Automation, Globalization and Vanishing Jobs: A Labor Market Sorting View

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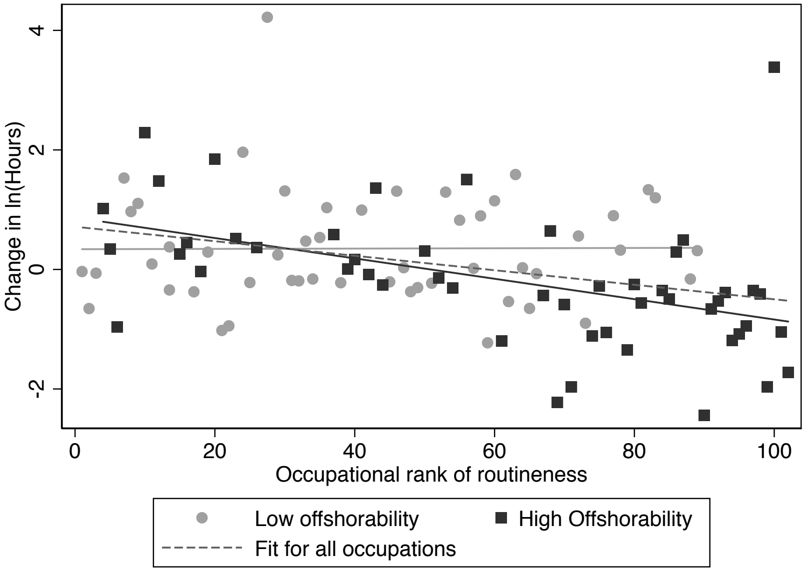
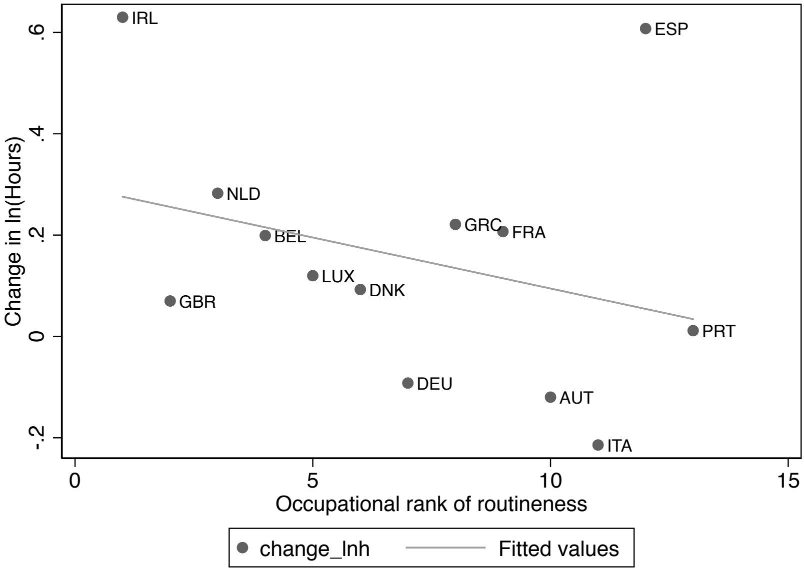
Motivation

