The Global Effects of R&D Tax Incentives

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Motivation

Unprecedented increase in prevalence & generosity of R&D tax incentives

- Today, 34 out of the 38 OECD countries offer preferential R&D tax treatment
- Significant government expenditures for R&D tax support: 11 billion US Dollars in US; 6 billion Euro in France; 3 billion British Pound in UK

Insights from the literature

- Theory: Granting R&D tax subsidies to private sector firms internalizes positive externalities (seminal work by Arrow 1962)
- Empirical evidence confirms that ...
  - social returns to R&D investments outweigh private returns (Hall et al. 2010, Bloom et al. 2013, Jones and Summers 2020)
  - reduced host country R&D tax costs raise firms' R&D investment (Bloom et al. 2002, Wilson 2009, Moretti and Wilson 2017; Lokshin and Mohnen 2012, Mulkay and Mairesse 2013; Rao 2016, Dechezlepretre et al. 2017, Agrawal et al. 2017, Guceri and Liu 2019, Chen et al. 2019)

- **Observation: Knowledge externalities do not stop at national borders**
  - Some fraction of R&D benefits accrue abroad
  - R&D tax incentives only internalize *domestic* knowledge spillovers
  - Consequence: set inefficiently small from global perspective
- **In this paper: We empirically quantify domestic and foreign knowledge spillovers induced by R&D tax incentive**
  - Merge accounting data and information on patent filings
  - Use patent forward citations to proxy for knowledge flows
  - Distinguish between multinational firms and national firms
- **Key Findings**
  - Significant fraction of knowledge externalities accrue abroad
  - R&D tax incentives $\uparrow \rightarrow$ Domestic and cross-border knowledge flows $\uparrow$ in about equal proportion
  - Induced knowledge flows shape the real economic activity of knowledge-receiving firms

Data

- **Match data on patents to accounting and ownership data for firms in Europe**
  - Accounting & ownership data from BvD's **AMADEUS database**
    Distinguish between multinational firms and national firms (GUO links)
  - AMADEUS matched to successful patent applications per firm and year
  - Drawn from the administrative patent database **PATSTAT**
    (national and supranational patent offices worldwide)
  - Inventors located in the same country as the patent filing firm
    (e.g. Guellec and van Pottelsberghe de la Potterie 2001)
  - Knowledge flows approx. by five-year forward citations of patent family
    Distinguish between 'domestic' forward citations and 'foreign' forward citations, constructed based on location of inventors of citing patent

- Countries' R&D tax treatment modeled by 'B-index' (McFetridge and Warda 1983)
- B-index for country c in period t is defined as

$$T_{c,t} = \frac{1 - Z_{c,t} \cdot \tau_{c,t}}{1 - \tau_{c,t}} \tag{1}$$

where

  - $\tau_{c,t}$ indicates the corporate tax rate of country c at time t
  - $Z_{c,t}$ measures the deductibility of R&D expenditures from the corporate tax base (tax allowances, tax expenditures, tax credits).

- $T_{c,t}$: minimum pre-tax earnings required for an R&D project to break even
  $\Rightarrow$ measure R&D tax costs of a representative firm in country c

