Knowledge Spillovers, Market Power, and Innovation under Trade Shocks

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Trade, Knowledge Diffusion, and Innovation

- Recent trade–growth models emphasize knowledge spillovers as a key engine of innovation and productivity growth.
- Trade shocks, however, also reshape market structure and firms' incentives to innovate.
- The role of knowledge in this process is theoretically ambiguous.
  - Knowledge may help innovators learn from one another;
  - while it may also enable non-innovators to catch up and erode innovation rents.
- **Research question:** When do knowledge externalities amplify innovation responses to trade shocks, and when do they dampen them?

This paper

We answer this in three steps:

1. **Empirical:** first paired evidence across two opposite trade episodes — China's WTO accession (2001) and the U.S.–China trade war (2018–).

2. **Theoretical:** a model of oligopolistic innovators and a competitive fringe with *two distinct* knowledge externalities, yielding a threshold that separates dampening from amplifying regimes.

3. **Quantitative:** counterfactual policy exercises on sector-targeted R&D subsidies and diffusion infrastructure.

Headline result: same variable, opposite sign

	China (WTO) Import Tariffs ↓	**United States (Trade War)** Import Tariffs ↑
Average innovation effect	$+7$ to $+12\%$	-3 to -5%
$\times$ High spillover	-2.4% (dampens)	-2.4 to -2.7% (amplifies)
$\times$ High market share	stronger response	stronger response

- Spillover **dampens** the positive response under liberalization.
- Spillover **amplifies** the negative response under protection.
- Market power amplifies the response in *both* directions.

Related literature

- **Trade & innovation, imperfect competition**: Atkeson and Burstein (2008), Atkeson and Burstein (2010), Melitz and Ottaviano (2008), Impullitti and Licandro (2018), Impullitti, Licandro, and Rendahl (2022), Helpman and Niswonger (2023), and Helpman (2024)
  ⇒ separates spillover among innovators from diffusion to non-innovators
- **Knowledge externalities & growth**: Akcigit, Ates, and Impullitti (2018), Buera and Oberfield (2020), Cai, Li, and Santacreu (2022), Lind and Ramondo (2023), Sampson (2016), and Perla, Tonetti, and Waugh (2021)
  ⇒ endogenises spillover/diffusion balance jointly with market power
- **Empirical trade & innovation**: Bloom, Draca, and Van Reenen (2016), Autor et al. (2020), Liu and Ma (2020), Fajgelbaum et al. (2020), and Bilir and Morales (2020)
  ⇒ first paired evidence across two opposite trade episodes
- **Competition & innovation**: Aghion et al. (2005) and Aghion et al. (2019)
  ⇒ shows how knowledge spillovers and market power *jointly* shape the competition–innovation relationship under trade shocks

Roadmap

Empirical Findings

- China's WTO Accession
- U.S. Trade War

Model

Calibration and Counterfactuals

Empirical Findings

Setting: China's WTO accession (2001)

- China applied 1995 $\rightarrow$ accession Nov 2001 $\rightarrow$ tariff cuts implemented 2002–2004.
- Tariff schedules pre-negotiated at HS product level and aggregated to 4-digit CIC sectors $\Rightarrow$ **plausibly exogenous** to short-run firm decisions (Lu and Yu, 2015).
- Prior work: Liu and Ma (2020) document a post-accession surge in patenting; Liu and Qiu (2016) find input-tariff cuts sometimes depress innovation.
- **Our question:** how does pre-accession spillover intensity and market power shape the response?

Data: matched firm–patent panel (1998–2007)

- **Firm data**: ASIF, manufacturers with sales $>$ 5M RMB
  - Restricted to **domestic-owned firms** (ASIF codes 110–190)
  - Restricted to firms with at least one patent **before the WTO shock** (pre-2001)
- **Patent data**: SIPO patents merged to ASIF firms (He et al., 2018)
- **Spillover**: accumulated **backward** citations per patent at ISIC sector level, 1985–2000 (pre-determined) (Griffith, Lee, and Van Reenen, 2011; Bloom, Schankerman, and Van Reenen, 2013; Cai, Li, and Santacreu, 2022)
  - Captures *average prior-art base each patent absorbs*
- **Sample**: 234 CIC-4 sectors; sector switchers excluded

⏩ Top/bottom sectors

Specification

PPML (firm-level patent counts), clustering at 4-digit sector:

$$y_{ist} = \exp\Big(\alpha_0 + \alpha_1 TG_s \times Post01 + \alpha_2 TG_s \times Post01 \times HighS_{s,2001} + \alpha_3 TG_s \times Post01 \times HighM_{i,2001} + \mu_i + \mu_t + \mathbf{X}\Big) + \varepsilon_{it}$$

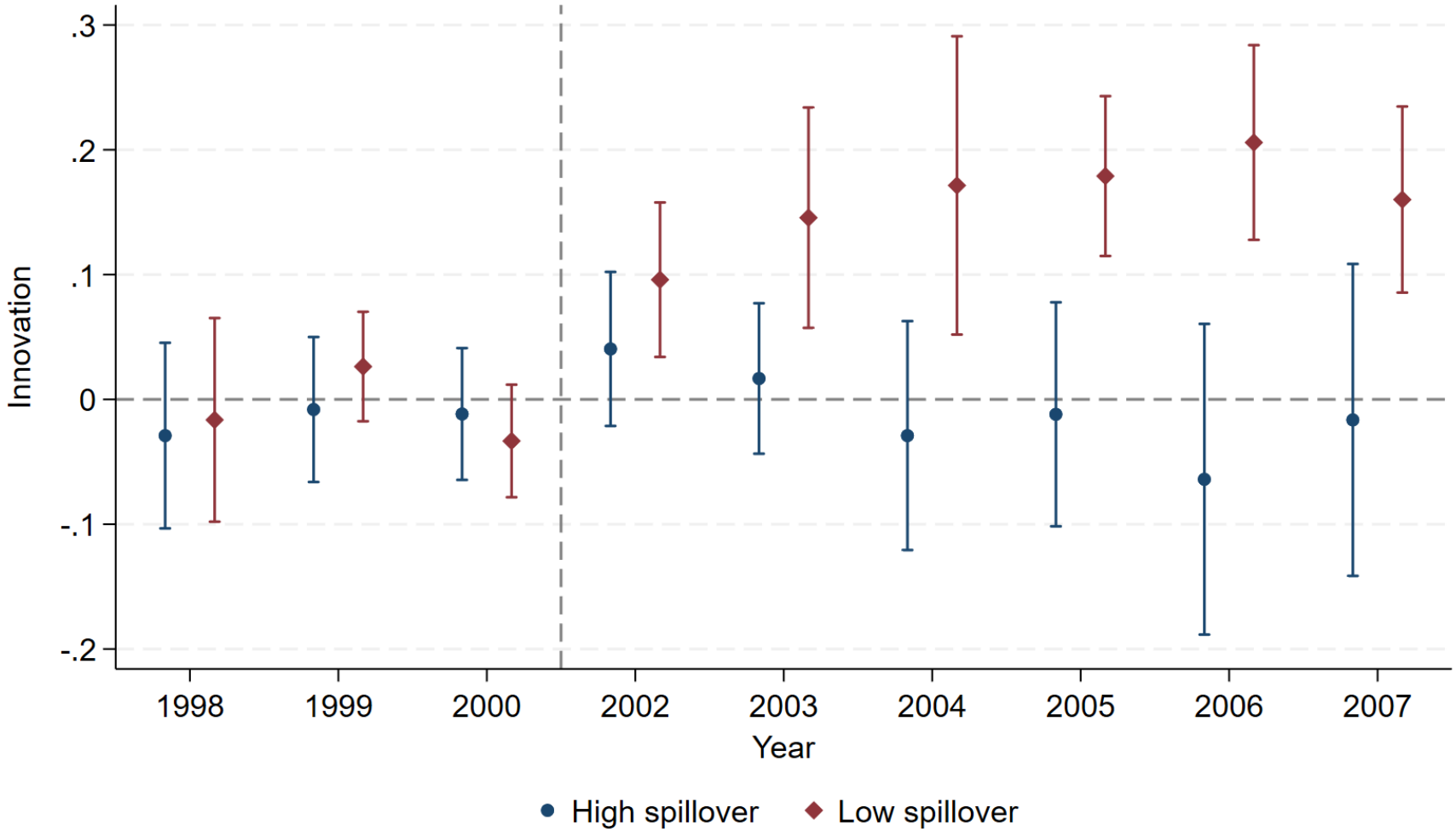
- $TG_s = 2001 - 2002$ applied tariff. $\quad Post01 = \mathbf{1}\{t > 2001\}$.
- $HighS_{s,2001}$: above-median accumulated citations per patent.
- $HighM_{i,2001}$: above-median within-sector revenue share.
- $\mathbf{X}$: pre-shock patent stock, HHI, capital/labor $\times Post$ + time-varying firm controls.
- μ_i, μ_t: firm & year FE.