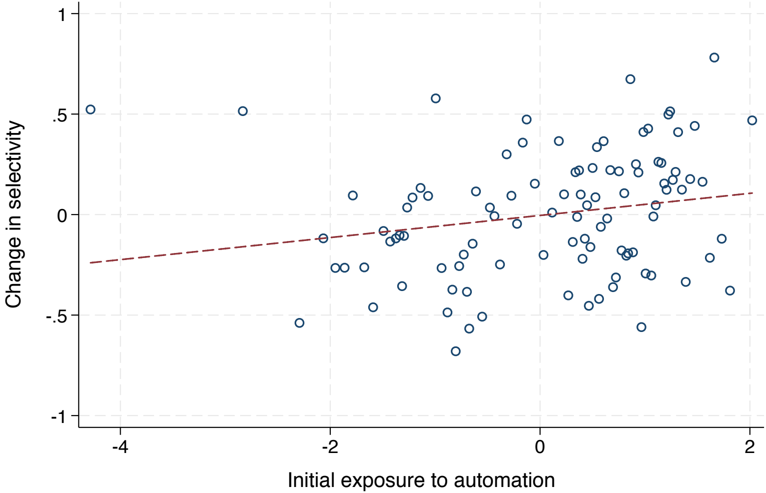
- Concerns about the effects of new technologies on labour demand:
  - Routine-Biased Technological Change / Automation
  - Offshoring (works just like a "new technology")
- BUT "it is harder than one might think to write down economic models in which workers as a group are harmed by new technology" (Caselli, Manning, 2018)
  - Threats to employment from new technology may come more from impacts on the competitiveness of markets in the presence of *frictions* than from changes in the production function in the presence of *frictionless* markets.



Change in ln(Hours)
-2
0
2
4
0
20
40
60
80
100
Occupational rank of routineness
Low offshorability
High Offshorability
Fit for all occupations



IRL
ESP
NLD
GRC
FRA
BEL
LUX
DNK
GBR
PRT
DEU
AUT
ITA
Change in ln(Hours)
.6
.4
.2
0
-.2
0
5
10
15
Occupational rank of routineness
change_lnh
Fitted values



1
.5
0
-.5
-1
Change in selectivity
-4
-2
0
2
Initial exposure to automation

- Challenges to the "rosy" neoclassical view come from ...

  ... "Structural Story"

  - Structural demand shift for certain skills (RBTC vs. SBTC).
  - *Vertical* skill-task mismatch.
  - Growing empirical and theoretical evidence.

  ... "Frictional Story"

  - Search frictions hinder the efficient matching between heterogeneous firms and workers.
  - *Horizontal* skill-task mismatch.
  - TC increases productivity of ideal match relative to less-than-ideal ones, above and beyond any considerations of skill or routine bias.

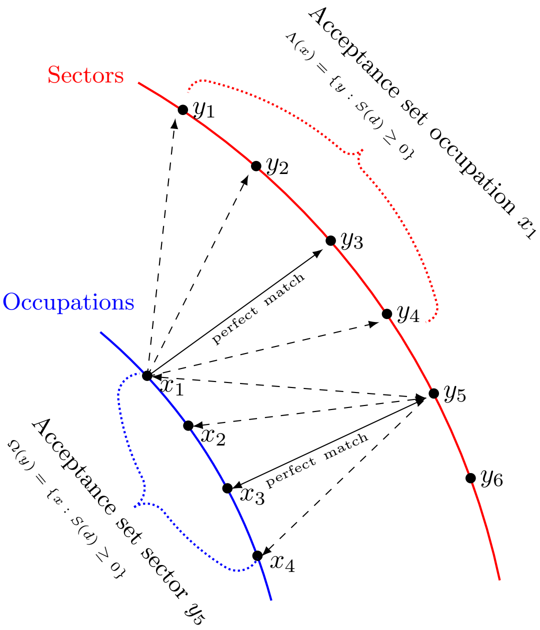
  $\Rightarrow$ **Core-Biased Technological Change**

  - Additional effects of automation and offshoring that are at work independently from any vertical heterogeneity.

The Model: Two-Sided Heterogeneity

- Firms that need heterogeneous tasks to be performed and workers who are endowed with heterogeneous skills to perform those tasks.
- Heterogeneity as *horizontal differentiation* with workers/firms having a different "address" along the unit circle.
  - *Circular Sorting Model*
  - Symmetry!
- Continuum of workers with heterogeneous occupation-specific "core-skills" indexed $x \in [0, 1]$ clockwise from noon, uniform pdf $g_w[x]$ and measure L.
- Continuum of firms with heterogeneous sector-specifc "core-tasks" indexed $y \in [0, 1]$ clockwise from noon (free entry).
- Complementarity induces sorting
  - "Mismatch" between occupation and sector adresses:

$$d(x, y) = min(x - y + 1, y - x)$$


Sectors
Occupations
Acceptance set occupation x_1
$\Lambda(x) = \{y : S(d) \geq 0\}$
Acceptance set sector y_5
$\Omega(y) = \{x : S(d) \geq 0\}$
y_1
y_2
y_3
y_4
y_5
y_6
x_1
x_2
x_3
x_4
perfect match
perfect match

