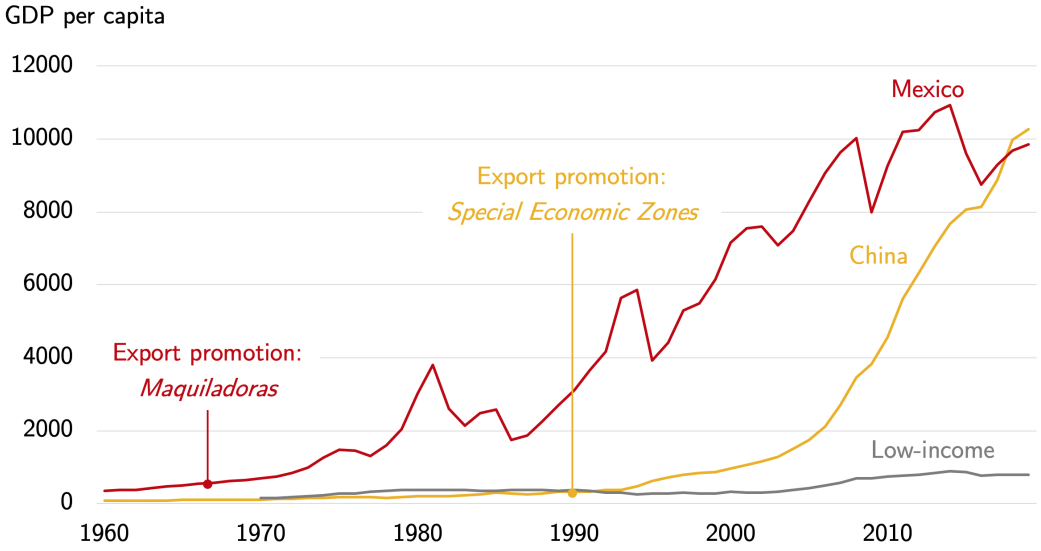
ASSA 2021

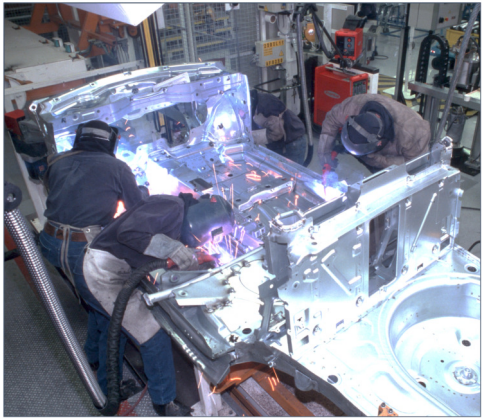
January 2021

In last 50 years, some countries have made leap from low-income to middle-income by using cheap, manual labor to their advantage

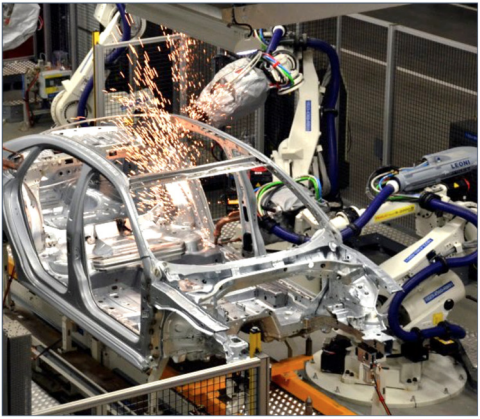


More recently, industrial robots have become powerful alternative to perform many routine, manual tasks

1990s: Puebla, Mexico



2010s: Tennessee, USA



Worries whether export-led growth still a viable path to economic growth in age of automation, but empirical evidence focuses on developed world

Literature so far

- OECD countries: Gratz & Michaels (2018, REStat)
- United States: Acemoglu & Restrepo (2020, JPE)
- Germany: Dauth, Findeisen, Suedekum & Woessner (2020, R&R JEEA)

This paper

Research question

How do robots affect employment in offshoring countries?