WTO: average effect and spillover heterogeneity

	(1) Binary	(2) lncpc	(3) lncp	(4) lncpa
Tariff × Post01	0.120***	0.083**	0.068**	0.084***
	(0.034)	(0.033)	(0.033)	(0.033)
Tariff × Post01 × High spillover	-0.053*			
	(0.029)			
Tariff × Post01 × Accum. CpP (dep.)		-0.024***		
		(0.009)		
Tariff × Post01 × Current CpP			-0.024***	
			(0.006)	
Tariff × Post01 × Accum. CpP				-0.024**
				(0.009)
Observations	23266	23266	23266	23266
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

- Low-spillover sectors: **7–12%** more patents per 1 p.p. tariff cut.
- High-spillover sectors respond -5.3 **pp less** (binary, col 1) $\Rightarrow \sim 2.4$ **pp less** per unit increase in continuous citation measures (cols 2–4, all $p < 0.01$).

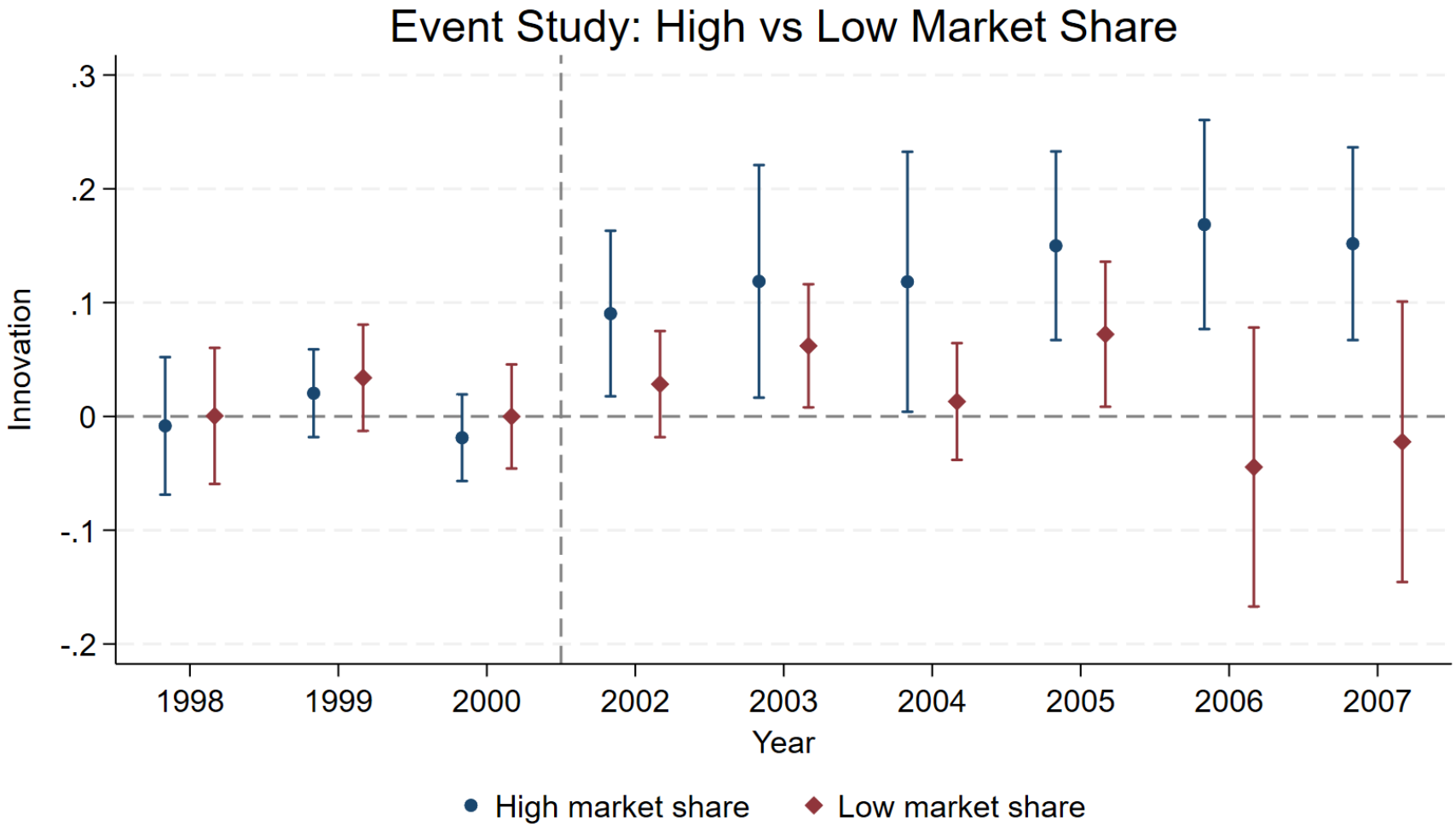
WTO: high vs. low spillover sectors over time



Low-spillover sectors respond significantly: **12%** more patents per 1 p.p. tariff cut. High-spillover sectors respond **5.3 p.p. less** (col 1, $p < 0.10$).

⏩ Event study (appendix)

WTO: market share amplification



High-market-share firms exhibit **significantly larger** post-WTO innovation gains (**17.6%** binary; **3.9%** per 1 p.p. share continuous).

⏩ Full table (appendix)

WTO: robustness checks (summary)

- High-exporter sector dummy $\rightarrow$ rules out export-channel confound.
- Excluding 1998 (first ASIF year): unchanged.
- **Broader sample**: include all firms that patent at any point during 1998–2007 (not just pre-shock patenters). Continuous citation measures remain significant ($p < 0.01$); magnitudes attenuate $\sim 25\%$. Table
- **Province $\times$ year FE: all signs preserved**, heterogeneity coefficients attenuate $\sim$30% but remain significant. Table

Takeaway: liberalization raised innovation on average, but **less so** *in knowledge-intensive sectors and* **more so** *for dominant firms.*

Setting: the 2018 U.S. trade war

- Feb 2018: tariffs on \$8bn solar/washing machines, then steel/aluminum.
- Subsequent waves cover \$247bn of Chinese imports.
- Retaliation from China, EU, Mexico, Canada, Turkey, Russia — $7{,}000+$ products (Fajgelbaum et al., 2020).
- **Identification**: sector-level import-tariff increases (NAICS-4); retaliatory tariffs as separate regressor.
- Mirrors the China analysis with reversed sign on the shock.