The Model: Search

- Workers/Firms are infinetly lived, risk-neutral, discount rate ρ
- Search is random with matching function:

$$M(U, V) = \theta U^{\varphi} V^{1-\varphi}$$

- Productive matches fall in the acceptance ranges for y and x $\Rightarrow$ Symmetry implies one $d*$

$$V_E(d) = w(d) - \delta\,(V_E(d) - V_U)$$

$$V_U = 2 * q_u(\theta) \int_0^{d^\star} (V_E(z) - V_U)\,dz$$

$$V_P(d) = f(d) - w(d) - c) - \delta * (V_P(d) - V_V) > V_P(d^*) = 0$$

$$V_V = -c + 2 * q_v(\theta) \int_0^{d^\star} (V_P(z) - V_V) \overset{!}{=} 0$$

- Nash Bargaining, free-entry and steady-state flow condition close the model.

Production Function

- Cobb-Douglas production function at match level with distance d

$$f(d) = AK(d)^{\beta} L(d)^{1-\beta} \tag{1}$$

with state of technology:

$$A \tag{2}$$

With endogenous capital in elastic supply production becomes

$$f(d) = \phi A^{\frac{1}{1-\beta}} \left(F - \frac{\gamma A^{\eta}}{2} d \right) \tag{3}$$

with effective labor

$$L(d) = \left(F - \frac{\gamma A^{\eta}}{2} d \right) \tag{4}$$

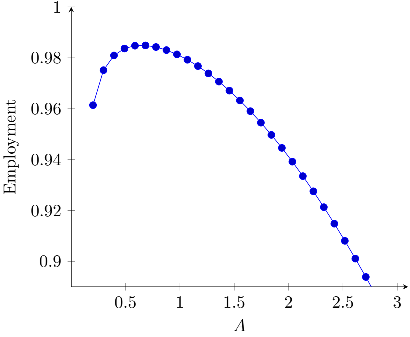
where

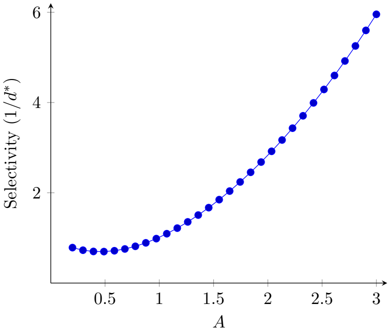
- $\xi = \left(\frac{\beta}{r}\right)^{\frac{\beta}{1-\beta}}$ with return to capital r.

$$f(d) = \phi A^{\frac{1}{1-\beta}} \left(F - \frac{\gamma A^{\eta}}{2} d \right) \tag{5}$$

