

Racing With or Against the Machine? Evidence on the Role of Trade in Europe

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Teaching slides — *JEEA Virtual Issue in honor of Giovanni Peri*

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Motivation

- ▶ Rapid diffusion of ICT, automation, and AI renews the “end of work” debate.
- ▶ **False dichotomy** (Acemoglu & Restrepo 2018):
 - ▶ Alarmists in the public press: “47% of jobs are at risk”
 - ▶ Canonical SBTC models: technology is always complementary to (skilled) labor

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 - ▶ Alarmists in the public press: “47% of jobs are at risk”
 - ▶ Canonical SBTC models: technology is always complementary to (skilled) labor
- ▶ **Routine-Replacing Technological Change (RRTC)**
 - ▶ Capital replaces workers in routine tasks (Autor, Levy & Murnane 2003)
 - ▶ Employment effects theoretically ambiguous — depends on offsetting forces
 - ▶ Whether labor races *with* or *against* the machine is an **empirical question**

Our Paper

Research Question

- ▶ What is the **net employment effect of RRTC** in Europe?

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1. Develop a task-based **theoretical framework** capturing the main mechanisms
 - ▶ Labor-saving: capital substitutes for routine labor
 - ▶ Product demand: lower prices raise demand for tradables
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2. Estimate key parameters to analyze **RRTC's net employment effect** (EU LFS data, 1999–2010, 238 regions in 27 EU countries)
3. **Decompose** the total effect into the three channels

Our Paper — Preview of Results

Preview of Results

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Contributions

- ▶ First estimate of RRTC's **net employment effect**
- ▶ Quantifies the **mechanisms** — bridges reduced-form work and theory

Framework

- ▶ Regional modeling approach
 - ▶ Regions $i = 1, 2, \dots, I$
 - ▶ Two sectors: **tradable** and **non-tradable**
 - ▶ Local spillovers between sectors
 - ▶ Exploit regional variation in exposure to RRTC

Framework

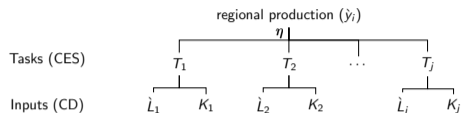
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 - ▶ RRTC only directly in the tradable sector
 - ▶ Non-tradable sector affected indirectly through **local spillovers**
- ▶ Captures **technology-induced regional trade** within the EU
- ▶ Takes into account **labor supply responses**

Notation throughout: grave accent ($\hat{\cdot}$) = tradable sector; tilde ($\tilde{\cdot}$) = non-tradable sector

Production of Tradables



Task aggregation (CES, $0 < \eta < 1$):

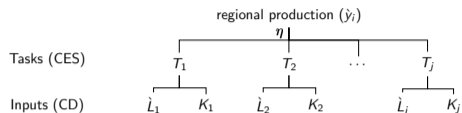
$$\dot{Y}_i = \left[\sum_{j=1}^J \left(\dot{\beta}_{ij} T_{ij} \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

Task production (Cobb–Douglas):

$$T_{ij} = (\dot{L}_{ij})^{\kappa} (\dot{K}_{ij})^{1-\kappa}$$

$\dot{\beta}_{ij}$: region–task efficiency η : substitution elasticity between tasks κ : labor share
 r_j : capital cost of task j T_{ij} : output of task j in region i

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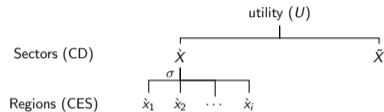
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Labor-saving effect

Cheaper capital replaces **routine workers** ($r_j \downarrow$) and production shifts toward **routine tasks** →
labor demand falls

Consumption / Product Demand



Utility (Cobb–Douglas):

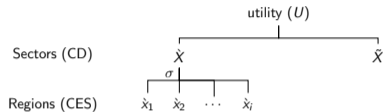
$$U = \tilde{X}^\mu \bar{X}^{1-\mu}$$

Demand for region i 's tradables in i' :

$$\tilde{x}_{ii'} = \left(\frac{\tau_{ii'} \bar{p}_i}{\bar{P}_{i'}} \right)^{-\sigma} \mu \frac{I_{i'}}{\bar{P}_{i'}}$$

μ : expenditure share on tradables $\tau_{ii'}$: iceberg trade cost (region i to i') $\bar{P}_{i'}$: tradable price index in i'
 σ : substitution elasticity between regions $I_{i'}$: local income