Data: Compustat × USPTO (2013–2019)

- **Firm data**: Compustat (balance sheet, R&D, employment, capital, total assets), positive-asset firms only.
- **Patents**: USPTO (PatentsView); assignees matched via Dyevre (2023).
- **Spillover**: CPC-based accumulated **backward** citations per patent, 1975–2017, mapped to NAICS via Lybbert and Zolas (2014); averaged over **2000–2012** to remain pre-determined.
- **Sample window**: 2013–2019 (stop pre-COVID).
- 85 NAICS-4 sectors. ⏩ Top/bottom sectors

Specification

$$y_{isdt} = \exp\Big(\alpha_0 + \alpha_1 TG_s \times Post18 + \alpha_2 TG_s \times Post18 \times HighS_s + \alpha_3 TC_s \times Post18 + \mathbf{X} + \mu_i + \mu_t\Big) + \varepsilon_{isdt}$$

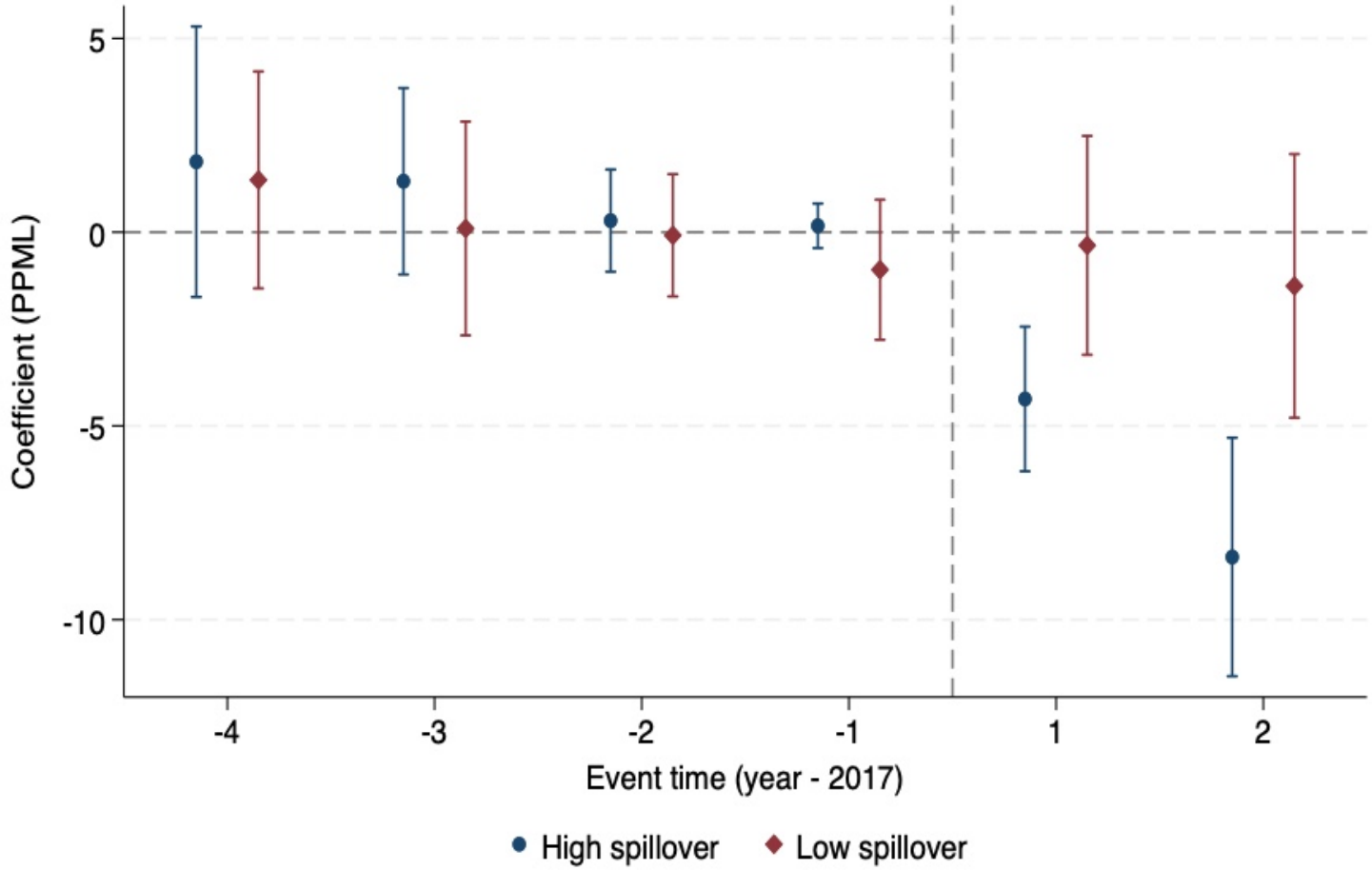
- TG_s: U.S. import-tariff increase. TC_s: foreign retaliatory tariffs.
- $HighS_s$: above-median accumulated citations per patent (2000–2012).
- Controls: pre-shock patent stock, HHI, capital, labor $\times Post$; firm employment, capital, total assets.
- Standard errors clustered at NAICS-4 sector level.

Trade War: baseline result

	Patents				log R&D			
	contemp.		1-yr ahead		contemp.		1-yr ahead	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Import tariff × Post18	-0.033***	-0.038***	-0.055***	-0.051***	-0.020**	-0.003	-0.011**	-0.004
	(0.009)	(0.008)	(0.015)	(0.012)	(0.008)	(0.005)	(0.005)	(0.004)
Retaliatory tariff × Post18	0.006	0.014**	-0.000	0.011	-0.018	-0.004	-0.010	-0.001
	(0.009)	(0.007)	(0.013)	(0.012)	(0.011)	(0.007)	(0.007)	(0.007)
Observations	8,875	8,131	7,502	6,798	7,871	7,362	6,841	6,302
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes

- 1-unit tariff increase $\Rightarrow$ **3–5%** decline in patenting (cols 1–4).
- Effect on log R&D expenditure: negative but imprecise (cols 5–8; R&D budgets are sticky).

