# The Global Effects of R&D Tax Incentives - Evidence from Micro Data

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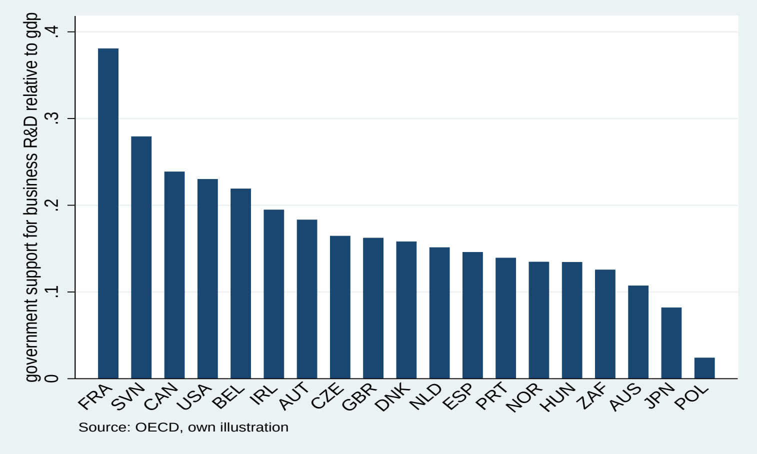
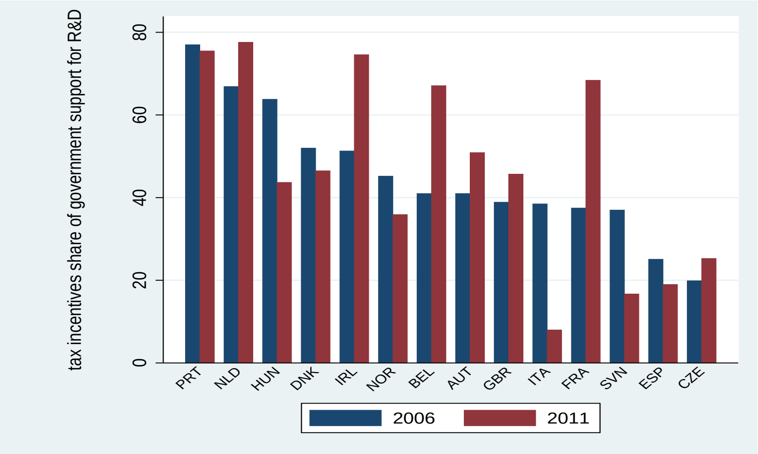
# Government Support for Private Sector R&D



# Tax Incentives as a Fraction of Government Support for Private Sector R&D



- Strong **increase in the prevalence of R&D tax incentives** over recent decades
- Main **theoretical justification** for providing R&D tax incentives to the private sector:
    - **Positive externalities, in particular knowledge spillovers** (see e.g. Arrow (1962))
    - **Confirmed by empirical evidence** that social returns to R&D outweigh the private ones (e.g. Jaffe (1988), Griliches (1992))
- Whether R&D tax incentives are instrumental in raising inefficiently low R&D levels is **ultimately an empirical question**
    - If corporate responses to R&D tax incentives are small, instruments just generate **windfall gains to the corporate sector**
    - **Empirical evidence: significant effects of domestic R&D user costs on R&D** spending (e.g. Bloom et al. (2002))
    - In the policy arena, this finding is commonly interpreted to lend support to the notion that R&D tax incentives raise inefficiently low corporate R&D levels.

- **This interpretation may be misleading though.**
- **R&D increasingly mobile** across countries
  (see e.g. Griffith and Bloom (2001) and Abramovsky et al. (2008))
- From this it follows that...
  - increases in R&D investment in response to R&D incentives in one country may come at the expense of other countries (**beggar-thy-neighbor**)
  - governments set **inefficiently high R&D tax incentives**

# Our Paper

- **Purpose of our paper**:
  Assess whether observed responses of national private sector R&D to tax incentives reflect a genuine increase in R&D activities or beggar-thy-neighbor policies.
- **Unique panel data** that links
  - accounting and ownership information on MNEs in Europe
  - data on the number of quality adjusted patent applications to the EPO between 1998 and 2006 to proxy for innovative activity at the affiliate level
  - data on host country characteristics, most importantly R&D user costs, which are determined by tax allowances and tax subsidies
- **Estimation strategy**:
  - Standard fixed effects models
  - Main regressors:
    - R&D user costs in the affiliates' host country
    - R&D user costs at other group locations