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Product demand effect

Lower prices raise demand for tradables ($\hat{p}_i \downarrow$, requires $\sigma > 1$) \rightarrow **labor demand rises**

Non-Tradable Sector

- ▶ Production: **labor only** ($\tilde{Y}_i = \alpha \tilde{L}_i$, α : labor productivity)
- ▶ Occupational labor demand:

$$\tilde{L}_{ij} = (1-\mu) \tilde{\beta}_{ij}^{1-\eta} \left(\frac{\tilde{w}_{ij}}{\tilde{w}_i} \right)^{-\eta} \frac{l_i}{\tilde{w}_i}$$

$\tilde{\beta}_{ij}$: region–occupation efficiency; $\tilde{w}_{ij}/\tilde{w}_i$: relative wage
 \tilde{L}_{ij} rises with local income l_i , falls with relative wage

- ▶ Local income:

$$l_i = \underbrace{\tilde{w}_i \tilde{L}_i}_{\text{non-tradable}} + \underbrace{\kappa \dot{p}_i \dot{Y}_i}_{\text{tradable}}$$

RRTC affects l_i only through **tradable sector income** $\kappa \dot{p}_i \dot{Y}_i$

⇒ **indirect channel** to non-tradables

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Product demand multiplier effect

Higher tradable output raises local income ($\dot{Y}_i \uparrow$, $l_i \uparrow$) \rightarrow demand for local non-tradables rises
 \rightarrow **labor demand rises**

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Labor Supply

$$\hat{N}_{ij} = \bar{N}_{ij} \hat{w}_{ij}^{\epsilon} \quad \text{and} \quad \tilde{N}_{ij} = \bar{\tilde{N}}_{ij} \tilde{w}_{ij}^{\epsilon}$$

\bar{N}_{ij} , $\bar{\tilde{N}}_{ij}$: baseline employment (reference level prior to wage change); ϵ : wage elasticity of labor supply

Stylized approach following Acemoglu & Restrepo (2017):

- ▶ Constant wage elasticity of labor supply ϵ in each segment of the labor market
- ▶ Region-occupation **wages respond** to employment changes
- ▶ Identical to pure labor demand case if $\epsilon \rightarrow \infty$

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- ▶ **Intensive and extensive margins** of labor supply
- ▶ Workers' **mobility** between labor market segments

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Rising wages partly absorb demand effects (down-scaling)

Empirical Implementation: Estimation

(A) Labor demand in region–occupation–year cells \rightarrow yields η and ρ :

$$\log \dot{L}_{ijt} = \beta_0 + \beta_Y \log \dot{Y}_{it} + \underbrace{\beta_c}_{=\eta} \log \frac{\dot{c}_{it}}{\dot{w}_{it}} + \underbrace{\beta_R}_{=(1-\eta)(1-\kappa)\rho} d_j^R \times t + \theta t + v_{ij} + \varepsilon_{ijt}$$

(B) Product demand in region–year cells \rightarrow yields σ :

$$\log \dot{Y}_{it} = \delta_0 + \underbrace{\delta_c}_{=-\sigma} \log \dot{c}_{it} + \delta_{MP} \log MP_{it} + \nu_i + \varepsilon_{it}$$

\dot{c}_{it} : avg. capital cost in region i d_j^R : routine-task dummy v_{ij} : region–occupation FE ν_i : region FE

MP_{it} : market potential (weighted sum of trade partners' income, controls for demand access)

Additionally: κ observed directly in data; $\epsilon = 0.5$ from Chetty et al. (2011)

Identification: Bartik shift-share IVs for \dot{Y}_{it} and \dot{c}_{it} ; leave-one-out female labor supply IV for \dot{w}_{it} ; market potential IV for MP_{it}

Empirical Implementation: Decomposition

Five estimated/observed parameters feed into the decomposition of ΔN :

$$\Delta N = \underbrace{(1-\kappa)\rho}_{\substack{\text{scale: from } \beta_R, \eta, \kappa \\ \text{(labor demand eq.)}}} s^R \dot{N} \frac{\epsilon}{\epsilon + 1 - \kappa + \kappa\sigma} \left[\underbrace{1}_{\substack{\text{labor-} \\ \text{saving}}} \underbrace{-\sigma}_{\substack{\text{product} \\ \text{demand}}} + \underbrace{(1-\sigma)\frac{\tilde{N}}{\dot{N}}}_{\substack{\text{spillover}}} \right]$$

s^R : routine employment share in EU tradables \dot{N} : total EU tradable employment \tilde{N} : total EU non-tradable employment

