Robots and reshoring: Evidence from Mexican labor markets

Marius Faber
University of Basel

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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.
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):

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

- In offshoring country, considerable share of employment in export-producing sector ($\sim 30\%$ of GDP in Mexico)

- Workers compete not only with *domestic* robots ($R^d_i$), but also *foreign* robots ($R^f_i$) in offshorable industries (indicator $O_i = 1$)

- Account for this by including exposure to foreign robots:

$$d \ln L_c = \beta_c \sum_{i \in I} \ell_{ci} \frac{dR^d_i}{L_i} + \beta_c \sum_{i \in I} \ell^f_{ci} \frac{dR^f_i O_i}{L^f_i} + \epsilon_c \quad (2)$$
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 workplace, 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

\[ c_{i,t} \equiv \sum_{i \in I} \ell_{ci,1990} \left( \frac{R_{i,t_1}^{MX} - R_{i,t_0}^{MX}}{L_{i,1990}} \right) \]

\[ c_{i,t} \equiv \sum_{i \in I} \ell_{ci,1990}^f \left( \frac{R_{i,t_1}^{US} - R_{i,t_0}^{US}}{L_{i,1990}^f} \right) O_{i,1992} \]

- \( \ell_{ci,1990} \): 1990 share of Commuting Zone \( c \) employment in industry \( i \) (\( f = \)exports sector)
- \( L_{i,1990} \): 1990 employment in industry \( i \) (\( f = \)exports sector)
- \( R_{j,t}^i \): 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

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

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

- $\ell_{ci,1990}$: 1990 share of Commuting Zone c employment in industry i ($^f$=exports sector)
- $L_{i,1990}$: 1990 employment in industry i ($^f$=exports sector)
- $R_{i,t}^j$: 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

Foreign robots per thousand workers, 1993-2015 (normalized):
- 10.1 - 29.3
- 0.14 - 10.1
- 0.07 - 0.14
- 0.00 - 0.07
- -0.01 - 0.00
- -0.02 - -0.01
Estimating equation

\[ \Delta y_{c,(t_0,t_1)} = \beta^d_{c,(t_0,t_1)} \text{ Exposure to domestic robots } + \beta^f_{c,(t_0,t_1)} \text{ Exposure to foreign robots } + \gamma X_{c,1990} + \delta_{(t_0,t_1)} + \varepsilon_{c,(t_0,t_1)} \]

- \( c \): 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
- \( X_{c,1990} \): 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

1970-1990 (pre-period)

1990-2000

2000-2015

Change in employment-to-population ratio

External exposure to foreign robots, 1993-2015

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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

A. Gender

- Total
- Male
- Female

B. Education

- Less than primary
- Primary
- High school
- University

C. Occupation

- Mgrs, profs & techn's
- Clerks
- Supervisors
- Crafts workers
- Machine operators
- Transport conductors
- Retail & laborers

D. Industry

- Agriculture
- Mining
- Manufacturing
- Utilities
- Construction
- Education and R&D
- Other services
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Reshoring as mechanism: Reduction in exports

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Kleibergen-Paap rank $F$:

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(2SLS) $\Delta$ 2004-2014
Effect of US robots on exports by industry
Overview

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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

⇒ Automation technologies capable of changing comparative advantages across countries