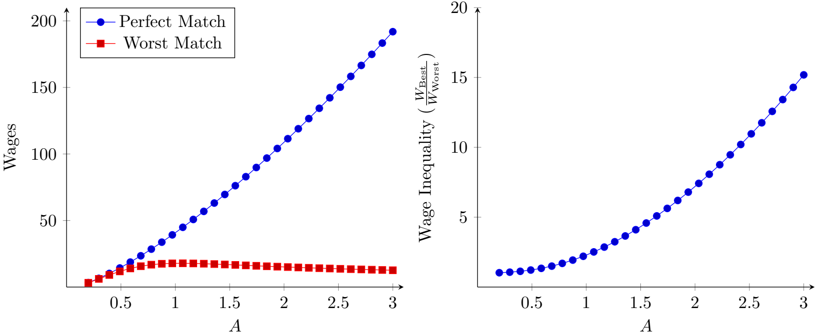
- log-submodular in d and A
- γA^{η} is a "mismatch cost" parameter capturing how much output is lost when mismatch increases:
  - $\Rightarrow$ Substitutability of skills (tasks) with core ones in performing (employing) any given task (occupation).
  - $\Rightarrow$ $\gamma \longrightarrow 0$ no mismatch cost (perfect substitutability).
  - $\Rightarrow$ $\gamma \longrightarrow \infty$ prohibitive mismatch cost (no substitutability).
  - $\Rightarrow$ $\eta = 0$ mismatch cost does not depend on the state of technology.
- $A \nearrow$ (automation/offshoring) has two opposing effects:
  - $\Rightarrow$ *Neoclassical Effect* through $A^{\frac{1}{1-\beta}}$
  - $\Rightarrow$ *Mismatch Effect* through γA^{η}
  - $\Rightarrow$ **Core-biased Technological Change**
- Key intuition: If change in productivity is large, the value of the ideal match increases such that both parties prefer to sit on the fence waiting for a better match and employment decreases!

The Model: Simulation I

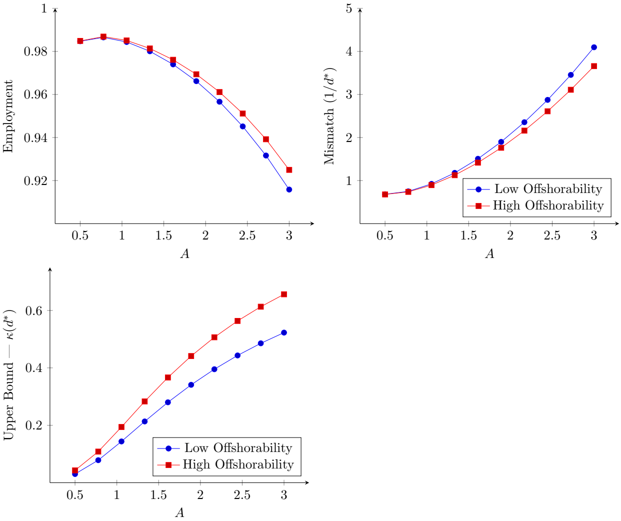




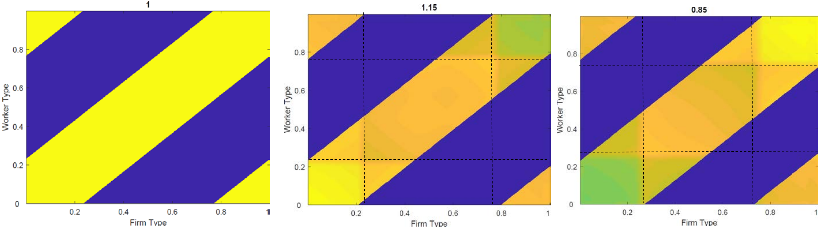
The Model: Simulation II



Model Robustness I: Offshoring

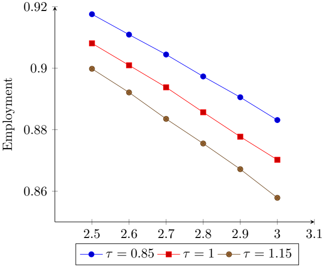


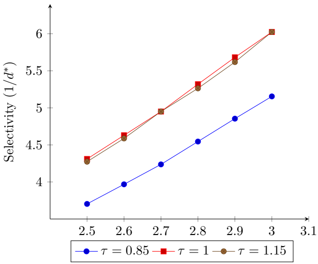
Model Robustness II: Vertical Heterogeneity I



(a) (b) (c)

Model Robustness II: Vertical Heterogeneity II





Data

- We capture skill heterogeneity at the occupational level and task heterogeneity at the sectoral level.
- Data on employment and mismatch from EULFS for country $\times$ industry $\times$ occupation $\times$ year
  - 16 sectors (out of 21 sectors in the NACE Rev.2 classification; dropped public and agricultural sectors).
  - 92 occupations (out of 28 occupations in the ISCO-88 classification; dropped occupations closely associated to public and agricultural sectors).
  - Years: 1995-2010.
  - 13 Countries with full coverage (Austria, Belgium, Germany, Denmark, Spain, France, Great Britain, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal).

