Free Movement of Inventors: Open-Border Policy and Innovation in Switzerland

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Introduction

Immigration and Innovation Research

- The positive effects of immigration on innovation
  - Evidence on the US
    (Hunt and Gauthier-Loiselle, 2010; Kerr and Lincoln, 2010)
  - Historical studies on leading scientists
    (Moser et al., 2014; Ganguli, 2015; Moser and San, 2020)
  - Less evidence on other countries and contemporary contexts
    (Ozgen et al., 2013; Parrotta et al., 2014; Bosetti et al., 2015; Beerli et al., 2021)
- Effects on natives' productivity and mechanisms
  - Immigrants' spillovers and learning effects
    (Moser et al., 2014; Ganguli, 2015; Bernstein et al., 2018)
- Contemporary S&Es migration flows: inexperienced and relatively young (d'Aiglepierre et al., 2020)
- Age and great achievement in science, engineering, and entrepreneurship
  (Jones, 2010; Jones and Weinberg, 2011; Azoulay et al., 2020)

→ *Specialization and division of R&D labor* (Jones, 2009)

This paper

- We study the **innovation effects** of the Agreement on the Free Movement of Persons (AFMP), signed by Switzerland and the EU in 1999

- Natural experiment:
  - Regional differences in the exposure to the AFMP (Beerli et al., 2021)
  - Focus on permit G holders: **cross-border inventors (CBIs)**

- Research questions:
  - What were the AFMP effects on innovation in Switzerland?
  - What were the AFMP effects on Swiss inventors (displacement, productivity)?
  - How were Switzerland's neighbouring countries affected?

Switzerland: an ideal "laboratory"

- Innovation hub
  - Ranked first worldwide for patents per million inhabitants
    (EPO Annual Reports, 2013-2019)
  - Ranked twelfth worldwide for Researchers / Population
    (Global Innovation Index, 2020)

- Leading role of immigrants
  - 28% of all inventors active in 2002-2015 are immigrants, the majority of which from France, Germany, and Italy (Cristelli, 2021)
  - Also historically:

Alexander Clavel	Henri Nestlé	Walter Boveri
▷ 1805-1873	▷ 1814-1890	▷ 1865-1924
▷ French-born	▷ German-born	▷ German-born
▷ CIBA owner (now Novartis)	▷ Nestlé founder	▷ Brown, Boveri, & Co. co-founder (now ABB)

- Importance of cross-border commuting
  - 32% of immigrant inventors are cross-border commuters (2002-2012) (Cristelli, 2021)

Preview of Results

In the post-AFMP, in regions close to the Swiss border:

1. Sharp inflow of CBIs and 15%-54% annual increase in patenting over the first eight years
2. No evidence of displacement of Swiss resident inventors
3. No adverse effects on patenting in Switzerland's neighbouring countries
4. Incumbent inventors raise their patenting by 17%-46% per year, almost entirely through new collaborations with CBIs
5. Incumbents team up with more distinct co-inventors and cite more prior art from CBIs' home countries
6. No major knowledge transfers: incumbents' new patents do not introduce novel terms or depart from their prior technological classes
7. R&D locations expand inventor headcount, with no change in team size or experience $\rightarrow$ capacity expansion, not reorganization

Previous literature

- **The AFMP as a natural experiment** (Beerli et al., 2021)
  - No adverse effects on Swiss workers' employment and wages
  - Increased Swiss firms' propensity to patent (survey-based)
  - → We use full EPO patent data; quantify and qualify innovation effects; link directly the supply shock of foreign inventors to patenting; extend to neighbouring countries; analyse individual inventors and their collaborations

- **Immigration and innovation in destination countries**
  (Kerr and Lincoln, 2010; Hunt and Gauthier-Loiselle, 2010; Kerr et al., 2015; Burchardi et al., 2020; Doran et al., 2020; Glennon, 2020)
  - European studies mostly use immigrant shares at workforce/population level (Ozgen et al., 2013; Parrotta et al., 2014; Bosetti et al., 2015; Nathan, 2015; Ferrucci and Lissoni, 2019)
  - → One of few studies on the EU's Free Movement of Workers principle (Kahanec et al., 2016; Dorn and Zweimüller, 2021)