Method

- Use context of Mexico and its trading relations with US
- Exploit variation in *exposure to foreign robots* across Mexican local labor markets between 1990 and 2015
- Construct instrumental variable based on robot adoption outside of US and Mexico to purge results from reverse causality

Results

- US robots reduce employment in Mexico
- Low-educated machine operators in manufacturing most affected
- Evidence for reshoring (reverse of offshoring) as mechanism

Overview

1. Empirical strategy and data
2. Main results
3. Mechanism
4. Conclusion

Accounting for foreign robots in Acemoglu & Restrepo (2020) framework

- Equilibrium response of employment in commuting zone c (L_c) to advances in robotic automation technology from AR (2020):

$$d \ln L_c = \beta_c \sum_{i \in I} \ell_{ci} \frac{dR_i}{L_i} + \epsilon_c, \quad \text{where } \ell_{ci} = \frac{L_{ci}}{L_c} \tag{1}$$

- In offshoring country, considerable share of employment in export-producing sector (∼30% of GDP in Mexico)
- Workers compete not only with *domestic* robots (R_i^d), but also *foreign* robots (R_i^f) in offshorable industries (indicator $O_i = 1$)
- Account for this by including *exposure to foreign robots*:

$$d \ln L_c = \beta_c \underbrace{\sum_{i \in I} \ell_{ci} \frac{dR_i^d}{L_i}}_{\substack{\text{Exposure to} \\ \textit{domestic} \text{ robots}_c \\ \text{as in AR (2020)}}} + \beta_c \underbrace{\sum_{i \in I} \ell_{ci}^f \frac{dR_i^f O_i}{L_i^f}}_{\substack{\text{Exposure to} \\ \textit{foreign} \text{ robots}_c}} + \epsilon_c \tag{2}$$

Taking this to the data using four sources

1. **Robots** (IFR):
   - Shipments of *industrial robots* for 11 countries and 19 industries since 1993
   - Typical applications:
     - Handling, welding, assembling, packaging, dispensing (Manufacturing)
     - Harvesting (Agriculture)
     - Inspecting of structures and equipment (Utilities)
2. **Mexican census** (INEGI):
   - Employment status, municipality of residence and work place, and education level, among others
   - Can construct Commuting Zones (CZs)
3. **Maquiladoras** (UN CEPAL):
   - Factories in Mexico required by law to export all goods they produce
   - Information on number of Maquiladora employees by industry and municipality in 1990
4. **Exports** (Mexico's Tax Administration Service, SAT):
   - Value of exports and number of export-producing plants
   - By municipality and product code, from 2004-2014

Endogenous measures

$$\text{Exposure to domestic robots}_{c,(t_0,t_1)} \equiv \sum_{i \in I} \ell_{ci,1990} \left(\frac{R^{MX}_{i,t_1} - R^{MX}_{i,t_0}}{L_{i,1990}} \right)$$

$$\text{Exposure to foreign robots}_{c,(t_0,t_1)} \equiv \sum_{i \in I} \ell^{f}_{ci,1990} \left(\frac{R^{US}_{i,t_1} - R^{US}_{i,t_0}}{L^{f}_{i,1990}} \right) O_{i,1992}$$

- $\ell_{ci,1990}$: 1990 share of Commuting Zone c employment in industry i (^{f}=exports sector)
- $L_{i,1990}$: 1990 employment in industry i (^{f}=exports sector)
- $R^j_{i,t}$: Industrial robots in country j and industry i at time t
- $O_{i,1992}$: 1992 share of Mexican imports of US output in industry i

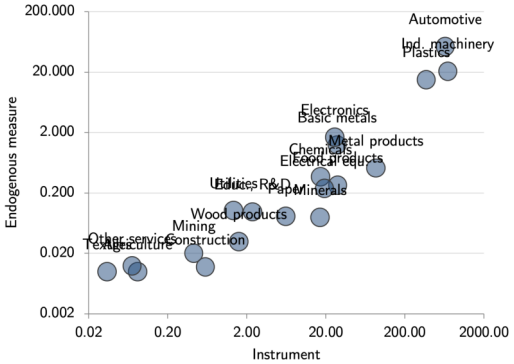
External instruments

$$\text{External exposure to domestic robots}_{c,(t_0,t_1)} \equiv \sum_{i \in I} \ell_{ci,1990} \left(\frac{R^{WLD}_{i,t_1} - R^{WLD}_{i,t_0}}{L_{i,1990}} \right)$$

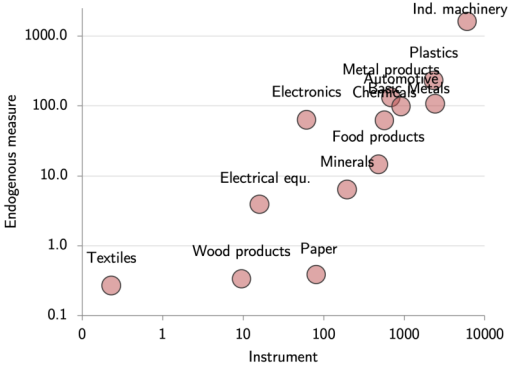
$$\text{External exposure to foreign robots}_{c,(t_0,t_1)} \equiv \sum_{i \in I} \ell^{f}_{ci,1990} \left(\frac{R^{WLD}_{i,t_1} - R^{WLD}_{i,t_0}}{L^{f}_{i,1990}} \right) \tilde{O}_{i,1990}$$