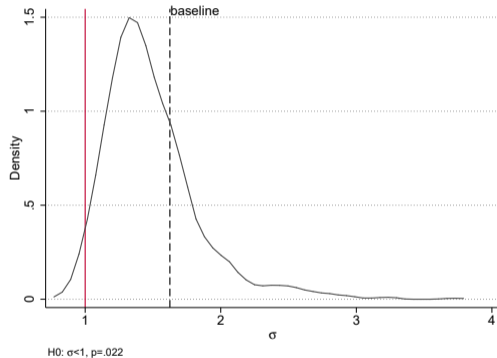
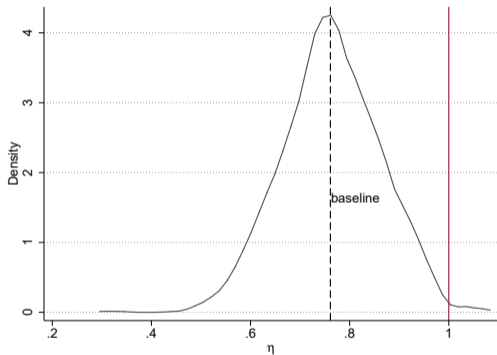
Channel	Driven by	Sign condition
Labor-saving	$\rho < 0, \kappa, s^R$	always negative
Product demand	σ (product demand eq.)	positive if $\sigma > 1$
Spillover	$\sigma, \tilde{N}/\dot{N}$ (data)	positive if $\sigma > 1$
Net	all parameters	positive if $\sigma > 1$

Parameter Estimates

Parameter	Description	Estimate
$(1 - \eta)(1 - \kappa)\rho$	routinization coefficient	-0.028^{***}
η	substitution elasticity between tasks	0.761^{***}
κ	labor share	0.650
ρ	annual log decline in routine capital costs	-0.335^*
σ	substitution elasticity between tradable bundles	1.625^{***}
ϵ	labor supply elasticity (Chetty et al. 2011)	0.500

Key condition for net positive effects: $\eta < 1$ and $\sigma > 1$ — both supported by estimates.

Bootstrapped Parameter Distributions (η and σ)

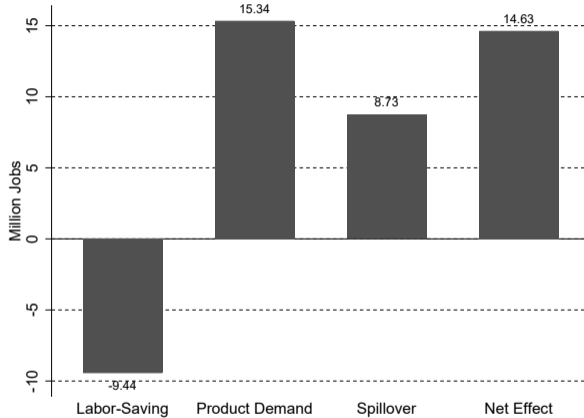


(a) Estimates of η

(b) Estimates of σ

$\eta < 1$ in 99.3% of bootstrap draws; $\sigma > 1$ in 97.8% of bootstrap draws.

Main Results: Predicted European Employment Change, 1999–2010



- ▶ Large substitution effects (-9.4M jobs), overcompensated by product demand effects ($+15.3\text{M}$) and spillovers ($+8.7\text{M}$)
- ▶ **Net: $+14.6$ million jobs** — lower bound estimate

Main Results: Decomposition Table

Channel	Effect (million jobs)	Sign
Labor-saving effect	-9.44	-
Product demand effect	+15.34	+
Spillover effect	+8.73	+
Net effect	+14.63	+

- ▶ All three channels **statistically significant** (bootstrapped p-values < 0.03)
- ▶ Net effect corresponds to ~**64%** of total EU employment growth of 23M jobs over 1999–2010
- ▶ Implied **local non-tradable multiplier**: $\frac{8.73}{15.34 - 9.44} \approx 1.48$ (similar to Moretti 2010)

Extension 1: Elastic Capital–Labor Substitution

Baseline assumes Cobb–Douglas within tasks (unit substitution elasticity, $\eta^K = 1$).