# Our Paper

- **Main findings**
  - **Significant own-price elasticities** of R&D activities: increase in tax subsidies that trigger a reduction in R&D costs by 10% raises patent counts by 5%.
  - **Augmenting the model by foreign R&D costs** offers two insights:
    - **Omitted variable bias:** elasticity of corporate R&D activities to domestic user costs of capital increases in absolute terms (by one third).
    - **Externality:** negative effects of tax subsidies at foreign group locations: reduction in foreign R&D costs by 10% decrease the affiliate's innovative activity by around 6%.
  - **Welfare implications**
    - Global response of R&D activities to tax incentives is weak.
    - Strong international competition for mobile R&D.
    - Decentralised policy choices are suboptimal from a global perspective, which calls for **international coordination** of R&D policies.

- **Comprehensive empirical literature on the impact of R&D subsidies on domestic R&D expenditures** (see e.g. Hall (1993) and Hines (1994) for early papers and e.g. Bloom et al. (2002), Mairesse and Mulkay (2011), Bond and Guceri (2012), Lokshin and Mohnen (2012) for more recent work)
- Unclear though whether the observed responsiveness of R&D activities to domestic tax incentives reflects a **genuine increase in the (global) resources allocated to R&D activities or relocation of R&D from abroad**
- **Two exceptions:**
  - Bloom and Griffith (2001) and Wilson (2009)
  - Both rely on **aggregated data**
  - Evidence for sizeable spillover effects (foreign R&D cost effect quantitatively larger than effect of domestic R&D costs)
  - By using **micro data our approach allows to tackle potential omitted variable and simultaneity bias in previous work**

- **Patent Data**
  - **Universe of patent applications to EPO** drawn from PATSTAT
  - Sample frame: 1998 and 2006
  - Previous research has shown that the **value of patents is highly dispersed** (e.g. Schankerman and Pakes (1986), Harhoff et al. (1999))
  - To account for that, we exploit the information in PATSTAT to construct **quality-adjusted patent counts** as measured by
    - the family size of the patent
    - its forward citations within 5 years from publication date
    - the number of industry classes
  - Use **factor analysis** to determine a composite quality index which accounts for the three value proxies described above.

- **Firm level data**
  - Data on patent applications is linked to firm level data in the **Amadeus data** base provided by Bureau van Dijk.
    - Rich accounting and ownership information
    - Unbalanced panel (1998 to 2006)
  - Link achieved through **name matching procedures**
  - Determine **quality-adjusted number of patent counts** for our sample affiliates per year (that were invented in the host country)

$$1 + \frac{c - \overline{c}}{\overline{c}} \tag{1}$$

where c indicates the composite quality index from the factor model for the considered patent and $\overline{c}$ represents the average quality index for patents in the same industry and application year.

- **The Value of R&D Tax Incentives: Construction of the B-Index**
  - Generosity of a country's R&D tax treatment captured by so-called B-index (Warda, 1983)
  - **Domestic B-index** $B_{kt}$ for country $k$ in period $t$ is defined as

$$B_{kt} = \frac{1 - Z_{kt} \cdot \tau_{kt}}{1 - \tau_{kt}} \tag{2}$$

  - Numerator: marginal cost of a 1 EUR investment in R&D after taxes
  - Interpr. B-Index: Minimum Pre-tax earnings required for project to break even
  - **Foreign B-Index** at other group affiliates

$$AVGB_{it} = \sum_{j \in M(i)-(i)} W_{ijt} B_{jt} \tag{3}$$

  - $W_{ijt}$: weighting matrix: uniform and size weighting

$$\log PAT_{ikt} = \beta_0 + \beta_1 B_{kt} + \beta_2 AVGB_{it} + \gamma_1 X_{it} + \rho_t + \phi_i + \epsilon_{it} \quad (4)$$