Trade War: spillover heterogeneity

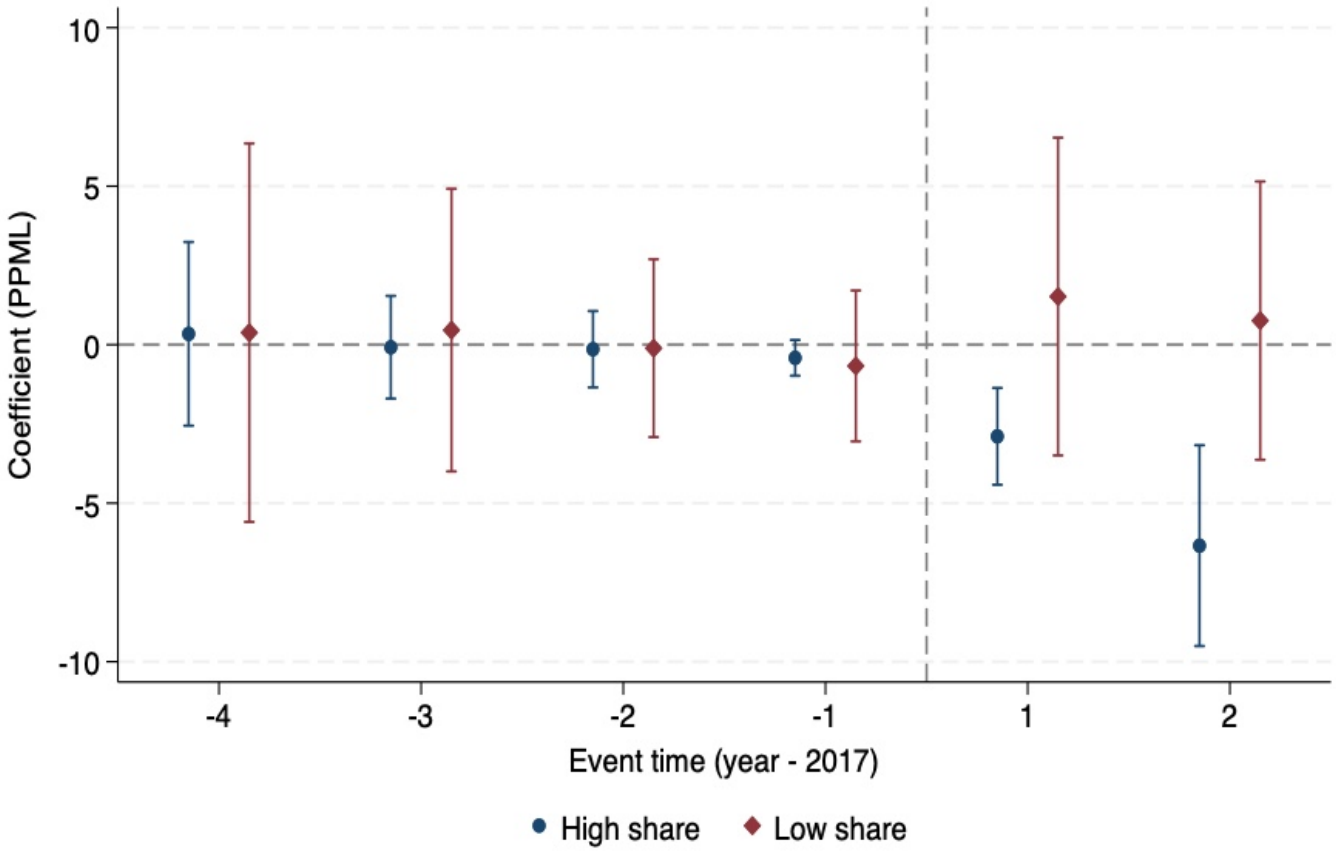


Pre-trends parallel (✓); post-2018 split.

High-spillover sectors decline **2.4–2.7%** more than low-spillover sectors.

⏩ Full table

Trade War: market share amplification



High-market-share firms experience a **larger** decline (2.3–2.5% binary; 8–12% continuous). ⏩ Full table

Cross-episode comparison: the puzzle in one table

	China (Tariff ↓)	**U.S. (Tariff ↑)**
Average effect on patenting	+	−
× High spillover	− (dampens)	− (amplifies)
× High market share	+ (amplifies)	− (amplifies)

- **Same spillover variable, opposite role.**
- Market share consistently amplifies the response.
- These two facts jointly motivate the model.

Model

Why a model?

- Two robust empirical facts:
  1. Spillover's role **flips sign** with the direction of the trade shock.
  2. Market share **amplifies** the response in both episodes.
- Existing frameworks treat these in isolation:
  - Trade–innovation: spillover exogenous (Buera and Oberfield, 2020; Cai, Li, and Santacreu, 2022).
  - Competition–innovation: no knowledge externalities (Aghion et al., 2005; Impullitti and Licandro, 2018).
- **Goal:** a unified framework where (i) variable markups and (ii) two distinct knowledge externalities determine the sign of the trade-innovation response.

Environment

- **Two symmetric countries**; numeraire good x_o + CES differentiated composite $\mathcal{X}$.
- Differentiated sector in each country populated by:
  - **Non-innovators (fringe)**: mass M, monopolistic competition, single period, zero-profit entry, M endogenous.
  - **Innovators (oligopolists)**: N firms, infinite horizon, invest in R&D, internalize price-index effects.
- Iceberg trade cost $\tau \geq 1$; labor immobile, only primary input.
- Two CES tiers $\sigma > \gamma > 1$, so $\delta \equiv \sigma - \gamma > 0$.

Household preferences and demand

- Representative household utility:

$$u = x_o + \tfrac{\gamma}{\gamma-1}\mathcal{X}^{(\gamma-1)/\gamma}, \quad \gamma > 1$$

- CES aggregator over varieties (M fringe + N innovators):

$$\mathcal{X} = \left[\int_0^M q_i^{\sigma/(\sigma-1)}\, di + \sum_{j=1}^{N} Q_j^{\sigma/(\sigma-1)}\right]^{(\sigma-1)/\sigma}, \quad \sigma > \gamma > 1$$

- Variety demand: $Q(\omega) = P^{\delta} p(\omega)^{-\sigma}$, with $\delta \equiv \sigma - \gamma > 0$

Second stage: Innovators

- There are N symmetric innovating firms in each country producing the other varieties j and all have the same productivity level z_j.
- Solving for the profit maximization problem for the domestic market (similar for the foreign market),

$$\max_{p_j} P^{\sigma-\gamma} p_j^{-\sigma} (p_j - {z_j}^{-1}) \tag{1}$$

We get the standard result that

$$p_j = \underbrace{\frac{\sigma - (\sigma-\gamma)s_j}{\sigma - (\sigma-\gamma)s_j - 1}}_{\textbf{markup} \equiv \theta_j} \frac{1}{z_j}, \tag{2}$$

where $s_j \equiv \frac{p_j q_j}{PQ} = \frac{p_j^{1-\sigma}}{P^{1-\sigma}}$.

First stage: Non-innovators

- Non-innovators engage in monopolistic competition, and each produces one variety.
- They hire f workers to pay the fixed cost to enter the market and correctly forecast the P in the second stage.
- Their productivity level is $1/\bar{a}$.
- All of them are exporters, charging $\frac{\sigma}{\sigma-1}\bar{a}$ domestically and $\frac{\sigma}{\sigma-1}\tau\bar{a}$ aboard $(\tau > 1)$.
- Zero profit condition implies:

$$\frac{1}{\sigma}P^{\sigma-\gamma}\left(\frac{\sigma}{\sigma-1}\bar{a}\right)^{1-\sigma}(1+\tau^{1-\sigma}) = f.$$

Innovators: R&D and the law of motion

- Innovators live forever and invest l_j^R labor units in R&D:

$$\max_{\{l_j^R(t)\}} \int_0^\infty e^{-rt} \left[\pi_{d,j} + \pi_{x,j} - l_j^R\right] dt$$

- Productivity evolves with own effort and aggregate spillover S:

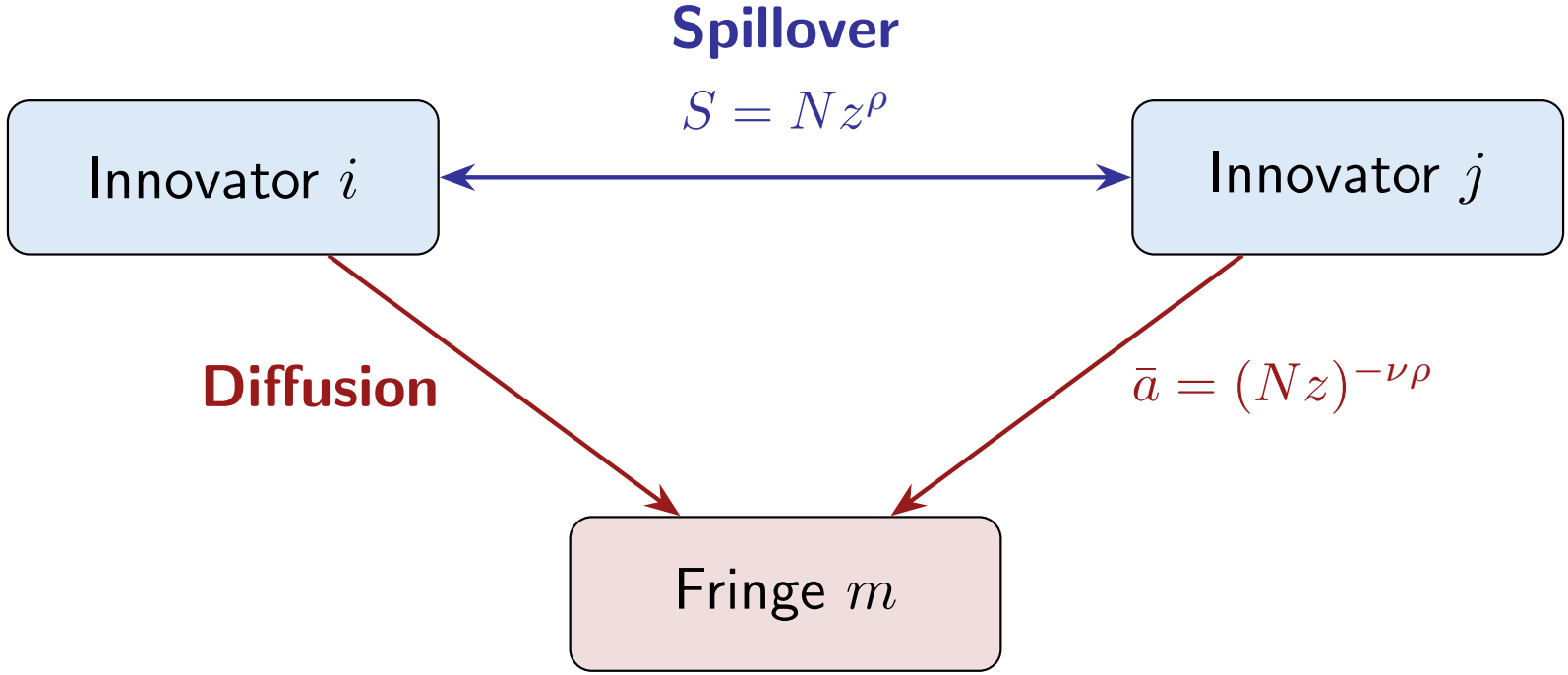
$$\dot{z}_j = z_j^{1-\alpha} S^\alpha (l_j^R)^\beta - \delta_z z_j, \quad \alpha, \beta \in (0,1)$$

- On the balanced growth path:

$$\frac{l_j^R}{\beta}\left[\frac{\rho}{\delta_z} + \alpha\right] = (\sigma - 1)\pi_j$$

$\Rightarrow$ higher profits drive higher R&D effort

Two knowledge externalities



- **Spillover** (innovator $\leftrightarrow$ innovator): lowers private R&D cost $\Rightarrow$ *dampens* incentive.
- **Diffusion** (innovator $\rightarrow$ fringe): raises fringe productivity, erodes innovator rents $\Rightarrow$ *amplifies* incentive.

Net effect depends on the regime: $\kappa^* = \nu(\sigma - 1)$ *vs.* α/β.

Trade shock and innovation: threshold result

Log-linearizing the steady-state condition wrt τ:

$$\underbrace{\frac{(1-\sigma)\tau^{1-\sigma}}{1+\tau^{1-\sigma}}\hat{\tau}}_{\text{demand}} - \underbrace{\hat{\theta}}_{\text{markup}} + \underbrace{\frac{\alpha}{\beta}(1-\rho)\hat{z}}_{\text{spillover}} = (\sigma-1)\hat{z} - \underbrace{(\sigma-1)\nu\rho}_{\text{diffusion}}\hat{z}$$

Proposition 1. A higher spillover intensity ρ implies:

- **Smaller** response to trade liberalization if $(\sigma-1)\nu < \alpha/\beta$ (**dampening regime**).
- **Larger** response to protection if $(\sigma-1)\nu > \alpha/\beta$ (**amplifying regime**).

Intuition: weak diffusion $\Rightarrow$ firms free-ride on spillover; strong diffusion $\Rightarrow$ firms must run faster to keep ahead of an encroaching fringe. ⏩ GE channel (Prop 2)

Market power amplification (Proposition 3)

Proposition 3. A higher pre-shock domestic markup θ_d amplifies the response of innovation to a trade shock:

$$\frac{\partial \varepsilon_{z,\tau}}{\partial \theta_d} > 0.$$

- Higher $\theta_d \Leftrightarrow$ larger domestic market share s_j.
- Foreign demand is a larger *relative* component of operating profits.
- Any change in τ shifts foreign profits more, which feeds through R&D incentives.
- Matches the **market share amplification** fact in both episodes.

Map model predictions to data

- Sign of $\partial\hat{z}/\partial\rho$ pins down regime $\Rightarrow$ *testable*.
- Estimable structural parameters:
  - ρ: from a Bartik-IV regression of sector knowledge growth on lagged spillover.
  - α/β: from profit–R&D regressions.
  - ν: from a TFP-on-knowledge stock regression.
  - σ: from a markup regression on cost shares.
- Predicted regime classification:
  - China: $\kappa^\star = \nu(\sigma - 1)$ small $\Rightarrow$ **dampening**.
  - U.S.: $\kappa^\star$ large $\Rightarrow$ **amplifying**.
- Cross-sector predictions $\hat{z}_s$ should correlate with sector-level DID estimates.

Calibration and Counterfactuals

Externally calibrated parameters

- Elasticity of substitution σ from mean output-to-cost ratio **among non-innovating firms** (constant markup $\sigma/(\sigma-1)$): $\sigma/(\sigma-1) = \overline{p/c}$
  - China: $\overline{p/c} = 1.96 \Rightarrow \sigma = 2.05$
  - United States: $\overline{p/c} = 1.77 \Rightarrow \sigma = 2.30$
- Demand curvature $\gamma = 1.25$ following Edmond, Midrigan, and Xu (2015); $\delta \equiv \sigma - \gamma$
  - $\delta = 0.80$ (China), 1.05 (U.S.)
- Remaining $\{\rho, \alpha/\beta, \nu\}$ estimated **sequentially** from model equations

Step 1: spillover intensity ρ

Bartik IV on knowledge-flow equation (z proxied by patent stock Pat):

$$\ln S_{st} = \rho \ln\left(\sum_{s' \neq s} w_{ss'} \sum_{j} \mathsf{Pat}_{js'}\right) + \mathsf{FE}_s + \mathsf{FE}_t + \varepsilon_{st}$$

- **China:** $\rho = 0.306$ ($F > 430$); subsamples $0.358/0.258$
- **U.S.:** panel IV co-trends $\Rightarrow$ firm-level long-difference: $\rho = 0.273\,(0.086)$

Step 2: R&D efficiency α/β

Model implies the BGP profit equation (empirical proxy for z is patent stock Pat):

$$\ln \pi_j = (1-\rho)\,\frac{\alpha}{\beta}\,\ln \mathsf{Pat}_j + \mathsf{FE}_{s\times t} + \varepsilon_j$$

Slope on $\ln \mathsf{Pat}_j$ identifies $(1-\rho)\alpha/\beta$; divide by $(1-\rho)$ to recover α/β.

- **China:** slope $= 0.075\,(0.028) \Rightarrow \alpha/\beta = 0.075/(1-0.306) = \mathbf{0.108}$
- **United States:** slope $= 0.055\,(0.031) \Rightarrow \alpha/\beta = 0.055/(1-0.273) = \mathbf{0.076}$
- α and β not separately identified — ratio suffices for counterfactuals

Step 3: diffusion to non-innovators ν

Non-innovator productivity vs. aggregate sectoral patent stock:

$$\Delta\overline{\text{TFP}}_i \;=\; \nu\rho\,\ln\!\Big(\sum_j \text{Pat}_{js,\text{pre}}\Big) + X'\gamma + \varepsilon_i$$

TFP: Olley–Pakes (China); cost-residual (U.S.).