Data

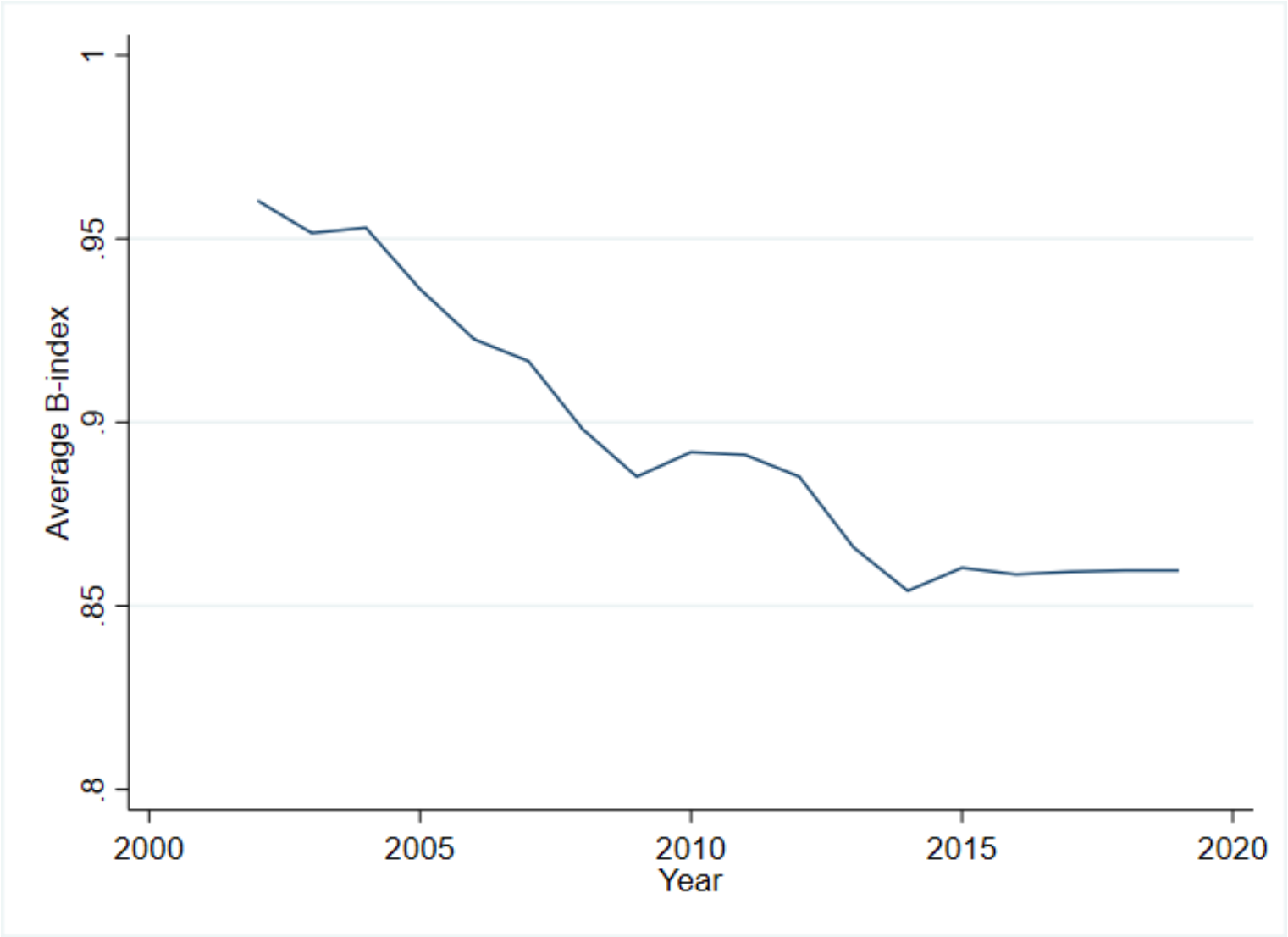


Table: Descriptive Statistics

Variable	Obs.	Mean	Std.Dev	Min	Max
Multinational Firms					
Total Citations	157,592	2.085227	8.295145	0	120
Foreign Citations	157,592	1.189443	5.229359	0	114
Domestic Citations	157,592	.8957836	4.113302	0	105
B-index (Lag)	157,592	.9291322	.1369279	.55	1.04
Statutory Tax	157,592	.2632472	.0627713	.1	.39
National Firms					
Total Citations	120,417	.6162376	2.965096	0	120
Foreign Citations	120,417	.3453436	2.135589	0	117.75
Domestic Citations	120,417	.270894	1.345629	0	91.96183

Estimation Methodology

Fixed effects PPML model, with the following parametrization:

$$E\left(y_{i,c,t}|T_{c,t-1}, X_{c,t-1}\right) = \exp\left(\beta_1 T_{c,t-1} + \beta_2 X_{c,t-1} + \lambda_i + \delta_t\right) \tag{2}$$

- $y_{i,t}$: total/foreign/domestic forward citations at time t
- $T_{c,t-1}$: Host country R&D tax costs
- λ_i and δ_t: full sets of MNE-location fixed effects and time fixed effects
- $X_{c,t-1}$: vector of host country controls
  country size, economic development, governance characteristics, FDI inflows and direct government support for business R&D (i.e. support not granted through the tax system)