- $PAT_{ikt}$: number of (quality-adjusted) patent applications
- $B_{kt}$: B-index in affiliate $i$'s host country k
- $AVGB_{it}$: average B-index at other affiliates which belong to the same MNE
- Affiliate and time fixed effects included
- $X_{it}$: country controls: host country and foreign affiliates
- We expect
  - $\beta_1 < 0$: R&D tax incentives may 1) lead to a genuine increase in R&D and 2) attract R&D from other group locations
  - $\beta_2 > 0$: R&D tax incentives may attract R&D from other group locations (2)
  - $\beta_2/|\beta_1|$ fraction of the effect of R&D tax incentives on domestic R&D which is related to activity that is attracted from abroad

| variable | obs. | mean | sd | min | max |
|---|---|---|---|---|---|
| patents | 16,644 | 2.141 | 18.192 | 0.000 | 760.000 |
| quality adjusted patents | 16,644 | 1.354 | 10.272 | 0.000 | 342.187 |
| B index | 16,644 | 0.980 | 0.094 | 0.428 | 1.048 |
| avg. B index | 16,644 | 0.977 | 0.079 | 0.428 | 1.044 |
| log gdp p.c. | 16,644 | 10.289 | 0.238 | 8.421 | 11.408 |
| avg. log gdp p.c. | 16,644 | 10.308 | 0.221 | 9.215 | 11.198 |
| R&D expenditures | 16,644 | 2.200 | 0.691 | 0.551 | 4.130 |
| avg. R&D expenditures | 16,644 | 2.252 | 0.549 | 0.861 | 4.130 |
| FDI inflow | 16,644 | 3.969 | 4.404 | -3.598 | 74.711 |
| avg. FDI inflow | 16,644 | 4.001 | 3.838 | -3.598 | 38.312 |
| log enrollment science | 16,644 | 11.876 | 1.029 | 5.421 | 12.812 |
| avg. log enrollment science | 16,644 | 11.933 | 0.897 | 8.222 | 12.812 |

# Results

| | (1) log q.a. patents | (2) log patents | (3) log q.a. patents | (4) log patents | (5) log q.a. patents | (6) log patents |
|---|---|---|---|---|---|---|
| B index | -0.405** | -0.498** | -0.416** | -0.510** | -0.338* | -0.468** |
| | (0.147) | (0.182) | (0.147) | (0.182) | (0.139) | (0.174) |
| log gdp p.c. | 0.0543 | 0.496** | 0.110 | 0.555*** | 0.120 | 0.553*** |
| | (0.129) | (0.156) | (0.127) | (0.155) | (0.125) | (0.152) |
| log enrollment science | 0.0583 | 0.0166 | 0.0405 | -0.00249 | 0.0774 | 0.0242 |
| | (0.0487) | (0.0581) | (0.0482) | (0.0579) | (0.0510) | (0.0599) |
| R&D expenditures | | | 0.147*** | 0.158*** | 0.128** | 0.134** |
| | | | (0.0400) | (0.0478) | (0.0401) | (0.0478) |
| FDI inflow | | | | | 0.00328** | 0.00165 |
| | | | | | (0.00115) | (0.00126) |
| constant | -0.905 | -4.715** | -1.556 | -5.414** | -2.075 | -5.676*** |
| | (1.391) | (1.652) | (1.391) | (1.653) | (1.357) | (1.612) |
| year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| r2_a | 0.0707 | 0.119 | 0.0716 | 0.119 | 0.0724 | 0.119 |
| N_clust | 2486 | 2486 | 2486 | 2486 | 2513 | 2513 |
| N | 16644 | 16644 | 16644 | 16644 | 17197 | 17197 |