Automatability and Offshorability

- Conceptually different:
  - Offshorability (Blinder, Krueger; 2013): "the ability to perform one's work duties in a foreign country, but supply good/service at home."
  - Automatability: linked to the routineness of a task, possibility to be solved algorithmically.
- Automability:
  - Autor and Dorn (2013): Routine Task Intensity (RTI)
    - ⇒ Log of Routine tasks minus Sum Log of Abstract and Log of Manual tasks.
- Off-shoring:
  - Blinder (2009) and Blinder and Krueger (2013): questionnaires and qualitative observations:
    - ⇒ Professional coders based on a worker's occupational classification (PDII: Princeton Data Improvement Initiative).

Specialization

- Sectors to proxy "tasks" and occupations to proxy "skills".
- Define selectivity as the concentration of an occupation's employment across sectors ⇒ "Sectoral Specialization of the Occupation" **(SSO)**.
- Herfindahl Index of occupation's employment share across industries.

⇒ **High SSO**: few sectors account for a large share of the occupation's employment.

⇒ **Low SSO**: implies that employees in an occupation are similarly spread across many sectors.

⇒ Inversely related to size of the theoretical matching set.

Empirical Strategy

- **Step 1:** From Technology to Selectivity

$$\Delta ln(SSO_{oi}) = \alpha + \beta_1 RTI_o^H + \beta_2 RTI_o^L + \beta_3 Offshor_o^{95} + Z_{oi}'\mathbf{C} + \mu_i + \epsilon_{oi} \quad (6)$$

- **Step 2:** From Selectivity to Employment

$$\Delta ln(Hours_{oi}) = \gamma + \underbrace{\delta_1 \Delta ln(SSO_{oi})}_{\substack{\text{Enodgeneity/Rev. Causality} \\ \Rightarrow\textbf{Double-Bartik Instrument}}} + K'\mathbf{C_2} + \eta_i + \upsilon_{oi} \quad (7)$$

The model has two main implications:

1. $\beta_1 > 0$
   - Automation and offshoring fosters selectivity from 1995 to 2010.
2. $\delta_1 < 0$
   - Increased selectivity decreases employment.

From Technology to Selectivity I

	$\Delta ln(SSO)$			
RTI^H_{95}	0.207**	0.168*		0.301**
	(0.100)	(0.0994)		(0.150)
RTI^L_{95}	-0.0151	0.00885		0.00952
	(0.0792)	(0.0781)		(0.0972)
$Offshor._{95}$	-0.0923**	-0.123**	-0.0691	-0.0943**
	(0.0432)	(0.0525)	(0.0427)	(0.0440)
RTI $\times$ Offshor.		0.0667		
		(0.0470)		
RTI_{95}			0.0312	
			(0.0552)	
$Share_{95}$			0.0727	
			(2.117)	
$Share_{95} \times RTI_{95}$			4.874***	
			(1.596)	
Observations	1,063	1,063	1,063	1,063
R-squared	0.143	0.149	0.146	0.115
Fixed effects	Country	Country	Country	Country
Spillover Controls				Yes

From Technology to Selectivity II — Spillovers Concerns

- Reallocation following a potential shock may bias the selectivity measure in other occupations of the same country (assuming that spillover effects are restricted within country)
  - In column (5) we control for potential spillover effects following Berg and Streitz (2019).
  - Effectively a linear-in-means estimate where spillovers are assumed to vary linearly with group-average treatment effect
  - Convert continuous RTI into indicator variable at the median $\mathbb{1}_{RTI_o^{95} > q_{50}(RTI_o^{95})}$
  - Mean-linearity implies the omission of any fixed effects at the group-level.