- **Productivity effects on natives**
  - Kerr and Lincoln (2010): H-1B raises foreign-inventor patenting, no positive effect on natives
  - Moser et al. (2014); Ganguli (2015): established émigrés generate major knowledge transfers
  - → We find positive effects on Swiss incumbents, but *no* major knowledge transfers

Database

Data

EPO patents filed between 1990-2012 (Patstat 2017b)

- **Switzerland:**
  - At least one inventor with Swiss address
  - At least one inventor in Permit G area + Swiss-based applicant
  - Inventors' and applicants' disambiguation
  - Identification of R&D labs based on inventors' addresses
    - Spatial mobility regions: small commuting-to-work areas
  - Cross-border inventors (CBIs): Address definition (1990-2012) & Permit G definition (matched database, 2002-2012)

  → *Patents: 67,869*
- **Neighbouring countries:**
  - At least one inventor with address in Austria, France, Germany, and Italy
  - Excluding patents co-filed with Swiss-based applicants
  - Patents assigned to Nuts-3 regions

  → *Patents: 28,253 (Austria); 161,132 (France); 429,198 (Germany); 83,480 (Italy)*

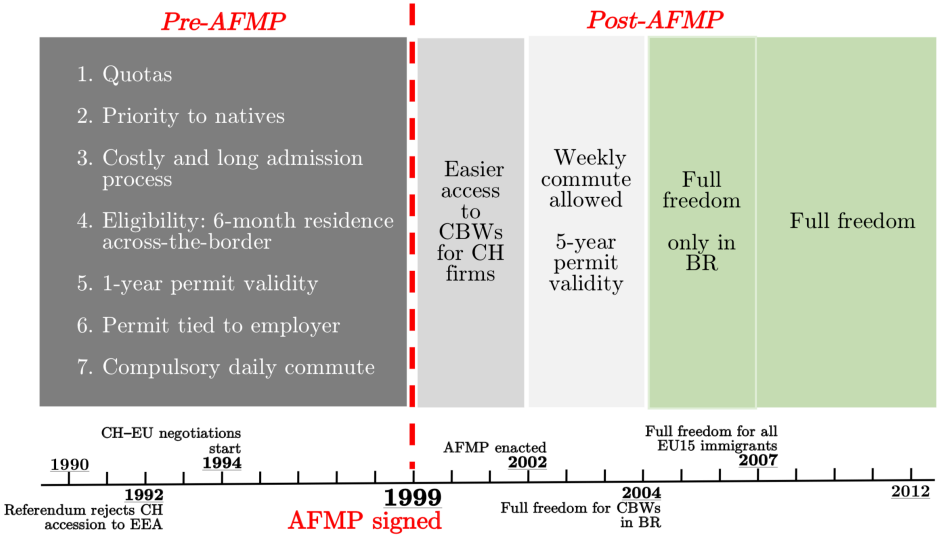
Matching inventor and immigrant records

EPO inventors + micro-level records in ZEMIS, administrative database on the full population of foreigners with a Swiss immigrant permit (2002-2012)

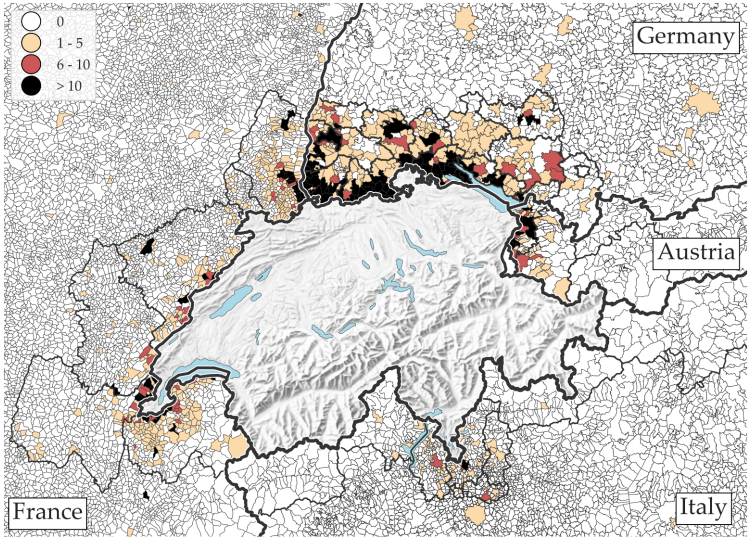
- Binary classification approach (Feigenbaum, 2016)
  - Hand-curated training set
  - Probit classifier
  - Features: name similarity, age, residence/work location
  - Algorithm's out-of-sample performance on validation set: precision: 93%; recall: 71%
  - Around 17,000 inventors

