# The impact of foreign direct investments on regional innovation

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# Outline
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# Background and aims

- ‣ EU **promotes within**-**EU** flows of cross-borders **investments**
- ‣ **Extra**-**EU** flows are under the EC's **scrutiny** ⇒ mitigate the negative impacts of FDIs (e.g. EU Merger Regulation, Council Regulation (EC) No 139/2004)
- ‣ **Ambiguous** impact of cross-border (innovative) investment flows on the **innovation** of the **target** region
- ‣ **Existing empirical literature** ⇒ **limited consideration** of the for the **endogeneity** of investment flows

Our paper:

- ‣ Provide **empirical evidence** on the link between **inward FDIs** and **patent applications** for EU NUTS3 **regions** accounting for the **endogeneity** of FDIs

# Related literature

- ‣ **Location** choices of (**innovative**) activities of **MNEs**:
  - ‣ **MNE-specific** characteristics ⇒ Lewin et al. (2009 JIBS) and many others
  - ‣ Characteristics of the **destination** area ⇒ Castellani et al. (2013 JIBS) with a gravity model
  - ‣ **Interaction** of the two dimensions ⇒ Le Bas and Sierra (2002 RP) ⇒ technology seeking, home base exploiting, home base augmenting, market seeking
- ‣ **Impacts** of innovative FDIs on innovation:
  - ‣ **Positive effects** of inward (innovative) FDIs on innovation ⇒ **knowledge spillovers**
  - ‣ **Absorptive capacity** matters
  - ‣ Stiebale and Reize (2011 IJIO) and Stiebale (2016 JIE) ⇒ **negative** effect of **M&A** on the innovation of the **target company** (accounting for endogeneity and selection bias)
  - ‣ Becker et al. (2020 JIBP) ⇒ inward innovative FDIs exacerbate the local '**war for talent**'

# Inward innovative greenfield FDIs and innovation: mechanisms

- ‣ Increase in the local '**production capacity**' (scale) of **knowledge** creation activities [*positive*]
- ‣ Local **competition** for talents/inventors
    - ‣ **Adjustment costs** (short run) and competition for **limited** crucial **inputs** (e.g. researchers) [*negative*]
    - ‣ Local **attraction** [*positive*] or **displacement** [*negative*] of **inventors**
- ‣ Knowledge **spillovers** [*positive*]

# Inward innovative brownfield FDIs and innovation: mechanisms

- **Predatory** investment to **acquire** the **patent portfolio** of the target company [*negative*]
- **Acquisition** of a **local team** of **researchers**
  - The team is **moved** back to the **headquarters** [*negative*], or
  - The **local team** benefits from **resources** and **knowledge** flows from the MNE's headquarters [*positive*]
- Knowledge **spillovers** [*positive*]
  - **Easier local diffusion** than for GF as the target company has tighter **local roots**

# Inward innovative FDIs and innovation by local applicants

- ▸ Depending on **taxation** (e.g. Patent Box legislation, corporate taxes, etc) and firm's **strategy** ⇒ MNEs **attribute patents** to the **subsidiaries** or to the **headquarters**
- ▸ Cross-country **heterogeneity** in **corporate taxation** and **conditions**
- ▸ Implication for **local patenting outcomes**:
    - ▸ **Limited** impact (positive or negative) on **inventor-based** count of patent applications
    - ▸ More **pronounced** impact (positive or negative) on **applicant-based** count of patent applications

## Data sources

- **Patent** data
    - OECD-REGPAT Database
    - EPO patent applications by priority year and NUTS3 region of the inventor/applicant
- **Greenfield FDIs**
    - fDI Markets
    - Number of FDI project by target region
    - Innovative FDIs $\Rightarrow$ business activities: R&D; Design, Development & Testing
- **Brownfield FDIs (M&A)**
    - Zephyr-BvD database
    - Number M&A by target region
    - Innovative FDIs $\Rightarrow$ target company with active patent portfolio
- Other **control variables** at the region level (Cambridge Econometrics database) and country-level (regulation/policy)