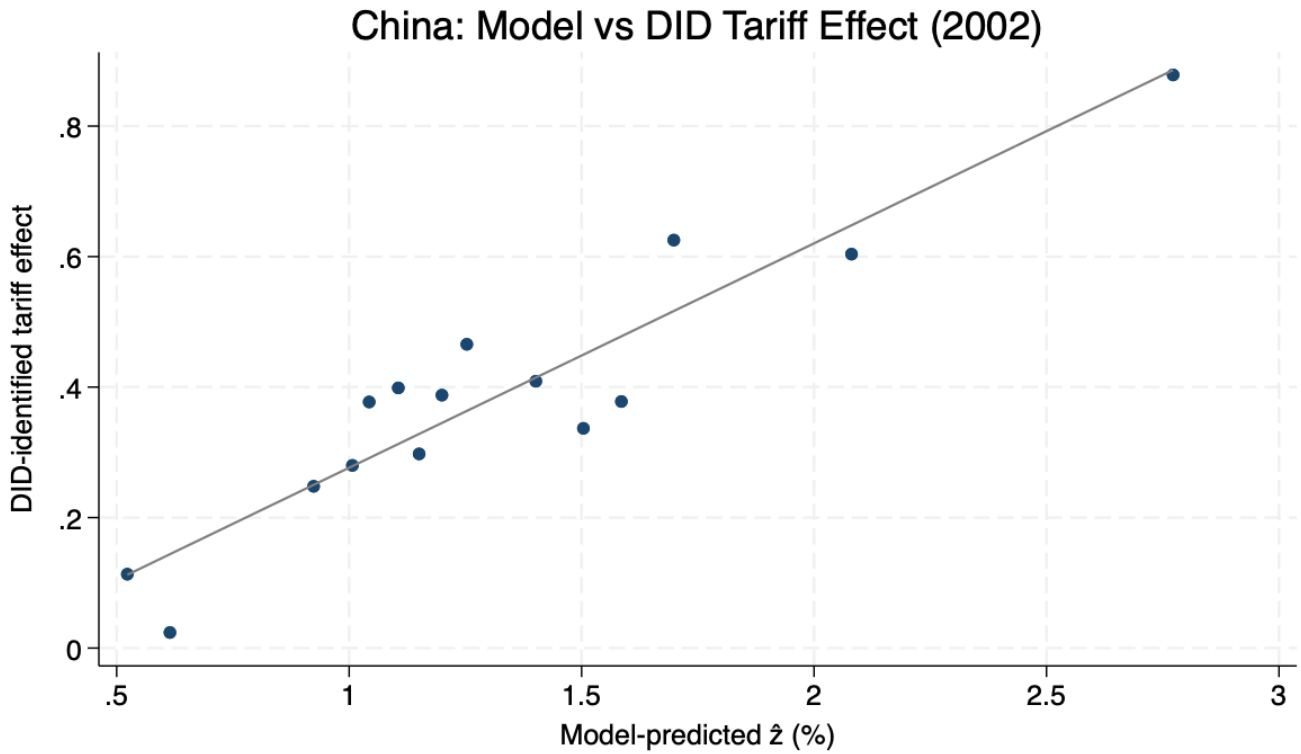
- **China:** long-difference $\nu\rho = 0.021\,(0.018) \Rightarrow \nu = 0.069$
  - Regime classification unchanged for $\nu\rho \in [0,\, 0.06]$
- **United States:** panel $\nu\rho = 0.100\,(0.251) \Rightarrow \nu = 0.366$
  - Much larger — mature patent system, dense supplier and licensing networks
- *Captures absorptive capacity of the fringe, not the leakage rate*

Regime classification and model fit

		China	United States
$\kappa^\star = \nu(\sigma - 1)$	*diffusion strength*	0.072	0.476
α/β	*R&D-productivity elasticity*	0.108	0.076
Predicted regime ($\kappa^\star \lessgtr \alpha/\beta$)		Dampening	Amplifying
DID heterogeneity ratio (high/low)		0.569 (<1) ✓	1.92 (>1) ✓
Pearson corr. ($\hat{z}$ vs DID)		0.662	0.151
Spearman rank corr.		0.614	0.356
R^2		0.438	0.023
N sectors		234	85

Structural parameters and DID estimated from different specifications — the agreement is genuine out-of-sample validation.

Model fit: predicted vs. DID tariff effect (China)



Pearson $= 0.66$**,** $R^2 = 0.44$**, 234 sectors.** Each dot = a sector; $\hat{z}$ predicted from structural parameters identified out-of-sample (no DID variation).

U.S. fit is weaker (Pearson $= 0.15$*,* $R^2 = 0.02$*) due to fewer sectors and shorter post-period.* ⏩ U.S. scatter

Same-tariff counterfactual: equalize real profits

Solve for transfer T s.t. $\hat{\pi}^h + T/\pi_t^h - \hat{P}^h = \hat{\pi}^l - \hat{P}^l$; R&D subsidy s and innovator change $\hat{N}^h$ derived from T. Uniform ± 5pp shock applied symmetrically to high and low groups.

	China (-5pp)	**United States ($+5$pp)**
ρ_h / ρ_l	0.36 / 0.26	0.22 / 0.37
Transfer T (% of profits)	$+0.056$	$+0.238$
aggregate	$\approx$ ¥40M ($\sim$\$5.5M)	$\approx$ \$1.6B
R&D subsidy s (%)	$+0.53$	$+1.09$
$\hat{N}^h$ (%)	$+0.52$	$+3.14$

- **Both countries:** transfer to *high*-spillover sectors $\Rightarrow$ uniform policy inefficient
- **U.S.** $\sim 4\times$ **larger** than China — reflects U.S. being closer to the amplifying regime ($\kappa^\star = 0.48$ vs. China's 0.07)

Counterfactual: strengthen China's diffusion infrastructure

Endow China with the U.S. diffusion parameter $\nu = 0.366$ (vs. baseline 0.068):

- $\kappa^\star$ rises from $0.072 \to 0.383 \Rightarrow$ regime **flips** to amplifying
- Innovation responses to WTO tariff cuts increase by **9–13%** (amplification $1.09\times$ low, $1.13\times$ high)
- Required transfer flips sign: $-0.013\% \to +0.044\%$ of profits

Takeaway. Diffusion infrastructure (ν) is *not just an exogenous parameter*: investments in patent disclosure, technology extension, and labor mobility can shift an economy across regimes — and *change the optimal policy response* to future trade shocks.

Conclusion

- **Empirical:** spillover *dampens* the response to liberalization, *amplifies* the response to protection; market power amplifies in both.
- **Theoretical:** threshold $\kappa^\star = \nu(\sigma - 1)$ vs. α/β classifies economies into dampening or amplifying regimes.
- **Quantitative:** China dampening, U.S. amplifying; sector-targeted subsidies offset welfare losses at minimal fiscal cost.

The innovation effects of trade depend not only on the direction of tariffs,

but on the structure of spillovers and market power.

Thank you.