Natural Experiment

The Agreement on the Free Movement of Persons (AFMP)



Number of cross-border inventors by municipality of residence, 1990-2012



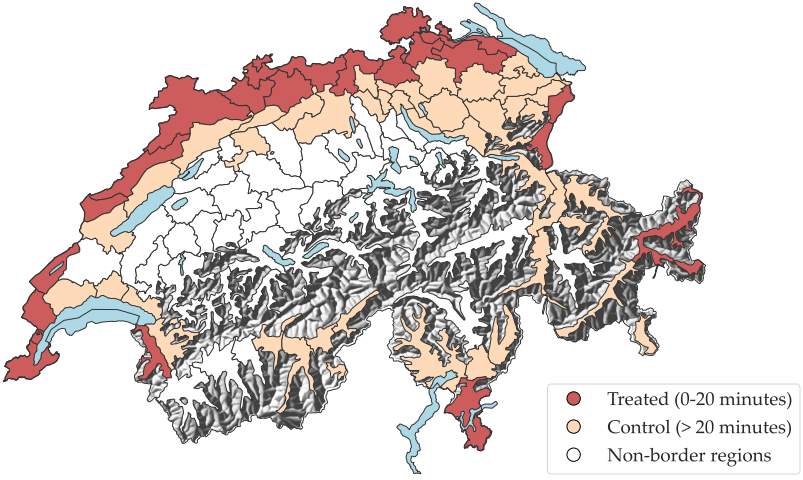
Treatment and control definition

- Until 2007, cross-border workers could work only in Swiss Border Region (BR) and not in the Non-Border Region (NBR)

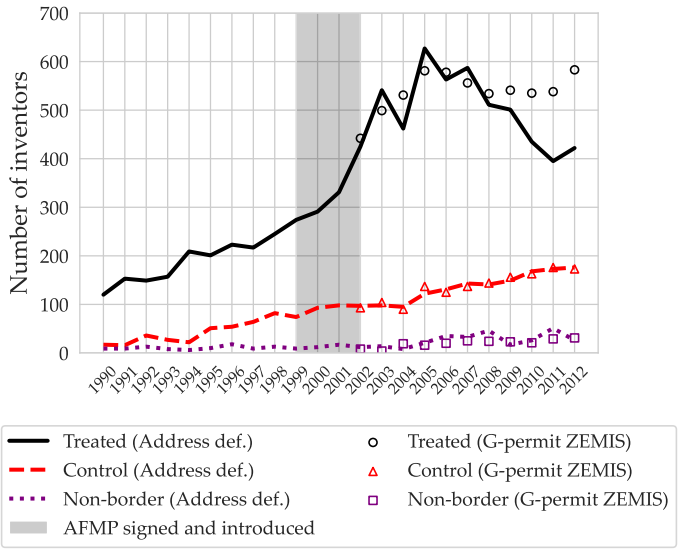
→ *Distance from the border determines the exposition to CBIs influx*

- **"Treated"**: Spatial mobility regions in the BR at $\leq$ 20 minutes from the border
- **"Control"**: Spatial mobility regions in the BR at $>$ 20 minutes from the border
- Spatial mobility regions in the NBR in control in robustness checks
- Three units of analysis: region, inventor, R&D location