## Figure: Inward FDI flows and patents per capita (level)



Innovative inward FDI per capita

Non-innovative inward FDI per capita
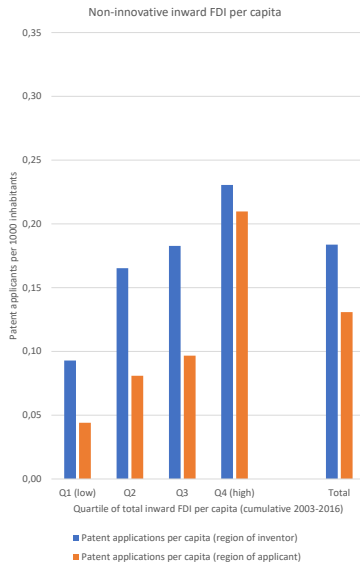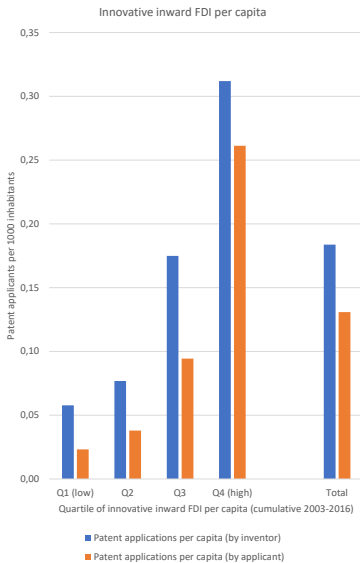
## Figure: Inward FDI flows and patents per capita (growth rate)
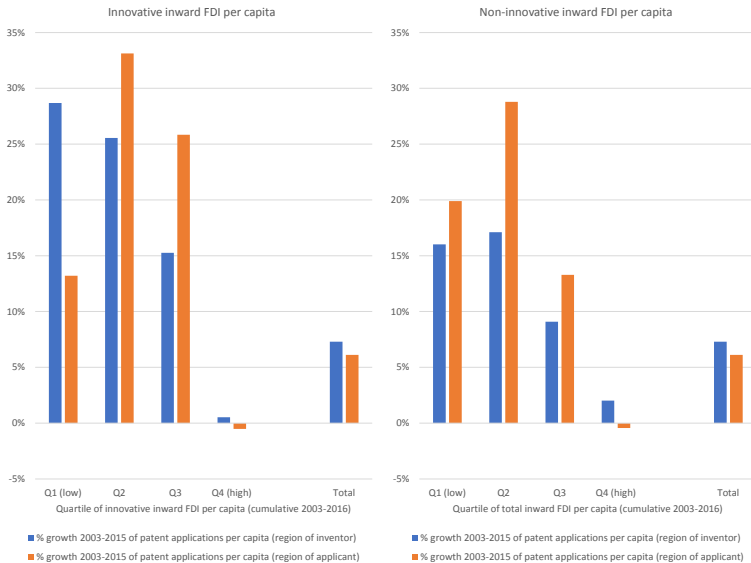
# Model: inward FDIs

▸ We **estimate** the following **equation**:

$$Y_{i;t} = \alpha_i + \beta FDI_{i;t-1,t-3} + X'_{i;t-1}\theta + \tau_t + \varepsilon_{i;t}$$

where:

- ▸ $Y_{i;t}$: **count** of **EPO patent applications** in region $i$ and priority year $t$ in logarithm (inverse hyperbolic sine transformation)
    - ▸ **Long(er) term effects** $\Rightarrow$ **3-years time window** for our dependent variable $Y_{i;t,t+2}$
- ▸ $FDI_{i;t-1,t-3}$: **number** of **innovative inward FDI projects** in region $i$ and years $t-1$, $t-2$ and $t-3$, in logarithm (inverse hyperbolic sine transformation)
- ▸ $X'_{i;t-1}$: **time-varying control variables** at the region (and country) level
- ▸ $\alpha_i$: region **fixed effect**
- ▸ $\tau_t$: **year dummy**