- $\ell_{ci,1990}$: 1990 share of Commuting Zone c employment in industry i (^{f}=exports sector)
- $L_{i,1990}$: 1990 employment in industry i (^{f}=exports sector)
- $R^j_{i,t}$: Industrial robots in country j and industry i at time t
- $\tilde{O}_{i,1990}$: 1990 share of offshorable intermediates in industry i in US (Feenstra & Hanson, 1999)

First-stage industry variation

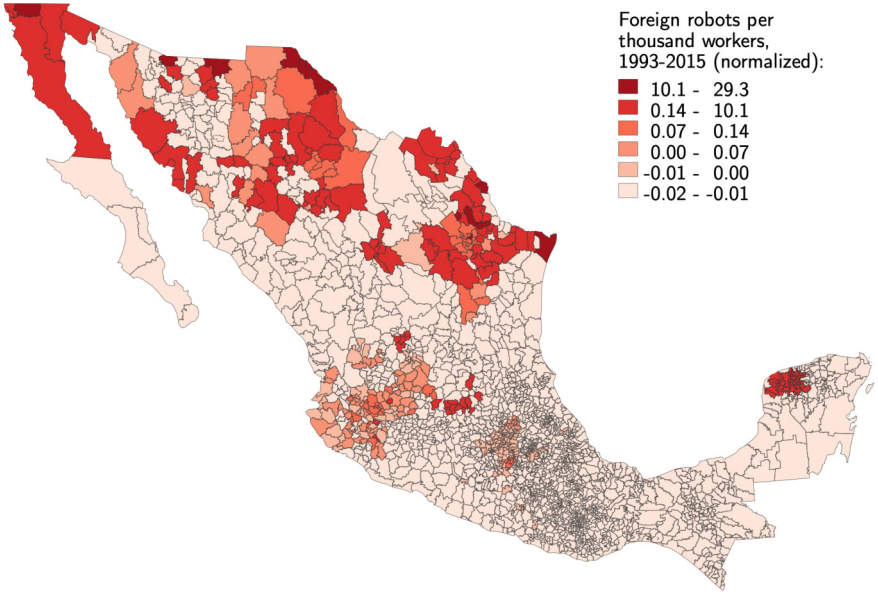


A. Domestic robots



B. Foreign robots

Regional variation in external exposure to foreign robots



Estimating equation

$$\Delta y_{c,(t_0,t_1)} = \beta^d \underbrace{\text{Exposure to domestic robots}}_{c,(t_0,t_1)} + \beta^f \underbrace{\text{Exposure to foreign robots}}_{c,(t_0,t_1)} + \gamma \mathbf{X}_{\mathbf{c,1990}} + \delta_{(t_0,t_1)} + \varepsilon_{c,(t_0,t_1)}$$

- $_c$: Commuting Zone c (1,805 CZs)
- $_{(t_0,t_1)}$: Two stacked time periods (1990–2000 & 2000–15)
- y: Employment-to-population ratio as main dependent variable
- $\mathbf{X}_{\mathbf{c,1990}}$: Vector of covariates for Commuting Zone c in 1990
  - Region dummies
  - Main effects (Maquiladoras, US import reliance)
  - Demographic characteristics & initial conditions
  - Broad industry shares
  - Contemporaneous changes (Chinese imports, NAFTA, computers)
  - Commuting Zone trends (in stacked differences)