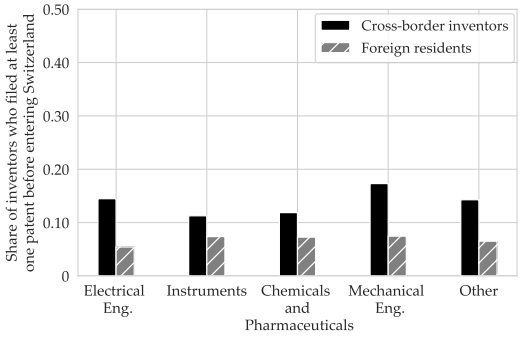
Spatial mobility regions in Switzerland by driving distance area



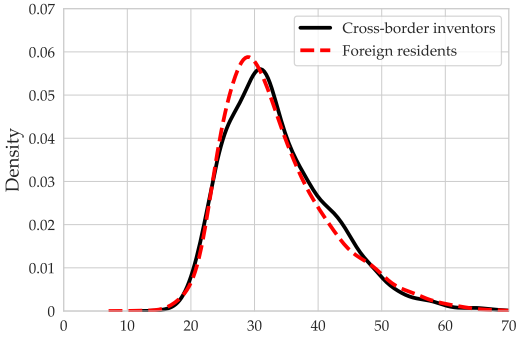
Cross-border inventors by driving distance area



Cross-border inventors' characteristics (ZEMIS-based definition)



(a) Pre-arrival patenting



(b) Age at arrival in Switzerland

Regional Analysis

Spatial mobility region panel, 1990-2012

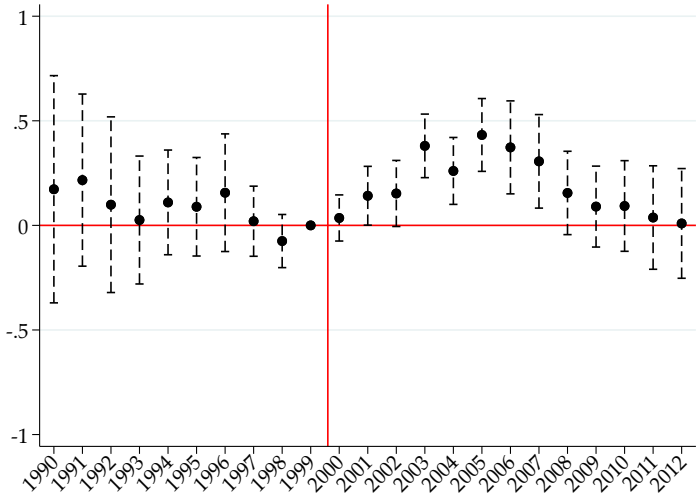
$$E[y_{m,t}|X_{m,t}] = exp[\alpha + \sum_{\substack{t=1990 \\ t\neq 1999}}^{2012} \beta_t * I_{year=t} \times Treated_m + \gamma_m + \phi_t]$$

where:

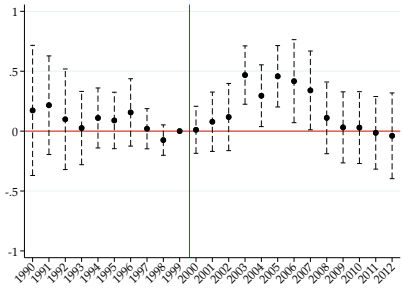
- $y_{m,t}$ innovation outcome for spatial mobility region m in year t
- $I_{year=t}$ = 1 in year t (1999 as reference year)
- $Treated_m$ = 1 for spatial mobility regions at $\leq$ 20 minutes from the border
- γ_m regional fixed effects
- ϕ_t year fixed effects