## Sources of endogeneity

- ▸ Innovative **FDIs attracted** by **regions** with high **innovation potential** ⇒ **reverse causality** (OLS/FE biased upward)
- ▸ **'Good' local conditions** (e.g. business environment, availability of skills and infrastructure, local policies, etc.): **favour** local **innovation** and **attract FDIs** ⇒ **omitted variable** bias (OLS/FE biased upward)
- ▸ Omitted variable even **more important** for **greenfield** FDIs than for M&A ⇒ decisions about GF consider **local conditions**, decisions about **M&A** consider the **characteristics** of the **target company** (while local conditions could be secondary)

## Rationale of the IV

- ▸ **Structural characteristics** of **target regions** as a source of **exogenous variation** in the number of **inward FDI projects**
- ▸ **Frankel and Romer (1999 AER)** and **Ortega and Peri (2014 JIE)** ⇒ value of **import** and **export given geographical** and **structural characteristics** via a **gravity model** for bilateral trade flows
- ▸ **Predicted total value** of import and export from the gravity model as an **instrumental variable** for trade in a growth regression ⇒ they keep the **exogenous component** of **trade** patterns
- ▸ **Miguelez and Moreno (2015 RP)**: approach extended to **migrations** of **inventors** across EU regions

- ▸ We consider **dyadic FDI flows** of different kinds and estimate the **predicted inward flow** of FDI given **structural characteristics** from a **gravity** model

## Details of the IV

- ▸ **Year-by-year cross-sectional gravity equations** (with PPML) of bilateral FDI flows across **EU NUTS3 regions** and between EU NUTS3 regions and **non-EU countries** $\Rightarrow$ gravity equation for year 2005 considers FDI flows for 2003-2005

$$FDI_{ijt} = X'_{ij}\beta_t + V'_i\theta_t + W'_j\gamma_t + \varepsilon_{ijt}$$

- ▸ $FDI_{ijt}$ is the **flow** of **FDI projects** from country/region $j$ to country/region $i$ in period (3-yrs time window), $X_{ij}$ is a set of **bilateral variables** (contiguity, distance, commonality of language, etc) between region/country $i$ and region/country $j$, $V_i$ and $W_j$ are, respectively, **characteristics** (area, population in 1995, GDP in 1995) of region/country $i$ and region/country $j$

- ▸ $\beta_t$, $\theta_t$ and $\gamma_t$ are **year-specific elasticities** (or semi-elasticities) of FDI wrt **time-invariant independent variables**

- ▸ $IV_{it} = \sum_j \hat{FDI}_{ijt}$

## Table: Pooled OLS and FE estimates

| Patent applications (t, log) | Pooled OLS | | Fixed effects | |
|---|---|---|---|---|
| | Region of inventor | Region of applicant | Region of inventor | Region of applicant |
| Inward innovative GF FDI projects (t-1, in log) | 0.236*** | 0.232*** | 0.0174 | 0.0120 |
| | (0.0473) | (0.0480) | (0.0124) | (0.0141) |
| Inward innovative BF FDI projects (t-1, in log) | 0.467*** | 0.582*** | 0.00427 | 0.00730 |
| | (0.0442) | (0.0558) | (0.0105) | (0.0148) |
| Share of industrial GVA (t-1) | 3.099*** | 2.876*** | 1.519*** | 0.990* |
| | (0.418) | (0.498) | (0.446) | (0.511) |
| Patent specialisation index (t-1) | -4.148*** | -4.390*** | -0.0998 | -0.195** |
| | (0.209) | (0.247) | (0.0845) | (0.0776) |
| Population (t-1, in log) | 0.248*** | 0.349*** | 0.495 | 1.072*** |
| | (0.0406) | (0.0471) | (0.331) | (0.350) |
| GDP per capita (t-1, log) | 0.188 | 0.189 | 1.241*** | 1.143*** |
| | (0.120) | (0.130) | (0.260) | (0.278) |
| 3-years growth in GDP per capita (t-1) | -0.0898 | 0.00512 | 0.943*** | 0.913*** |
| | (0.478) | (0.359) | (0.194) | (0.188) |
| 3-years growth in GDP per capita (country-level, t-1) | 1.059 | -0.268 | -1.105*** | -0.806*** |
| | (0.835) | (0.768) | (0.272) | (0.264) |
| Corporate tax rate (country-level, t-1) | 0.0639*** | 0.0508*** | 0.0210*** | 0.0186*** |
| | (0.00631) | (0.00785) | (0.00327) | (0.00327) |
| N | 10200 | 10200 | 10200 | 10200 |