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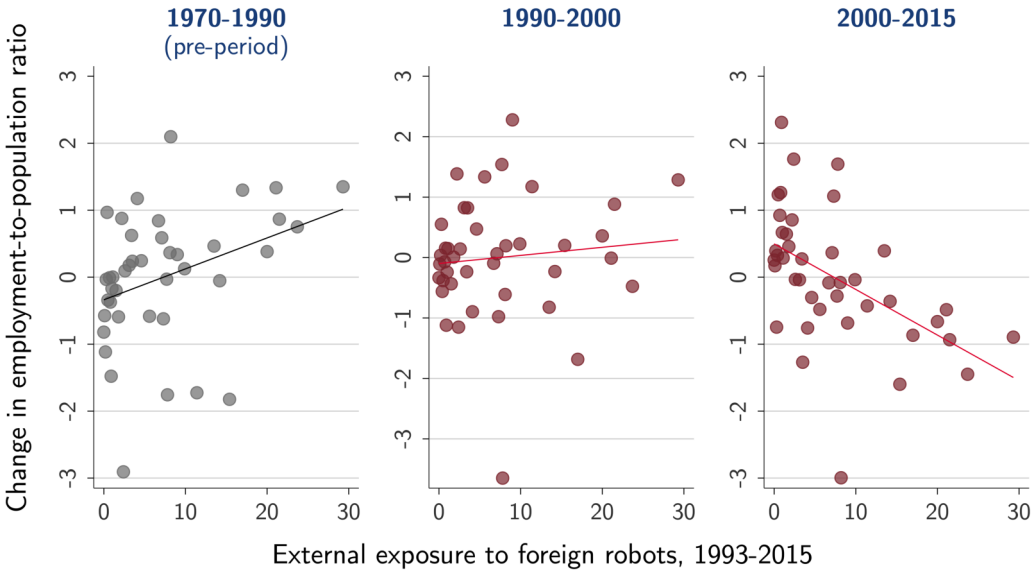
Raw binned scatter plot



Stacked differences regressions (1990–2000 & 2000–15)

	(1)	(2)	(3)	(4)	(5)	(6)
	Δ Employment-to-population ratio (2SLS)					
Exposure to *domestic* robots	-0.57*	-0.07	0.30	-0.17	0.58**	-0.11
	(0.33)	(0.23)	(0.24)	(0.24)	(0.29)	(0.33)
Exposure to *foreign* robots	-0.67***	-0.75***	-0.58***	-0.61***	-0.72***	-0.52**
	(0.18)	(0.19)	(0.14)	(0.16)	(0.13)	(0.23)
Kleibergen-Paap rank *F*	706	222	198	1318	159	104
Period dummies	✓	✓	✓	✓	✓	✓
Region & main effects	✓	✓	✓	✓	✓	✓
Baseline covariates		✓	✓	✓	✓	✓
Contemp. changes			✓	✓	✓	✓
Unweighted				✓		
Only Maquiladora CZs					✓	
CZ trends						✓
Observations	3,610	3,610	3,610	3,610	502	3,610

Effects by time period (1990–2000, 2000–15)

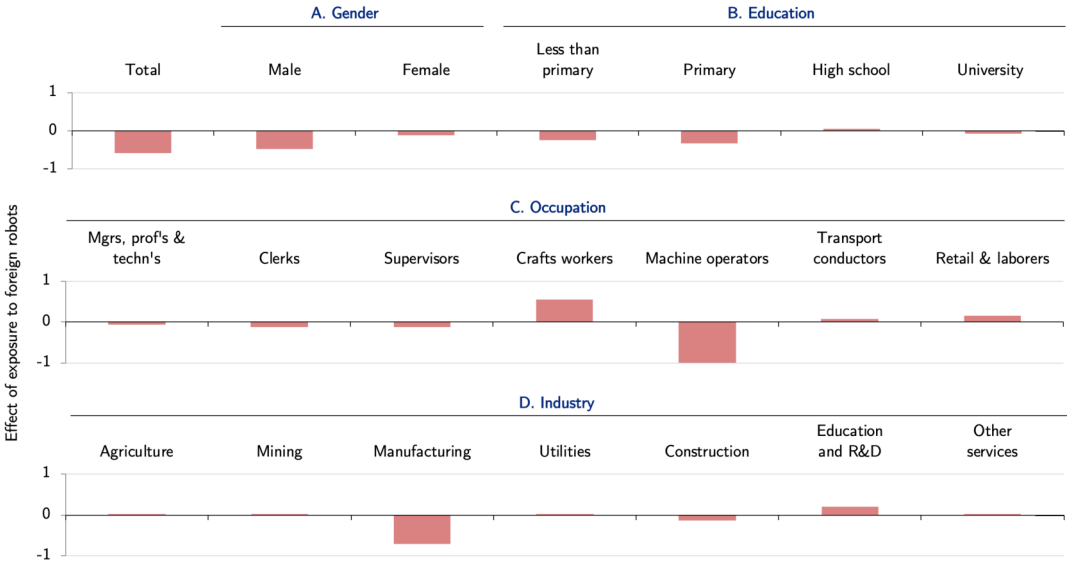
	(1)	(2)	(3)	(4)	(5)	(6)
	Δ Employment-to-population ratio (2SLS)					
	1990-2000			2000-2015		
Exposure to *domestic* robots	-4.73	0.69	3.14	-0.27	0.27	0.44
	(5.10)	(3.60)	(4.36)	(0.33)	(0.26)	(0.29)
Exposure to *foreign* robots	-0.23	-0.04	-0.02	-0.28**	-0.44***	-0.66***
	(1.23)	(1.52)	(1.48)	(0.14)	(0.15)	(0.13)
Kleibergen-Paap rank *F*	84	98	99	62	75	82
Region & main effects	✓	✓	✓	✓	✓	✓
Baseline covariates		✓	✓		✓	✓
Contemp. changes			✓			✓
Observations	1,805	1,805	1,805	1,805	1,805	1,805