$\rightarrow$ β_t are the parameters of interest

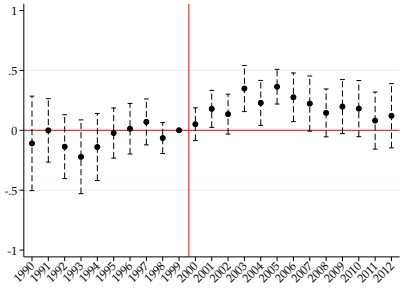
Patenting in Switzerland



Patenting in Switzerland: only incumbents or excluding "top" applicants

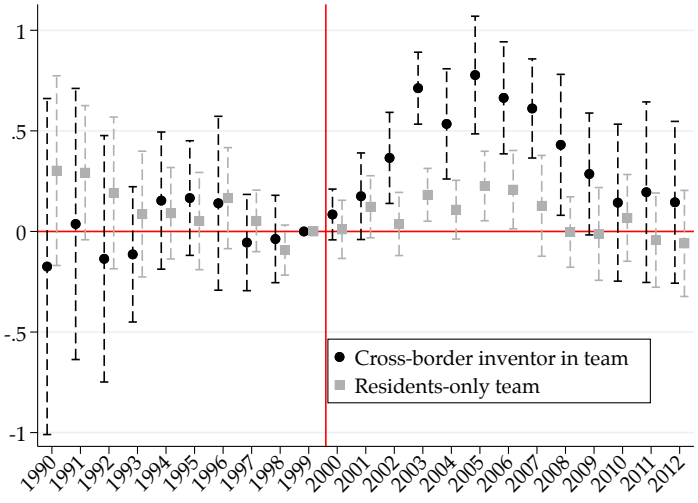


(a) Incumbents

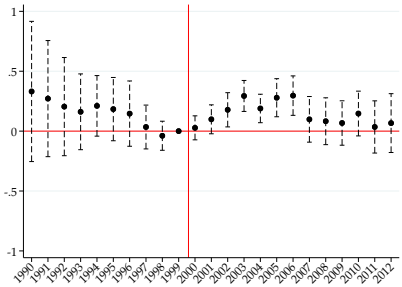


(b) Excluding "top" applicants

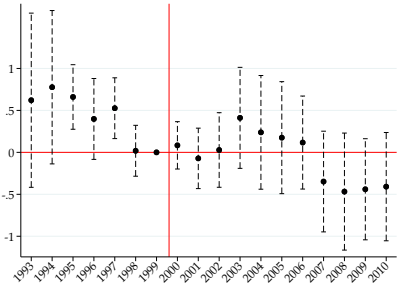
Patenting in Switzerland: CBI-in-team vs. Residents-only patents



Active Swiss Inventors

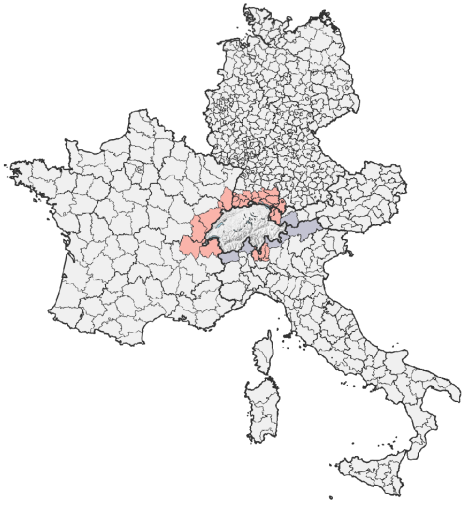


(a) Swiss residents

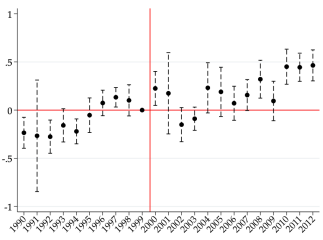


(b) Swiss nationals (subsample)

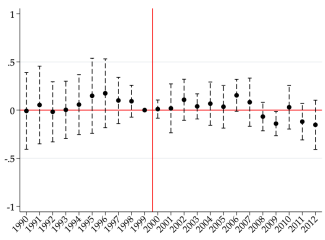
Neighbouring countries Nuts-3 regions



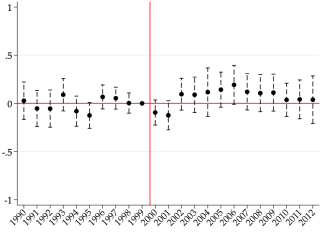
Patenting in neighbouring areas



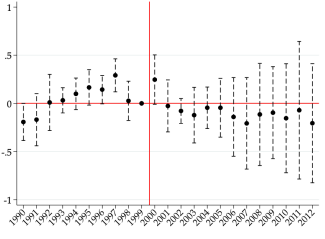
(a) Austria



(b) France



(c) Germany



(d) Italy

Inventor-level Analysis

Swiss-based inventors active since the pre-AFMP period. Individual-level panel, 1990-2012.