Regressions weighted with average population in 2005-2016. Standard errors clustered by NUTS3 region in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. The dependent variable and the FDI variables have been transformed with inverse hyperbolic sine before taking the log. Year dummies included.

### Table: Pooled OLS and FE estimates (3-yrs window for patents)

| Patent applications (t,t+2; log) | Pooled OLS | | Fixed effects | |
|---|---|---|---|---|
| | Region of inventor | Region of applicant | Region of inventor | Region of applicant |
| Inward innovative GF FDI projects (t-1, in log) | 0.263*** | 0.264*** | 0.0106 | -0.00108 |
| | (0.0532) | (0.0545) | (0.00960) | (0.0135) |
| Inward innovative BF FDI projects (t-1, in log) | 0.438*** | 0.535*** | -0.00727 | -0.00684 |
| | (0.0487) | (0.0617) | (0.00846) | (0.0107) |
| Share of industrial GVA (t-1) | 3.516*** | 3.215*** | 1.639*** | 1.246* |
| | (0.465) | (0.537) | (0.548) | (0.660) |
| Patent specialisation index (t-1) | -3.835*** | -4.307*** | -0.0472 | -0.190*** |
| | (0.228) | (0.263) | (0.0799) | (0.0734) |
| Population (t-1, in log) | 0.308*** | 0.407*** | -0.208 | 0.608 |
| | (0.0427) | (0.0498) | (0.401) | (0.432) |
| GDP per capita (t-1, log) | 0.198 | 0.217 | 0.898*** | 0.932** |
| | (0.130) | (0.148) | (0.344) | (0.433) |
| 3-years growth in GDP per capita (t-1) | -0.135 | 0.106 | 0.735*** | 0.831*** |
| | (0.608) | (0.440) | (0.182) | (0.190) |
| 3-years growth in GDP per capita (country-level, t-1) | 1.336 | -0.283 | -1.223*** | -0.796** |
| | (0.954) | (0.869) | (0.277) | (0.347) |
| Corporate tax rate (country-level, t-1) | 0.0688*** | 0.0571*** | 0.0239*** | 0.0210*** |
| | (0.00713) | (0.00859) | (0.00312) | (0.00334) |
| N | 9180 | 9180 | 9180 | 9180 |

Regressions weighted with average population in 2005-2016. Standard errors clustered by NUTS3 region in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. The dependent variable and the FDI variables have been transformed with inverse hyperbolic sine before taking the log. Year dummies included.

# Pooled OLS and FE: discussion

- ‣ **Cross-sectional positive** conditional **correlation** between **inward innovative FDI** flows and **patenting** outcomes
    - ‣ **Year-by-year** OLS **confirm** this result
    - ‣ **Net** of basic **structural characteristics**, **innovative FDIs go where patents are** (or the **other way around**)
- ‣ Accounting for **time-invariant** characteristics with region fixed effects makes **FDIs irrelevant** for patenting
    - ‣ **Unobserved heterogeneity** drives cross-sectional relationships