Theoretical expectation: sign of β_1 negative
Clustering at firm level; alternative assumptions in robustness checks

Baseline Results: Multinational Firms

	(1) Total Citations	(2) Foreign Citations	(3) Domestic Citations
B-index, Lag	-2.9674***	-2.6492***	-3.4863***
	(0.2589)	(0.2973)	(0.3391)
Stat. Tax Rate, Lag	-0.7933	-0.2800	-0.3588
	(0.5664)	(0.6539)	(0.7469)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Observations	157,592	131,611	120,584

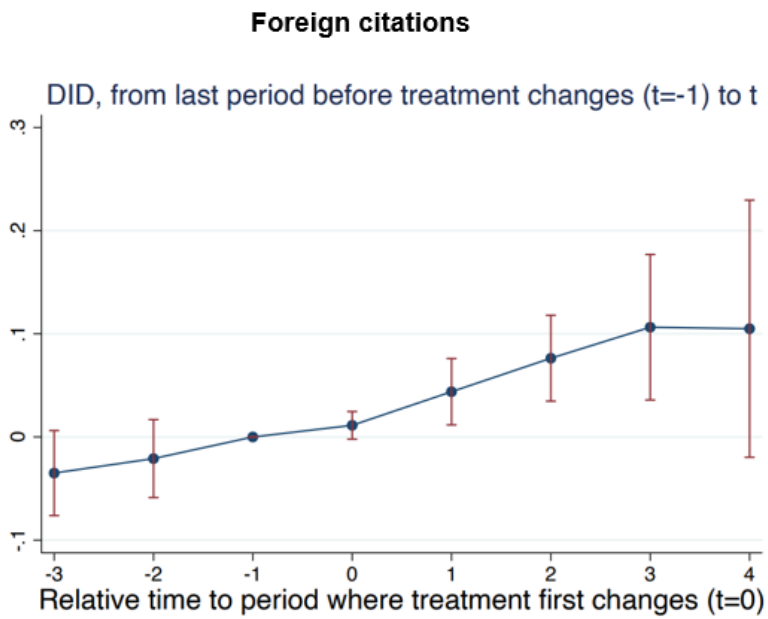
Results: Domestic Firms

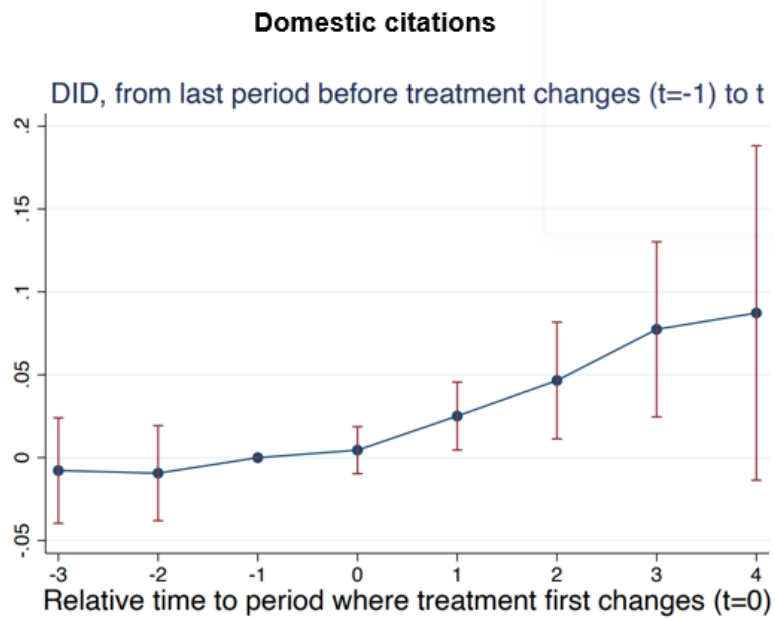
	Multinational Firms		
	(1) Total Cit.	(2) Foreign Cit.	(3) Domestic Cit.
B-index, Lag	-2.9674***	-2.6492***	-3.4863***
	(0.2589)	(0.2973)	(0.3391)
Stat. Tax, Lag	-0.7933	-0.2800	-0.3588
	(0.5664)	(0.6539)	(0.7469)
Observations	157,592	131,611	120,584
	National Firms		
	(4) Total Cit.	(5) Foreign Cit.	(6) Domestic Cit.
B-index, Lag	-2.0273***	-1.4141**	-3.4289***
	(0.2589)	(0.6309)	(0.4138)
Stat. Tax, Lag	-0.0063	-0.3136	0.2269
	(0.5664)	(1.1466)	(0.7764)
Observations	120,417	86,523	88,326
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes

Heterogeneous Treatment Effects

- Two-way fixed effects design
- Firms are subject to staggered treatment
- Estimates may be biased in presence of heterogeneous and dynamic treatment effects (e.g. Goodman-Bacon 2021)
- Idea: Compare treated units to 'never-treated' units or 'not-yet-treated' units (e.g. Roth et al 2022)
- Estimators proposed by de Chaisemartin and D'Haultfoeuille (2020, 2022)

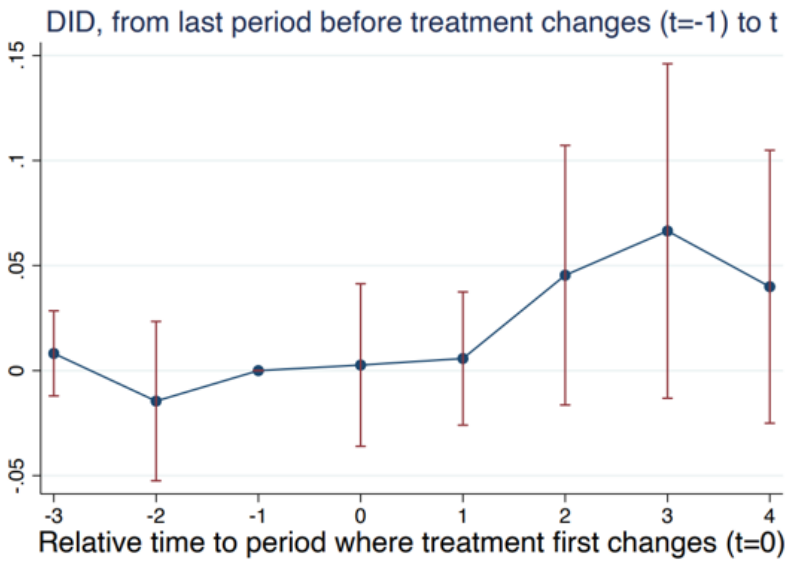
MNE: de Chaisemartin and d'Haultfoeuille (2020)



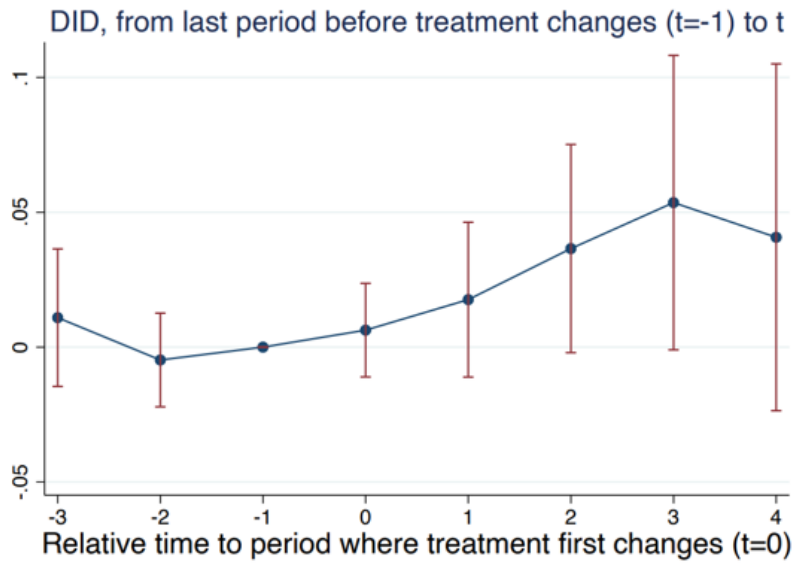


NE: de Chaisemartin and d'Haultfoeuille (2020)