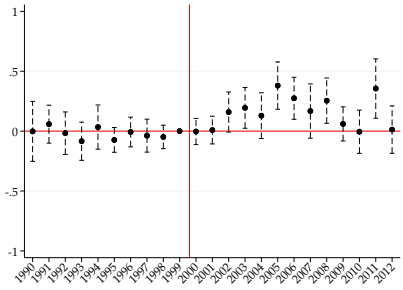
$$E[y_{i,m,t}|X_{i,m,t}] = exp[\alpha + \sum_{\substack{t=1990 \\ t \neq 1999}}^{2012} \beta_t * I_{year=t} \times Treated_m + \theta_i + \gamma_m + \phi_t]$$

where:

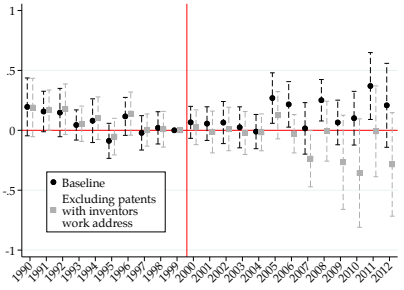
- $y_{i,m,t}$ innovation outcome for inventor i active in spatial mobility region m in year t
- $I_{year=t}$ = 1 in year t (1999 as reference year)
- $Treated_m$ = 1 for inventors located in spatial mobility regions at $\leq$ 20 minutes from the border
- θ_i inventor fixed effects
- γ_m regional fixed effects
- ϕ_t year fixed effects

$\rightarrow$ β_t are the parameters of interest

Incumbent inventors' patenting

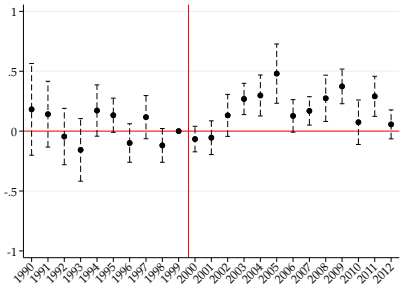


(a) Baseline

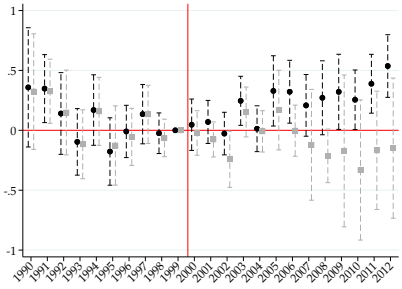


(b) Excluding CBIs

Incumbent inventors' distinct co-inventors

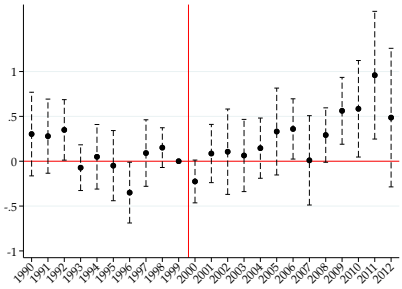


(a) Baseline

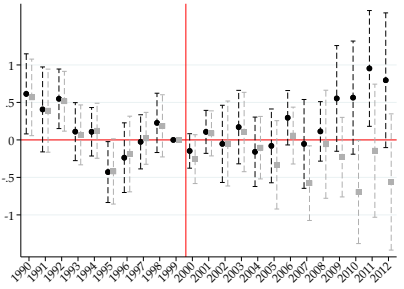


(b) Excluding CBIs

Incumbent inventors' cites to CBIs' countries

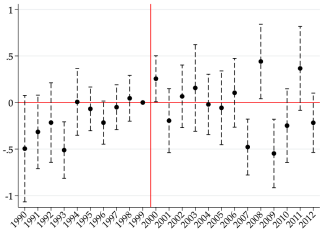


(a) Baseline

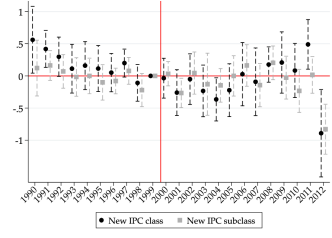


(b) Excluding CBIs

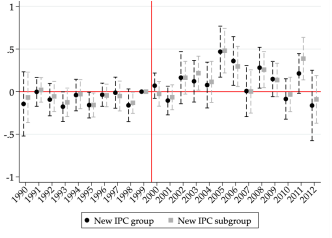
Incumbent inventors' patent characteristics