## Table: Baseline results: FE-IV estimates

| Patent applications (log) | Region of inventor; patents in t | Region of applicant; patents in t | Region of inventor; patents in t,t+2 | Region of applicant; patents in t,t+2 |
|---|---|---|---|---|
| Inward innovative GF FDI projects (t-1, in log) | -0.733*** | -0.570*** | -0.649*** | -0.538*** |
| | (0.161) | (0.132) | (0.170) | (0.142) |
| Inward innovative BF FDI projects (t-1, in log) | 0.00392 | 0.0283 | 0.0913 | 0.0958 |
| | (0.154) | (0.135) | (0.125) | (0.121) |
| Share of industrial GVA (t-1) | 0.451 | 0.173 | 0.689 | 0.487 |
| | (0.507) | (0.453) | (0.496) | (0.468) |
| Patent specialisation index (t-1) | -0.103 | -0.197** | -0.0180 | -0.168** |
| | (0.0867) | (0.0775) | (0.0787) | (0.0711) |
| Population (t-1, in log) | -0.00725 | 0.653 | -0.835* | 0.0650 |
| | (0.463) | (0.401) | (0.466) | (0.417) |
| GDP per capita (t-1, log) | 1.396*** | 1.263*** | 1.036*** | 1.043*** |
| | (0.219) | (0.204) | (0.250) | (0.283) |
| 3-years growth in GDP per capita (t-1) | 0.891*** | 0.870*** | 0.705*** | 0.801*** |
| | (0.217) | (0.208) | (0.229) | (0.251) |
| 3-years growth in GDP per capita (country-level, t-1) | -0.605* | -0.409 | -0.756** | -0.406 |
| | (0.331) | (0.308) | (0.309) | (0.308) |
| Corporate tax rate (country-level, t-1) | 0.00552 | 0.00682 | 0.0122*** | 0.0117*** |
| | (0.00495) | (0.00431) | (0.00456) | (0.00403) |
| F-test of excluded IV in first stage | 14.89 | 14.89 | 11.82 | 11.82 |
| N | 10200 | 10200 | 9180 | 9180 |

FE-IV regressions weighted with average population in 2005-2016. Standard errors clustered by NUTS3 region in parenthesis. * p<0.1, ** p<0.05, *** p<0.01. The dependent variable and the FDI variables have been transformed with inverse hyperbolic sine before taking the log. Year dummies included.

## Main results: discussion

- ‣ **IVs** are **strong enough** in first stage (but not very strong)
  - ‣ **Stronger** IVs in first stage when considering **one endogenous** at a time
  - ‣ **Results** are **confirmed**
- ‣ Inward **BF** innovative FDIs remain **not significant** (and very **small** in magnitude)
- ‣ **Negative**, **significant** and **large** effect of **GF** FDI projects
  - ‣ Both **short**- and **long**-term effect
  - ‣ **Larger** (point estimate) for **inventor**-based than for **applicant**-based patents
- ‣ Results are **robust** to the inclusion of **country-level policy variables** (back-up slide)

### Table: Patent quality: FE-IV estimates

| Quality-weighted patents (t,t+2; in log) | 5-yrs forward citations | | Patent family size | | NPL backward citations | |
|---|---|---|---|---|---|---|
| | Region of inventor | Region of applicant | Region of inventor | Region of applicant | Region of inventor | Region of applicant |
| Inward innovative GF FDI projects (t-1, in log) | -0.947*** | -0.923*** | -0.792*** | -0.655*** | -1.034*** | -0.622*** |
| | (0.229) | (0.242) | (0.206) | (0.181) | (0.279) | (0.204) |
| Inward innovative BF FDI projects (t-1, in log) | -0.230 | -0.244 | 0.104 | 0.136 | 0.268 | 0.106 |
| | (0.193) | (0.209) | (0.152) | (0.150) | (0.209) | (0.172) |
| F-test of excluded IV in first stage | 11.82 | 11.82 | 11.82 | 11.82 | 11.82 | 11.82 |
| N | 9180 | 9180 | 9180 | 9180 | 9180 | 9180 |

FE-IV regressions weighted with average population in 2005-2016. Standard errors clustered by NUTS3 region in parenthesis. * $p<0.1$, ** $p<0.05$, *** $p<0.01$. The dependent variable and the FDI variables have been transformed with inverse hyperbolic sine before taking the log. Year dummies included. Additional control variables: share of industrial GVA (t-1), Patent specialisation index (t-1), Population (t-1, in log), GDP per capita (t-1, in log), 3-years growth in GDP per capita (t-1), 3-years growth in GDP per capita (country-level, t-1), Corporate tax rate (country-level, t-1).