Foreign citations



Domestic citations



R&D Relocation

- Our evidence so far identified positive cross-border knowledge spillovers of R&D tax incentives
- **Countervailing factor: relocation** of R&D activity; probably mostly within MNEs (see e.g. Knoll et al. 2021; Wilson 2009; Akcigit et al. 2022)
- **Theoretical considerations**:

  ambiguous effect of B-index cut on forward citations of foreign firms
  - Relocation: forward citations of foreign firms $\downarrow$
  - In part genuinely new R&D: Knowledge spillovers on foreign country $\Rightarrow$ More and better R&D abroad $\Rightarrow$ Forward citations of foreign firms $\uparrow$
- Test: **add regressor for weighted average B-index** at other group locations (and same for vector of control variables)

	(1) Total Citations	(2) Foreign Citations	(3) Domestic Citations
B-index, Lag	-3.1580***	-2.8858***	-3.4523***
	(0.3050)	(0.3433)	(0.4037)
Avg. Foreign B-index, Lag	0.1855	0.0429	0.3492
	(0.3638)	(0.5083)	(0.3913)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Controls Avg.	Yes	Yes	Yes
Observations	98,168	82,830	75,528

Real Economic Changes

Real Economic Changes

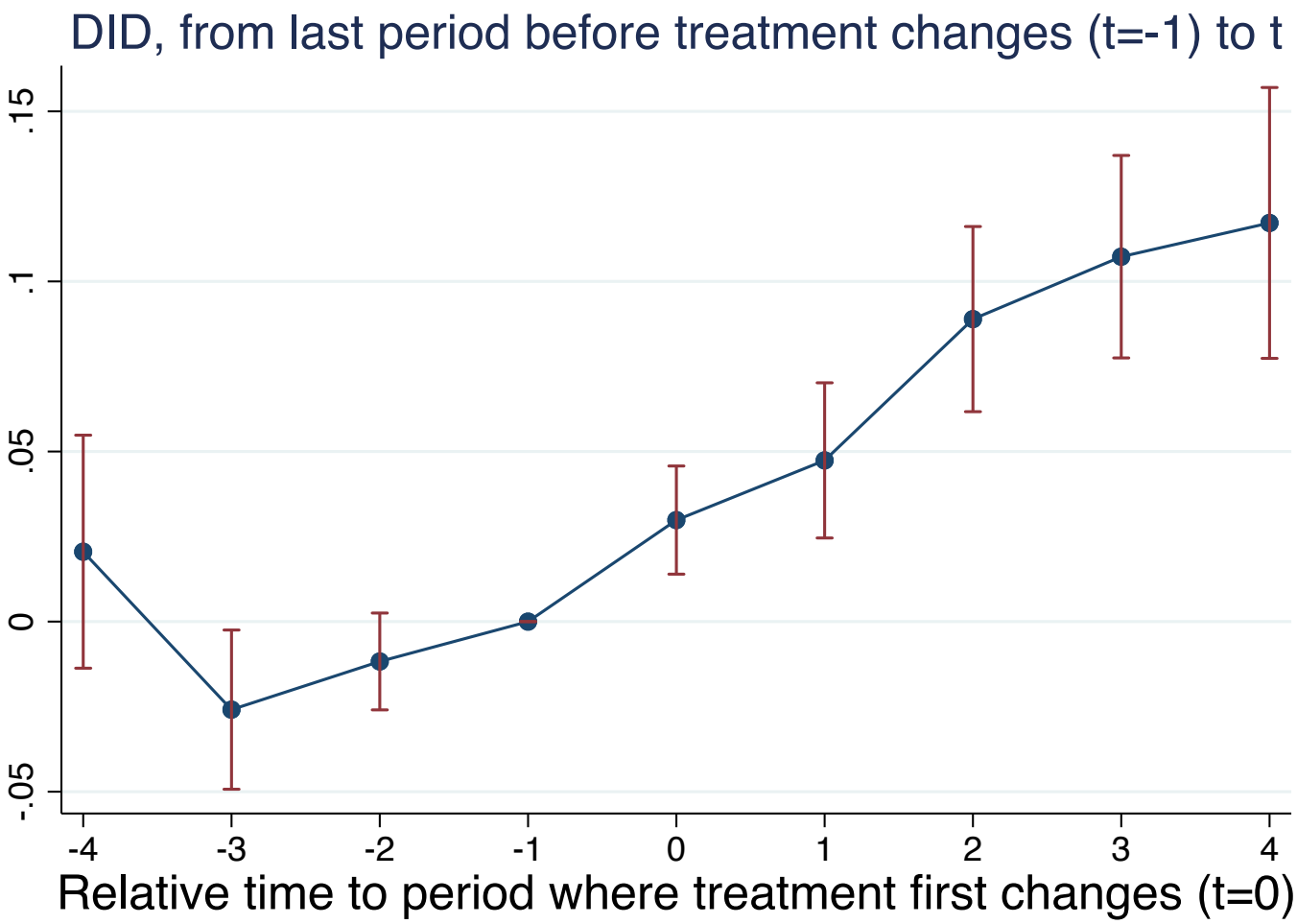
- First step: Intra-group perspective, similar to Bilir and Morales (2020)
- Sample: Multinational affiliates
- Baseline specifications: Track changes in fixed assets (Co-investments to exploit new knowledge (Brynjolfsson et al. 2021))
- Question: How does asset investment at foreign group locations change if B-index is reduced?
- Effect may differ across affiliates that do and do not engage in R&D
  - Non-R&D affiliates: positive knowledge spillovers
    $\Rightarrow$ Assets $\uparrow$
  - R&D affiliates: relocation and positive knowledge spillovers
    $\Rightarrow$ Effect on assets ambiguous