Robustness

Results robust to several alternative explanations:

- No significant pre-trends 1970–90
- Not driven by contemporaneous shocks to single industries
- Pattern arises from changes in employment, not migration
- Visible using alternative instruments
- Excluding top 1% of observations with respect to exposure to foreign robots
- Using fixed effects for 31 states instead of nine broad regions
- Using LASSO procedure for covariate selection

Effect heterogeneity



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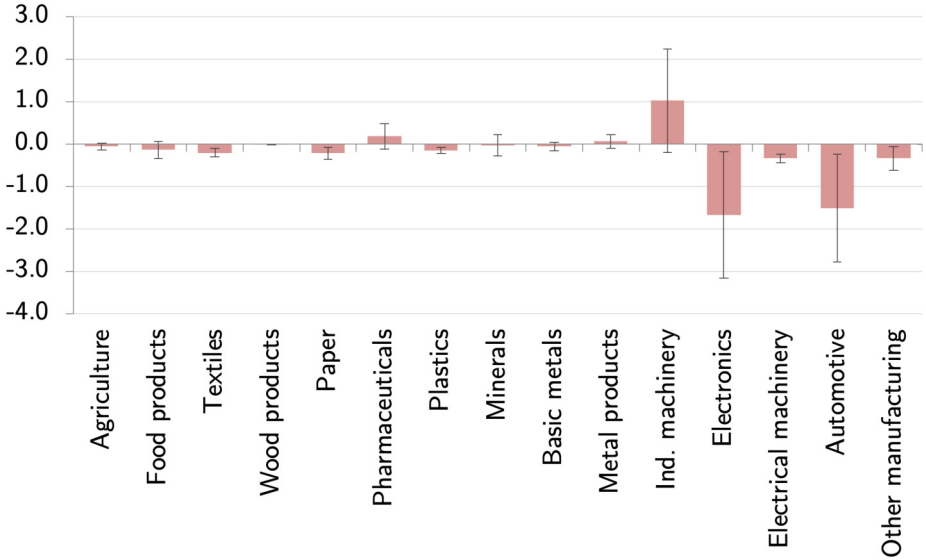
Reshoring as mechanism: Reduction in exports

	(1)	(2)	(3)	(4)	(5)	(6)
	Δ 2004-2014 (2SLS)					
	Exports value per worker			Exports plants per worker		
Exposure to *domestic* robots	5.23***	3.44	2.84	0.15***	0.02	0.05
	(1.87)	(2.89)	(3.03)	(0.05)	(0.06)	(0.05)
Exposure to *foreign* robots	-4.07***	-3.15***	-2.61**	-0.40***	-0.14***	-0.13***
	(1.06)	(1.07)	(1.03)	(0.08)	(0.04)	(0.04)
Kleibergen-Paap rank *F*	57	120	116	57	58	69
Region & main effects	✓	✓	✓	✓	✓	✓
Baseline covariates		✓	✓		✓	✓
Contemp. changes			✓			✓
Observations	1,805	1,805	1,805	1,805	1,805	1,805

Effect of US robots on exports by industry



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Conclusion

- US robots reduce employment in Mexico
- Regions with average exposure to foreign robots have 0.4 percentage points lower emp-to-pop ratio
- Nationally, amounts to roughly 270,000 fewer jobs
- Negative employment effect strongest for
  - men
  - less educated
  - machine operators
  - workers in manufacturing industry
- Reshoring as mechanism: Employment effects mirrored in reduced export volumes

$\Rightarrow$ **Automation technologies capable of changing comparative advantages across countries**