# Summary of the main results

- Accounting for the **endogeneity** of FDIs **matters**
- **No significant** effect on local patenting of **M&A**, **negative** effect of **greenfield** FDIs
- Both **short**- and **long**-run effects
- **Slightly different** effect for local **inventors** and local **applicants**

- **Competition** effect
- **Crowding out** of local inputs for innovation activities

# The way ahead

- ‣ **Knowledge spillovers** and the role of **absorptive capacity** $\Rightarrow$ **cohesion policy** as a tool to **build** absorptive capacity
- ‣ **Direct** vs **indirect** effects
- ‣ **Focus** on strategic **technologies** and **sectors**: green technologies, digital technologies, pharmaceuticals, bio-medical technologies

**THANK YOU FOR YOUR ATTENTION**

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## Table: Gravity regression for 2003-2005 and 2013-2015

| | 2003-2005 | | 2013-2015 | |
| --- | --- | --- | --- | --- |
| | Innovative GF inward FDI | Innovative BF inward FDI | Innovative GF inward FDI | Innovative BF inward FDI |
| Contiguity | 11.58*** | 19.14*** | 10.37 | -9.982*** |
| | (3.176) | (1.877) | (6.467) | (1.504) |
| Common language | 1.599*** | 1.777*** | 1.603*** | 1.480*** |
| | (0.260) | (0.220) | (0.168) | (0.179) |
| Time-zone difference | 0.228*** | 0.314*** | 0.281*** | 0.178*** |
| | (0.0594) | (0.0614) | (0.0427) | (0.0438) |
| Common religion | -0.916*** | -0.633** | -1.271*** | -0.471** |
| | (0.331) | (0.311) | (0.214) | (0.213) |
| Distance (log) | -0.243*** | -0.579*** | -0.209*** | -0.369*** |
| | (0.0922) | (0.0731) | (0.0705) | (0.0686) |
| Contiguity x Distance (log) | -2.113*** | -0.169* | -0.922*** | 2.242*** |
| | (0.478) | (0.100) | (0.215) | (0.248) |
| Area (origin, log) | 0.651*** | 0.513*** | 0.513*** | 0.418*** |
| | (0.0548) | (0.0664) | (0.0403) | (0.0423) |
| Area (destination, log) | 0.564*** | 0.437*** | 0.469*** | 0.365*** |
| | (0.0579) | (0.0668) | (0.0450) | (0.0448) |
| Contiguity x Area (origin, log) | 1.241*** | -1.046*** | 0.272 | -0.965*** |
| | (0.160) | (0.0779) | (0.806) | (0.136) |
| Contiguity x Area (destination, log) | -0.00316 | -0.608*** | 0.139 | 1.009*** |
| | (0.275) | (0.0746) | (0.602) | (0.129) |
| Pop 1995 (origin, log) | -0.757*** | -0.618*** | -0.126 | -0.561*** |
| | (0.257) | (0.169) | (0.0912) | (0.113) |
| Pop 1995 (destination, log) | 0.758*** | -0.532*** | 0.417*** | -0.773*** |
| | (0.121) | (0.137) | (0.0725) | (0.116) |
| Contiguity x Pop 1995 (origin, log) | 1.943*** | 0.182** | 0.463 | -0.529*** |
| | (0.640) | (0.0854) | (0.778) | (0.115) |
| Contiguity x Pop 1995 (destination, log) | -1.394*** | 1.174*** | -0.735* | -0.555*** |
| | (0.309) | (0.172) | (0.435) | (0.126) |

(*continue*)