- Empirical estimation model:

$$y_{i,c,t} = \beta_1 \overline{T}_{c,t-1} + \beta_2 \overline{X}_{c,t-1} + \lambda_i + \delta_{ct} + \epsilon_{i,c,t} \tag{3}$$

  - $y_{i,c,t}$: log of fixed assets of affiliate i at time t
  - $\overline{T}_{c,t-1}$: Avg. of R&D tax costs at foreign affiliates
  - λ_i: firm fixed effect
  - δ_{ct}: country-year FE
  - $\overline{X}_{c,t-1}$: avg. of country controls at foreign locations

	Dep Var: Log assets			
	(1)	(2)	(3)	(4)
B-index, Lag	-0.2647***		-0.2584***	
	(0.0379)		(0.0501)	
Avg. B-index, Lag	-0.3853***	-0.3566***	-0.1933**	-0.0025
	(0.0937)	(0.0942)	(0.0771)	(0.0794)
Sample	**NOPAT**	**NOPAT**	**PAT**	**PAT**
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes		Yes	
Ctry-Year FE		Yes		Yes
Controls Avg.	Yes	Yes	Yes	Yes
Observations	958,497	958,495	288,122	288,121
	Dep. Var.: TFP		**Log wage costs**	
	(5)	(6)	(7)	(8)
B-index, Lag	-0.2370***	0.0895**	0.0337	0.0908
	(0.0902)	(0.0416)	(0.0956)	(0.0616)
Sample	**NOPAT**	**PAT**	**NOPAT**	**PAT**
Firm FE	Yes	Yes	Yes	Yes
Ctry-Year FE	Yes	Yes	Yes	Yes
Controls Avg.	Yes	Yes	Yes	Yes
Observations	218,381	156,770	921,123	275,256


DID, from last period before treatment changes (t=-1) to t
.15
.1
.05
0
-.05
-4
-3
-2
-1
0
1
2
3
4
Relative time to period where treatment first changes (t=0)

Summary and Conclusion

- R&D tax incentives induce domestic and cross-border knowledge spillovers
- R&D tax incentives set inefficiently small from a global perspective
- Under additional assumptions: globally optimal incentives twice the size of national incentives
- Evidence consistent with knowledge flows triggering adjustment in real economic activity at foreign locations
- Welfare gains from international coordination of R&D tax incentives