$$
\begin{aligned}
\Delta ln(SSO_{oi}) &= \beta_1 (RTI_o^{95} \times \mathbb{1}_{RTI_o^{95} > q_{50}(RTI_o^{95})}) + \beta_2 \left(RTI_o^{95} \times \left(1 - \mathbb{1}_{RTI_o^{95} > q_{50}(RTI_o^{95})} \right) \right) \\
&+ \beta_3 \left(\overline{RTI}_i \times \mathbb{1}_{RTI_o^{95} > q_{50}(RTI_o^{95})} \right) + \beta_4 \left(\overline{RTI}_i \times \left(1 - \mathbb{1}_{RTI_o^{95} > q_{50}(RTI_o^{95})} \right) \right) \\
&+ Z' \mathbf{C} + \epsilon_{oi}
\end{aligned} \quad (8)
$$

Alternative Measures of Selectivity

	Δ Mismatch	Δ Under-educ.	Δ Over-educ.	Δ Unemp. Dur.
RTI_{95}	-0.0347	-0.00340***	0.00305***	0.0409*
	(0.0984)	(0.000742)	(0.000778)	(0.0243)
$Offshor._{95}$	0.0532	0.00220**	-0.00167**	-0.0183
	(0.114)	(0.000858)	(0.000795)	(0.0319)
$RTI_{95} \times Offshor._{95}$	-0.290***	-0.00177**	-0.00113	0.0454
	(0.111)	(0.000814)	(0.000805)	(0.0328)
Observations	1,915	1,915	1,915	905
R-squared	0.236	0.143	0.235	0.183
Fixed effects	Country-Industry			

- For educational mismatch, over-education and under-education,
  - Compare each worker's education in terms of years to the educational level of his peers (as defined by occupation, sector or country) at the date of the observation.
  - A worker is over-educated (under- educated) if her educational level is above (below) the average in her occupation, industry, country and 10-year cohort by more than 2 standard deviations.
- To compute the unemployment duration in a cell, we assign an unemployed worker to the cell of his last job and aggregate the observations at the 2-digit ISCO level.

From Selectivity to Employment I

$$\Delta ln(Hours_{oi}) = \gamma + \underbrace{\delta_1 \Delta ln(SSO_{oi})}_{\substack{\text{Enodgeneity/Rev. Causlity} \\ \Rightarrow \textbf{Double-Bartik Instrument}}} + K' \mathbf{C_2} + \eta_i + \upsilon_{oi} \tag{9}$$

- Construction of **Double-Bartik Instrument** (similar to Chodorow-Reich, Wieland 2019):
  1. Compute the *Bartik-predicted* change (cell-level employment growth exactly the same as in that occupation and industry in all other countries in our sample).

     $$\widehat{L^b_{oik,2010}} = g^b_{o,-i,k,2010} \times s_{o,i,k,1995} \tag{10}$$

  2. Compute the *Bartik-predicted* selectivity using the shares computed in the first step to derive the Herfindahl index

     $$\widehat{SSO^b_{oi,2010}} = \sum_{k \in \mathcal{K}} (\hat{s}^b_{oik,2010})^2$$

     $$\widehat{\Delta SSO^b_{oi}} = ln\left(\frac{\widehat{SSO^b_{oi,2010}}}{SSO_{oi,1995}}\right)$$

From Selectivity to Employment II

	$\Delta ln(Hours)$				
$\Delta ln(SSO)$	-0.160***	-0.161*	-0.169***	-0.267***	-0.446***
	(0.0417)	(0.0852)	(0.0349)	(0.0658)	(0.0809)
$\Delta ln(L^b)$	0.266***	0.266***	0.297***	0.302***	0.0697
	(0.0640)	(0.0647)	(0.0629)	(0.0650)	(0.0883)
RTI_{95}			-0.226***	-0.225***	
			(0.0425)	(0.0427)	
$Offshor._{95}$			0.0719	0.0668	
			(0.0562)	(0.0578)	
RTI $\times$ Offshor.			-0.178***	-0.181***	
			(0.0447)	(0.0453)	
FE	Country	Country	Country	Country	Country $\times$ Occup.
Instrument	No	Bartik	No	Bartik	Bartik
Observations	1,073	1,073	1,062	1,062	1,073