Table: Gravity regression for 2003-2005 and 2013-2015

| | 2003-2005 | | 2013-2015 | |
| --- | --- | --- | --- | --- |
| | Innovative GF inward FDI | Innovative BF inward FDI | Innovative GF inward FDI | Innovative BF inward FDI |
| (*continue*) | | | | |
| GDP 1995 (origin, log) | 1.771*** | 1.387*** | 1.057*** | 1.271*** |
| | (0.220) | (0.147) | (0.0745) | (0.0884) |
| GDP 1995 (destination, log) | 0.0496 | 1.245*** | 0.293*** | 1.356*** |
| | (0.0879) | (0.116) | (0.0623) | (0.0979) |
| Contiguity x GDP 1995 (origin, log) | -1.624*** | -0.0288 | -0.799 | 0.0983** |
| | (0.246) | (0.0551) | (0.660) | (0.0469) |
| Contiguity x GDP 1995 (destination, log) | -0.0328 | -1.642*** | 0.0712 | 0.250*** |
| | (0.250) | (0.146) | (0.249) | (0.0641) |

Pseudo-poisson maximum likelihood estimator. N=1,597,396. Standard errors in parenthesis. * p<0.1, ** p<0.05, *** p<0.01.

## Table: Robustness check: additional policy controls

| Patent applications (log) | Region of inventor; patents in t | Region of applicant; patents in t | Region of inventor; patents in t,t+2 | Region of applicant; patents in t,t+2 |
|---|---|---|---|---|
| Inward innovative GF FDI projects (t-1, in log) | -0.635*** | -0.522*** | -0.719*** | -0.618*** |
| | (0.165) | (0.144) | (0.177) | (0.155) |
| Inward innovative BF FDI projects (t-1, in log) | 0.196 | 0.116 | 0.0566 | -0.0202 |
| | (0.138) | (0.129) | (0.140) | (0.134) |
| Share of industrial GVA (t-1) | -0.0347 | -0.344 | -0.130 | -0.539 |
| | (0.622) | (0.618) | (0.627) | (0.588) |
| Patent specialisation index (t-1) | -0.0507 | -0.121 | 0.0761 | -0.104 |
| | (0.0995) | (0.0978) | (0.0887) | (0.0844) |
| Population (t-1, in log) | 0.761 | 0.980** | 0.455 | 0.769 |
| | (0.516) | (0.498) | (0.532) | (0.503) |
| GDP per capita (t-1, log) | 1.348*** | 1.409*** | 1.198*** | 1.392*** |
| | (0.231) | (0.252) | (0.216) | (0.237) |
| 3-years growth in GDP per capita (t-1) | 0.716*** | 1.027*** | 0.529*** | 0.955*** |
| | (0.225) | (0.221) | (0.196) | (0.204) |
| 3-years growth in GDP per capita (country-level, t-1) | -0.400 | -0.366 | -0.143 | -0.189 |
| | (0.466) | (0.450) | (0.445) | (0.425) |
| Corporate tax rate (country-level, t-1) | 0.00228 | 0.00515 | 0.00512 | 0.00585 |
| | (0.00491) | (0.00458) | (0.00521) | (0.00476) |
| FDI restriction index (country-level, t-1) | 3.229** | 1.009 | 2.688* | 1.665 |
| | (1.493) | (1.446) | (1.534) | (1.506) |
| Employment Protection Legislation (country-level, t-1) | -0.178* | -0.198** | -0.210** | -0.254*** |
| | (0.0982) | (0.0931) | (0.0916) | (0.0869) |
| Index of patent rights (Park, 2008; country-level, t-1) | 1.245*** | 0.726*** | 1.195*** | 0.823*** |
| | (0.198) | (0.194) | (0.193) | (0.185) |
| F-test of excluded IV in first stage | 11.42 | 11.42 | 10.86 | 10.86 |
| N | 8080 | 8080 | 7989 | 7989 |

FE-IV regressions weighted with average population in 2005-2016. Standard errors clustered by NUTS3 region in parenthesis. * $p<0.1$, ** $p<0.05$, *** $p<0.01$. The dependent variable and the FDI variables have been transformed with inverse hyperbolic sine before taking the log. Year dummies included. Excluded countries (policy indicators not available): BG, EE, HR, HU, LT, LV, RO, SI.