- ▶ Allow CES within-task technology with elasticity η^K
- ▶ Calibrate η^K to reproduce **observed declines in labor shares**
- ▶ Mean calibrated $\eta^K \approx 1.12$; 95th percentile $\eta^K \approx 1.87$

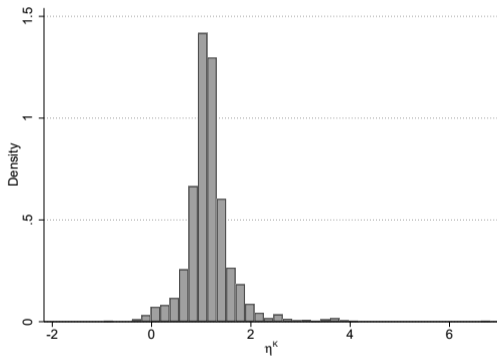
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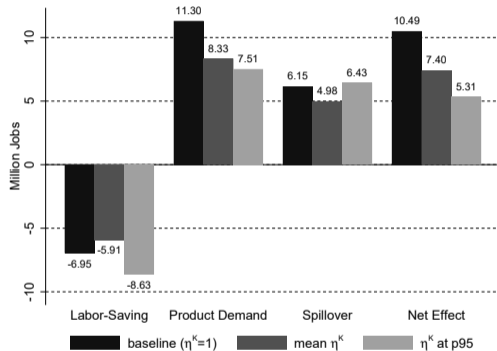
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Key insight: larger η^K strengthens substitution away from labor, reducing the net employment effect — but net effects remain **positive** throughout.

Extension 1: Elastic Capital–Labor Substitution (cont'd)



(a) Distribution of calibrated η^K



(b) Predicted European employment change, 1999–2010

Extension 2: Mark-Ups, Profits, and Local Demand

Baseline (lower bound): no firm profits feed back into local demand.

- ▶ Data show rising mark-ups: firms pass on only $\sim 68\%$ of cost declines to prices
- ▶ **Upper bound:** all additional profits spent locally \Rightarrow larger spillovers
- ▶ **Counterfactual:** had mark-ups not risen, price declines would be larger \Rightarrow stronger product demand

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Scenario	Net effect (million jobs)
Baseline (lower bound, no profit feedback)	+14.63
Upper bound (all profits spent locally)	+19.10
Counterfactual (no mark-up increase)	+25.81

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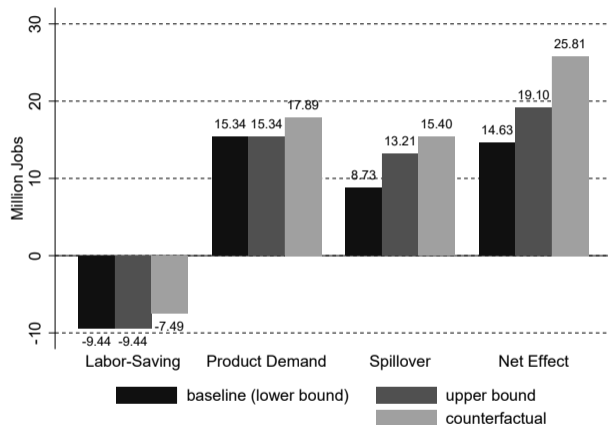
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Policy relevance: the **allocation of gains** — wages vs. profits, local vs. non-local capital owners — materially affects employment outcomes.

Extension 2: Mark-Ups, Profits, and Local Demand (cont'd)



Predicted employment change (million jobs), Europe 1999–2010: lower bound, upper bound (all profits spent locally), and counterfactual (no mark-up increase).

Racing *With* Rather Than *Against* the Machine

Key Results:

1. **Positive net employment effect** from RRTC in Europe, 1999–2010
2. Product demand effects **overcompensate** substantial capital-labor substitution
3. Size of spillovers depends on **where the gains from RRTC accrue**

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Labor was racing *with* the machine:

- ▶ Focusing on substitution potentials alone is **insufficient** — compensating effects are quantitatively large
- ▶ RRTC **did not reduce** aggregate employment; it is a **key driver** of European job growth
- ▶ **Who owns the capital?** The allocation of gains shapes whether routinization creates or destroys jobs

Thank you for your attention!

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