From Selectivity to Employment III

	$\Delta ln(Hours)$					
$\Delta ln(SSO)$	-0.339***	-0.694***				
	(0.101)	(0.151)				
$\Delta ln(SSO) \times RTI^{H}_{95}$			-0.343***	-0.507***	-0.357***	-0.714**
			(0.119)	(0.159)	(0.126)	(0.288)
$\Delta ln(SSO) \times RTI^{L}_{95}$			0.105	0.0594	0.244**	0.241**
			(0.107)	(0.112)	(0.0973)	(0.109)
$\Delta ln(L^{b})$	0.223***	-0.145	0.326***	0.248***	0.113	-0.0954
	(0.0845)	(0.109)	(0.0700)	(0.0764)	(0.0846)	(0.116)
RTI_{95}	-0.194***					
	(0.0511)					
$Offshor._{95}$	0.0445		0.00564	0.0340		
	(0.0644)		(0.0521)	(0.0606)		
RTI $\times$ Offshor.	-0.182***		-0.205***	-0.147***		
	(0.0507)		(0.0394)	(0.0485)		
FE		ISCO3			ISCO3	ISCO3
Instrument	Bartik	Bartik	Bartik	Bartik	Bartik	Bartik
$\Delta ln(SSO) > 0$	Yes	Yes		Yes		Yes
Observations	558	563	1,062	558	1,073	563
K-P F-Test 1st	90.11	63.88	24.31	17.93	9.593	11

Aggregate Effects

- Less structural approach than e.g. Salomons et al. (2019)
- Instead estimate econometric model and create counterfactual predictions without effect of initial automatability:

$$\begin{aligned} \Delta ln(Hours_{oik}) &= \beta_1 RTI^{95}_{oik} + \beta_2 Off^{95}_{oik} + \beta_3 RTI^{95}_{oik} \times Off^{95}_{oik} \\ &+ \mu_{ik} + \mu_{oi} + \epsilon_{okc}, \end{aligned} \tag{11}$$

- with $\ln\left(\widehat{H^k_{10}/H^k_{95}}\right) = \ln\left(\widehat{H^k_{10}}/H^k_{95}\right)$ we obtain predictions

$$\widehat{H^k_{10}} = H^k_{10} \exp\left(\ln\widehat{\left(\frac{H^k_{10}}{H^k_{95}}\right)} - \ln\left(\frac{H^k_{10}}{H^k_{95}}\right)\right)$$

and counterfactual predictions $\widetilde{H}^k_{10}$ with $\beta_1 = \beta_3 = 0$

Predicted impact of automation on aggregate employment

Country	Number of hours	
	Observed - Counterfactual $\Delta_1 = H^k_{10} - \widetilde{H}^k_{10}$	Predicted -Counterfactual $\Delta_2 = \widehat{H^k_{10}} - \widetilde{H}^k_{10}$
AUT	5588166	-3400177
BEL	4682215	2741240
DEU	-7083773	-15680964
DNK	3544136	51327
ESP	-33149281	-39131725
FRA	13787699	-10408017
GBR	65426662	6381045
GRC	-3572807	-5935122
IRL	12653495	1409682
ITA	39957419	-20904866
LUX	436904	-69497
NLD	12442593	4042058
PRT	10267282	-10856301

Conclusion

- Our aim is to understand the impact of "new technology" (automation/offshoring) on employment in frictional labor markets with sorting.
- Key hypothesis is that better-matched workers and firms enjoy a comparative advantage in exploiting new technologies.
- *Productivity Effect vs. Mismatch Effect*
- Capture task heterogeneity at the sectoral level and skill heterogeneity at the occupational level:
  - New technologies increase *Selectivity*
  - Higher Selectivity reduces *Employment*