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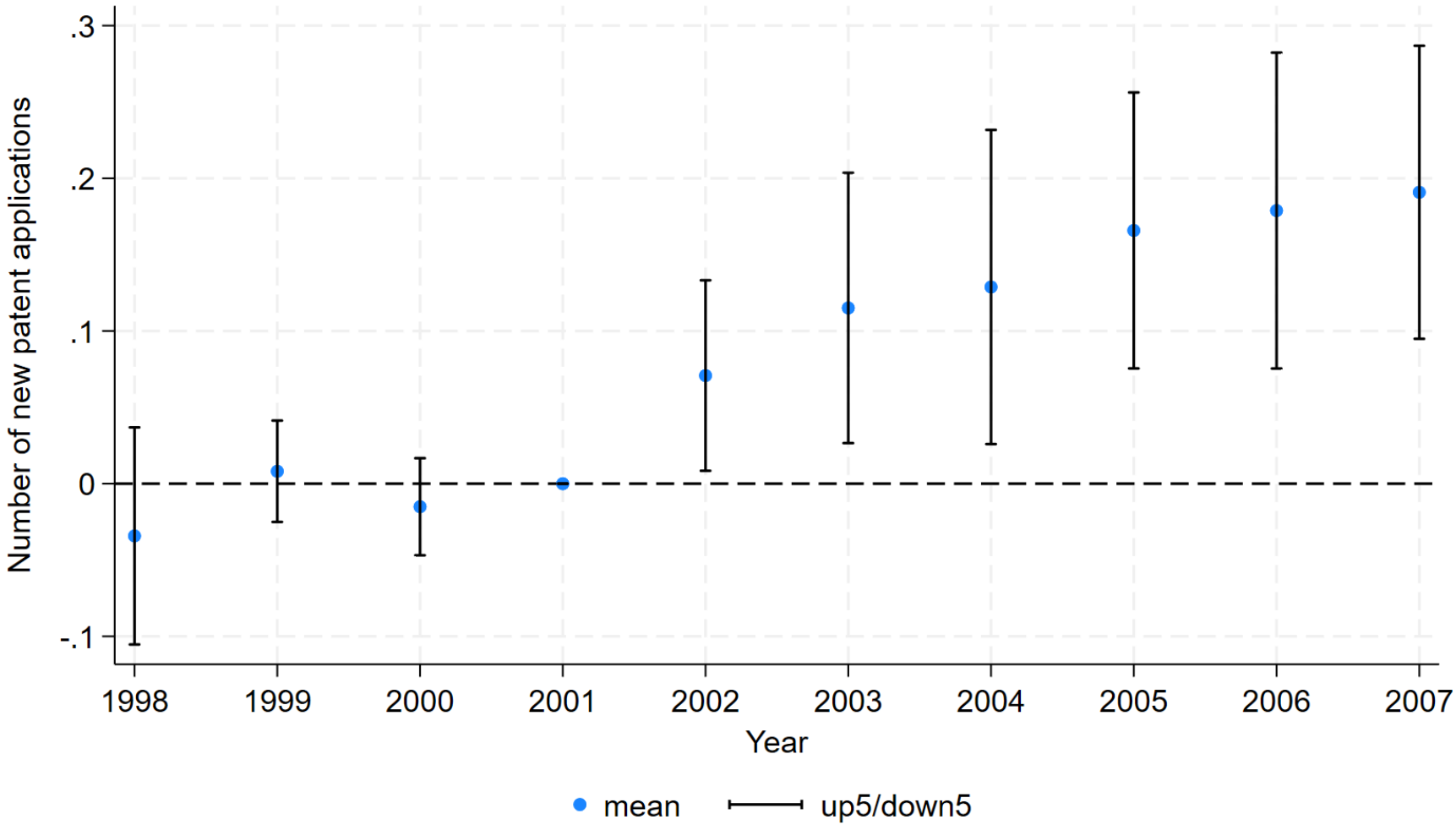
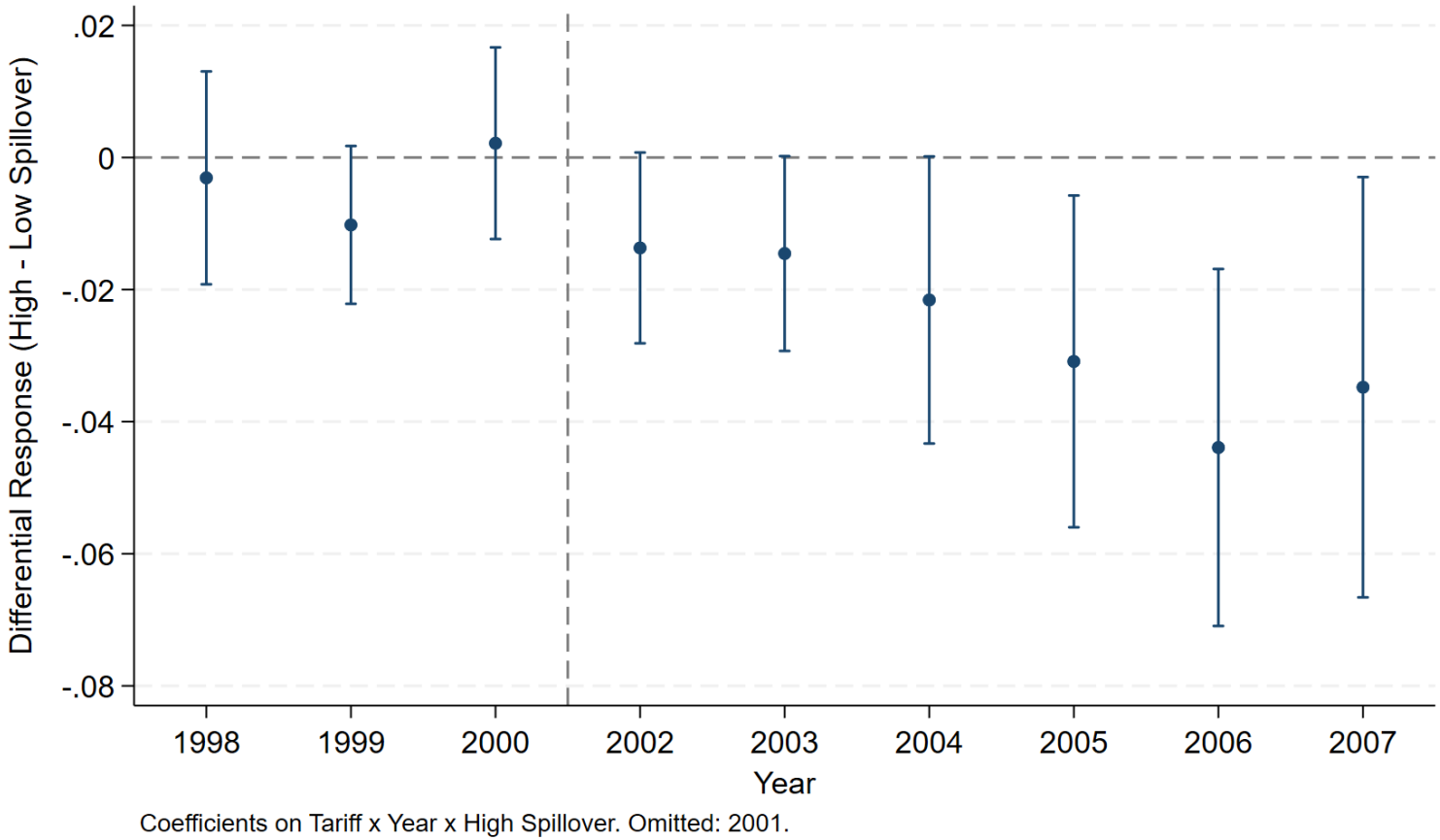
Appendix

WTO: baseline event study



WTO: event study — pre-trends and dynamic response



Triple DiD coefficients on Tariff $\times$ Year $\times$ High Spillover.

Pre-trends ≈ 0 (Wald $p = 0.134$); post-2001 sharply negative.

⏩ Baseline event study

WTO: robustness with province × year FE

	(1)	(2)	(3)	(4)
Tariff × Post01	0.123***	0.099***	0.089***	0.100***
	(0.036)	(0.033)	(0.033)	(0.033)
Tariff × Post01 × High spillover	-0.039*			
	(0.024)			
Tariff × Post01 × Accum. CpP (dep.)		-0.015*		
		(0.008)		
Tariff × Post01 × Current CpP			-0.017***	
			(0.006)	
Tariff × Post01 × Accum. CpP				-0.015*
				(0.008)
Observations	23240	23240	23240	23240
Firm FE	Yes	Yes	Yes	Yes
Province×Year FE	Yes	Yes	Yes	Yes

Replaces year FE with province × year FE. All heterogeneity terms attenuate ∼30% but remain significant. ◂ Back

WTO: high vs. low spillover groups

Ranked by accumulated $\ln(\text{cit/patent})$, pre-WTO (1985–2000).