(a) Patents with novel terms



(b) Patents with new IPC class or subclass



(c) Patents with new IPC group or subgroup

Study the patenting activity over the first eight years of career (years from the first patent) of two cohorts of inventors: those first patenting in 1999–2000 and those first patenting in 1990–1993.

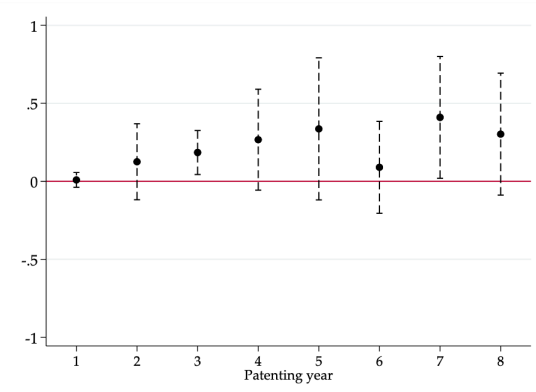
$$E[y_i|X_i] = exp[\alpha + \beta\tau(AFMP_{c(i)} \times Treated_{m(i)}) + \gamma_{m(i)} + \phi_{t(i)} + \lambda_{k(i)}]$$

where:

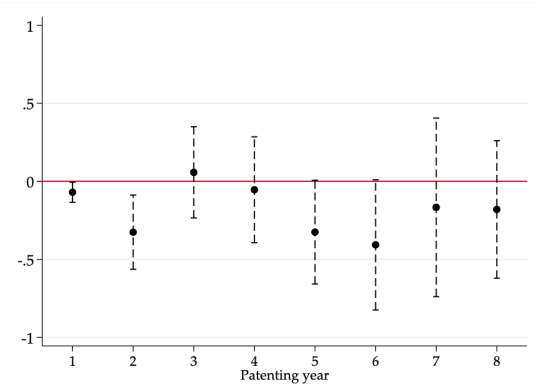
- y_i represents an outcome for inventor i, from cohort c, located in region m, active in year t, and in technology field k
- $AFMP_{c(i)}$ is an indicator equal to 1 for inventors in the 1999–2000 cohort
- $Treated_{m(i)}$ is an indicator equal to 1 for inventors whose first patent occurred in a treated region
- $\gamma_{m(i)}$ regional fixed effects
- $\phi_{t(i)}$ calendar year fixed effects
- $\lambda_{k(i)}$ technology field fixed effects

→ $\beta\tau$ are the parameters of interest

Junior inventors analysis: results

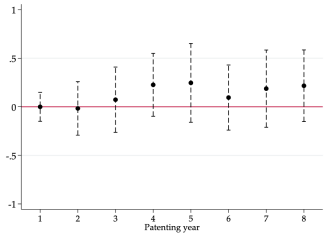


(a) Patents

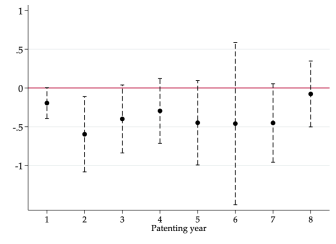


(b) Patents (excl. cross-border inventors)

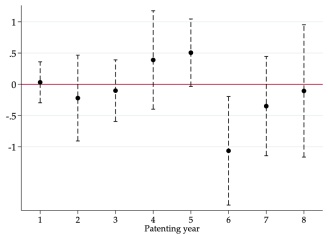
Junior inventors analysis: results (cont'd)



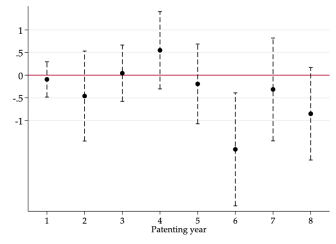
(c) Distinct co-inventors



(d) Distinct co-inventors (excl. cross-border inventors)



(e) Cites to cross-border inventors' countries



(f) Cites to cross-border inventors' countries (excl. cross-border inventors)

R&D location analysis

Panel of R&D locations active since the pre-AFMP period, tracked between 1990-2012.