# Results

| | (1) log q.a. patents | (2) log patents | (3) log q.a. patents | (4) log patents | (5) log q.a. patents | (6) log patents |
|---|---|---|---|---|---|---|
| B index | -0.722*** | -0.861*** | -0.722*** | -0.866*** | -0.648** | -0.815** |
| | (0.207) | (0.255) | (0.210) | (0.257) | (0.205) | (0.254) |
| avg. B index | 0.596* | 0.678* | 0.576* | 0.674* | 0.532+ | 0.621+ |
| | (0.267) | (0.327) | (0.275) | (0.335) | (0.272) | (0.333) |
| log gdp p.c. | 0.312+ | 0.759*** | 0.359* | 0.819*** | 0.348* | 0.810*** |
| | (0.172) | (0.204) | (0.171) | (0.204) | (0.171) | (0.204) |
| avg. gdp p.c. | -0.474* | -0.487+ | -0.464* | -0.506+ | -0.444+ | -0.495+ |
| | (0.230) | (0.276) | (0.231) | (0.281) | (0.231) | (0.281) |
| log enrollment science | 0.0696 | 0.0268 | 0.0523 | 0.00573 | 0.0876+ | 0.0246 |
| | (0.0501) | (0.0597) | (0.0499) | (0.0598) | (0.0521) | (0.0617) |
| avg. log enrollment science | -0.0266 | -0.0243 | -0.0269 | -0.0249 | -0.0270 | -0.0259 |
| | (0.0184) | (0.0250) | (0.0184) | (0.0248) | (0.0183) | (0.0248) |
| R&D expenditures | | | 0.144** | 0.177** | 0.151** | 0.182** |
| | | | (0.0528) | (0.0639) | (0.0533) | (0.0644) |
| avg. R&D expenditures | | | -0.00629 | -0.0517 | -0.0112 | -0.0538 |
| | | | (0.0675) | (0.0841) | (0.0677) | (0.0842) |
| FDI inflow | | | | | 0.00458** | 0.00312+ |
| | | | | | (0.00163) | (0.00173) |
| avg. FDI inflow | | | | | -0.00266 | -0.00279 |
| | | | | | (0.00166) | (0.00187) |
| year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| r2_a | 0.0720 | 0.119 | 0.0728 | 0.120 | 0.0734 | 0.120 |
| N_clust | 2486 | 2486 | 2486 | 2486 | 2486 | 2486 |
| N | 16644 | 16644 | 16644 | 16644 | 16644 | 16644 |

# Results

| | OLS | | | | ML-Poisson | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | q.a. patents | patents | q.a. patents | patents | q.a. patents | patents | q.a. patents | patents |
| main | | | | | | | | |
| B index | -7.208** | -13.35** | -7.156** | -13.49** | -4.066* | -3.223** | -4.294* | -3.190** |
| | (2.337) | (5.085) | (2.410) | (5.215) | (1.816) | (1.078) | (1.981) | (1.063) |
| avg. B index | 7.026* | 12.06+ | 6.797* | 12.32+ | 3.924+ | 2.698* | 3.796+ | 2.578* |
| | (2.943) | (7.011) | (3.097) | (7.315) | (2.107) | (1.064) | (2.219) | (1.092) |
| log gdp p.c. | 1.838 | 10.21 | 1.929 | 10.94 | -2.311+ | -0.544 | -2.482 | -0.271 |
| | (2.602) | (7.495) | (2.631) | (7.563) | (1.212) | (0.700) | (1.599) | (0.686) |
| avg. gdp p.c. | 0.228 | 0.509 | 0.518 | -0.147 | -1.458 | -0.971+ | -0.753 | -0.899 |
| | (5.665) | (13.46) | (5.539) | (13.44) | (1.074) | (0.535) | (1.176) | (0.584) |
| log enroll. science | 0.133 | -1.380+ | 0.0879 | -1.614* | 0.977* | 1.008* | 1.045+ | 0.899* |
| | (0.422) | (0.758) | (0.429) | (0.800) | (0.482) | (0.407) | (0.535) | (0.376) |
| avg. log enroll. science | -0.236 | -0.691 | -0.233 | -0.704 | 0.0881 | -0.0309 | 0.0882 | -0.00457 |
| | (0.271) | (0.613) | (0.270) | (0.607) | (0.0794) | (0.0513) | (0.0812) | (0.0572) |
| R&D expenditures | | | 0.361 | 1.988* | | | -0.472 | 0.373 |
| | | | (0.672) | (0.874) | | | (0.560) | (0.254) |
| avg. R&D expenditures | | | 0.361 | -1.213 | | | 0.978 | 0.0724 |
| | | | (1.196) | (1.637) | | | (1.092) | (0.366) |
| year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| r2_a | 0.00994 | 0.0174 | 0.00991 | 0.0175 | | | | |
| N_clust | 2486 | 2486 | 2486 | 2486 | | | | |
| N | 16644 | 16644 | 16644 | 16644 | 14781 | 14781 | 14781 | 14781 |