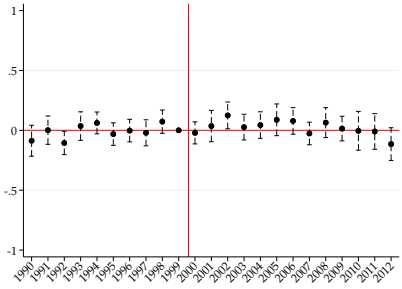
$$E[y_{j,m,t}|X_{j,m,t}] = exp[\alpha + \sum_{\substack{t=1990 \\ t\neq 1999}}^{2012} \beta_t \cdot I_{year=t} \times Treated_{m(j)} + \xi_j + \phi_t],$$

where:

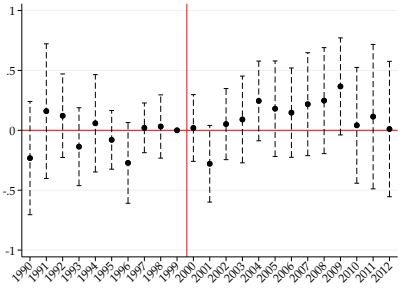
- $y_{j,m,t}$ innovation outcome for R&D location j in region m and patenting in year t
- $I_{year=t}$ = 1 in year t (1999 as reference year)
- $Treated_{m(j)}$ = 1 for R&D locations in spatial mobility regions at $\leq$ 20 minutes from the border
- ξ_j R&D location fixed effects
- ϕ_t year fixed effects

$\rightarrow$ β_t are the parameters of interest

R&D location analysis: results

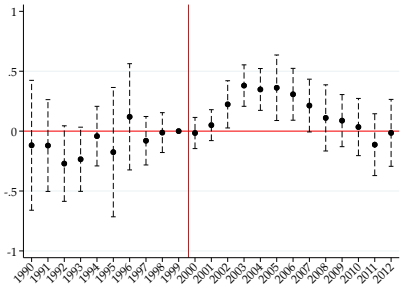


(a) Average team size

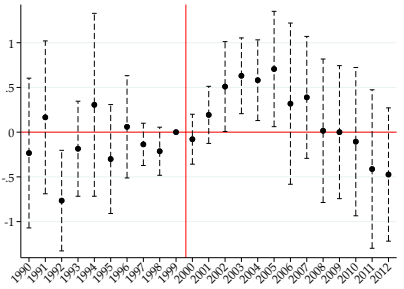


(b) Average team experience

R&D location analysis: results (cont'd)



(a) Active inventors



(b) Active cross-border inventors

Concluding remarks

- Abolishing immigration restrictions positively affected innovation in Switzerland: 15%-54% annual increase in patenting in treated regions over 2001-2007, driven by instruments, chemicals, and pharmaceuticals
- No evidence of displacement of Swiss inventors, nor of adverse effects on patenting in Switzerland's neighbouring countries
- Incumbent inventors in treated regions increased their productivity, almost entirely through new collaborations with CBIs
- R&D locations expanded inventor headcount, without changes in average team size or experience $\rightarrow$ capacity expansion, not organizational change
- Joint reading with Beerli et al. (2021): contemporary high-skilled migration between advanced economies can ease supply shortages and complement native STEM workers, without negative wage or employment effects
- Policy relevance: cross-border commuting matters for innovation in other corridors (Germany–Benelux, France–Germany, Denmark–Sweden, US–Canada)

References

References I

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Beerli, A., Ruffner, J., Siegenthaler, M., and Peri, G. (2021). The abolition of immigration restrictions and the performance of firms and workers: Evidence from Switzerland. *American Economic Review*, 111(3):976–1012.

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