# Jackknife Analysis

| | (1) q.a. patents | | (2) patents | | (3) q.a. patents | |
|---|---|---|---|---|---|---|
| | min | max | min | max | min | max |
| B index | - 0.528 | - 1.019 | -0.580 | -1.066 | -0.517 | -0.975 |
| Country Controls | | | | | Y | |
| Avg. Country Controls | | | | | | |
| Countries | 18 | | 18 | | 18 | |

| | (4) patents | | (5) q.a. patents | | (6) patents | |
|---|---|---|---|---|---|---|
| | min | max | min | max | min | max |
| B index | -0.570 | -1.014 | -0.441 | -0.889 | -0.532 | -0.973 |
| Country Controls | Y | | Y | | Y | |
| Avg. Country Controls | | | Y | | Y | |
| Countries | 18 | | 18 | | 18 | |

# Further Robustness Checks

- Lagged B-Index Information
- Dynamic models
- Separate indicators for innovation (forward citations) and earnings (family size)

- **Follow-up project:** Special focus on **R&D activities in emerging markets** $\rightarrow$ Role in the transition from imitation to innovation economy
- **Question:** Are government R&D tax subsidies instrumental in raising private sector R&D in emerging markets?
- **Presumption:** Institutional quality decisive $\rightarrow$ If quality of public institutions is poor, firms are not willing to locate in a country, even with generous R&D subsidies
- **Estimation Strategy:**

$$\log PAT_{m,k,t} = \alpha_0 + \alpha_1 B_{k,t} + \alpha_2 I_{k,t} + \alpha_3 (B_{k,t} \times I_{k,t}) + \alpha_4 X_{k,t} + \phi_{m,t} + \rho_k + \mu_{m,k,t}$$

  - $PAT_{m,k,t}$ quality adjusted patent counts in industry $m$ of country $k$ at time $t$
  - $B_{k,t}$ domestic B-Index
  - $I_{k,t}$ quality of institutions
  - $X_{k,t}$ is a vector of control variables

| | (1)<br>Property Rights | (2)<br>Freedom from Corruption | (3)<br>Business Freedom |
|---|---|---|---|
| B-Index | -0.762* | -0.824* | -0.606 |
| | (0.362) | (0.363) | (0.380) |
| Institution Quality | -0.00401 | -0.00498 | -0.00369 |
| | (0.00334) | (0.00310) | (0.00265) |
| Corporate Tax | 0.0216 | 0.0820 | 0.0358 |
| | (0.528) | (0.539) | (0.520) |
| GDP p.c. (log) | 1.021*** | 1.004*** | 0.988*** |
| | (0.182) | (0.180) | (0.184) |
| population (log) | 2.624+ | 2.349+ | 2.278+ |
| | (1.364) | (1.338) | (1.359) |
| Country FE | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes |

| | (1) Property Rights | (2) Freedom from Corruption | (3) Business Freedom |
|---|---|---|---|
| B-Index X Inst. Quality | - 0.0913* | - 0.0324* | - 0.0347+ |
| | (0.0464) | (0.0134) | (0.0209) |
| B-Index | - 1.002** | -1.093** | -0.707+ |
| | (0.379) | (0.382) | (0.386) |
| Institution Quality | -0.00368 | -0.00658+ | -0.00431 |
| | (0.00418) | (0.00337) | (0.00272) |
| Country Controls | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes |

# Summary and Conclusion

- **Purpose:** assess impact of domestic and foreign R&D tax subsidies on R&D activity
- **Previous papers:** evidence that domestic R&D tax credits and tax allowances increase R&D spending
- **From welfare perspective:** decisive to understand whether tax incentives genuinely expand R&D activities or attract mobile R&D from abroad
- **Our strategy:** exploit micro data on MNEs in Europe to determine impact of domestic and foreign R&D costs on R&D activity
- **Results:**
  - Domestic tax incentives increase R&D: decrease in user cost of capital by 10% raises R&D activities by 7%
  - Foreign tax incentives reduce R&D: decrease in foreign user cost of capital by 10% raises R&D activities by 6%
  - Effect of domestic tax incentives underestimated if foreign tax incentive information is omitted
  - Large fraction of the observed sensitivity of R&D activities to domestic R&D subsidies reflects R&D activities that is attracted from abroad
- **Implications for policy debate**
  - Beggar-thy-neighbor policies: from global perspective, R&D tax subsidies inefficiently high
  - Elasticity of global R&D as small as $0.1$
  - International policy coordination of R&D subsidy schemes may significantly increase aggregate welfare