Group	ISIC3	Sector Description
	2421	Pesticides and other agro-chemical products
	2915	Lifting and handling equipment
Highest	2930	Domestic appliances, n.e.c.
	2423	Pharmaceuticals
	3520	Railway and tramway locomotives
	2692	Refractory ceramic products
	1511	Meat processing
Lowest	3530	Aircraft and spacecraft
	2899	Other fabricated metal products n.e.c.
	1512	Fish processing

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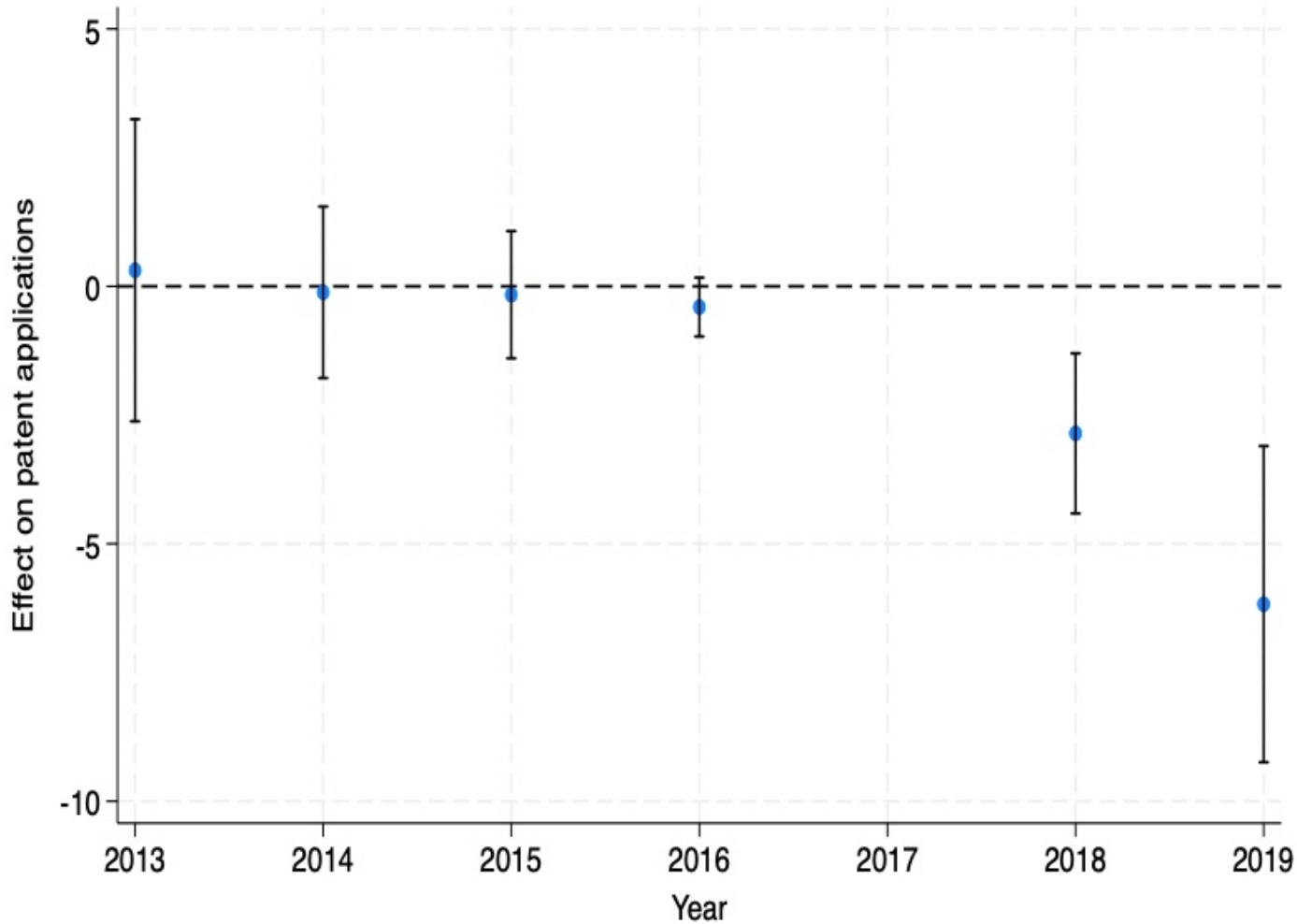
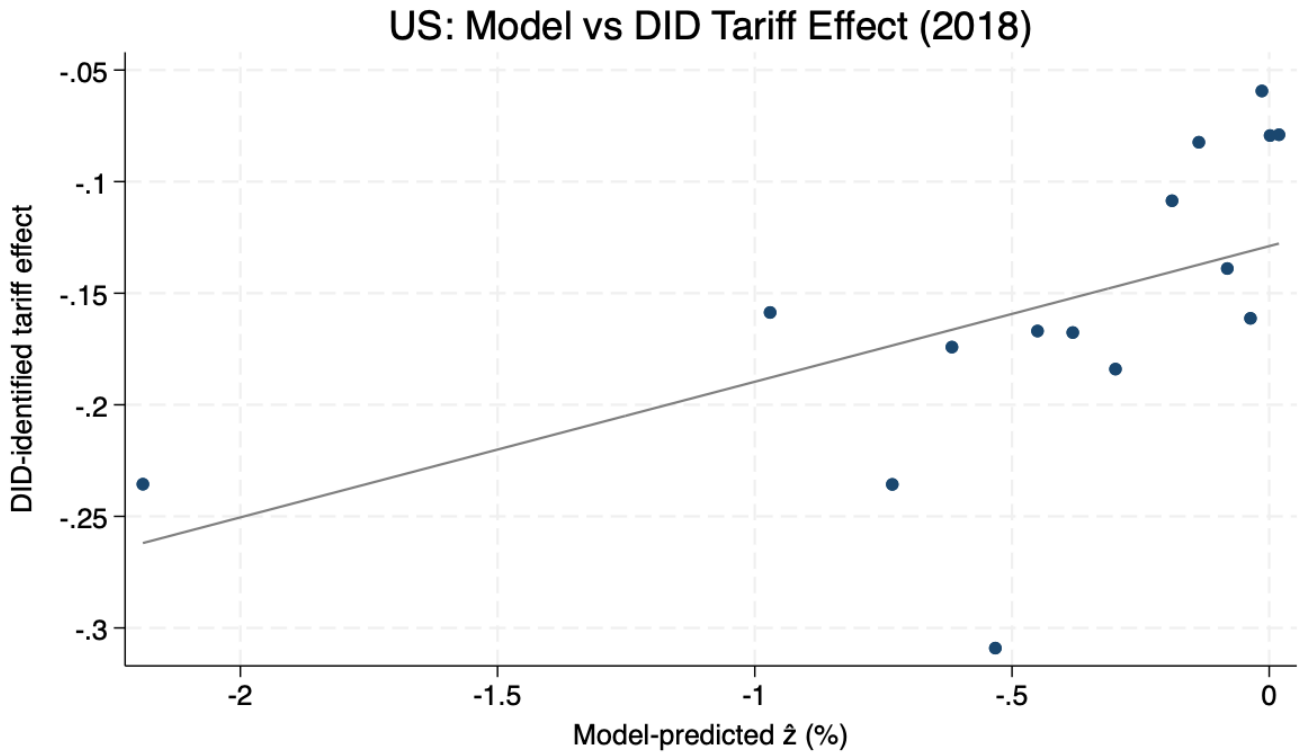
Trade War: baseline event study



Model fit: predicted vs. DID tariff effect (U.S.)



Pearson $= 0.15$**,** $R^2 = 0.02$**, 85 sectors.**

Fewer sectors and shorter post-period (2018–19) limit precision; slope direction consistent with model.

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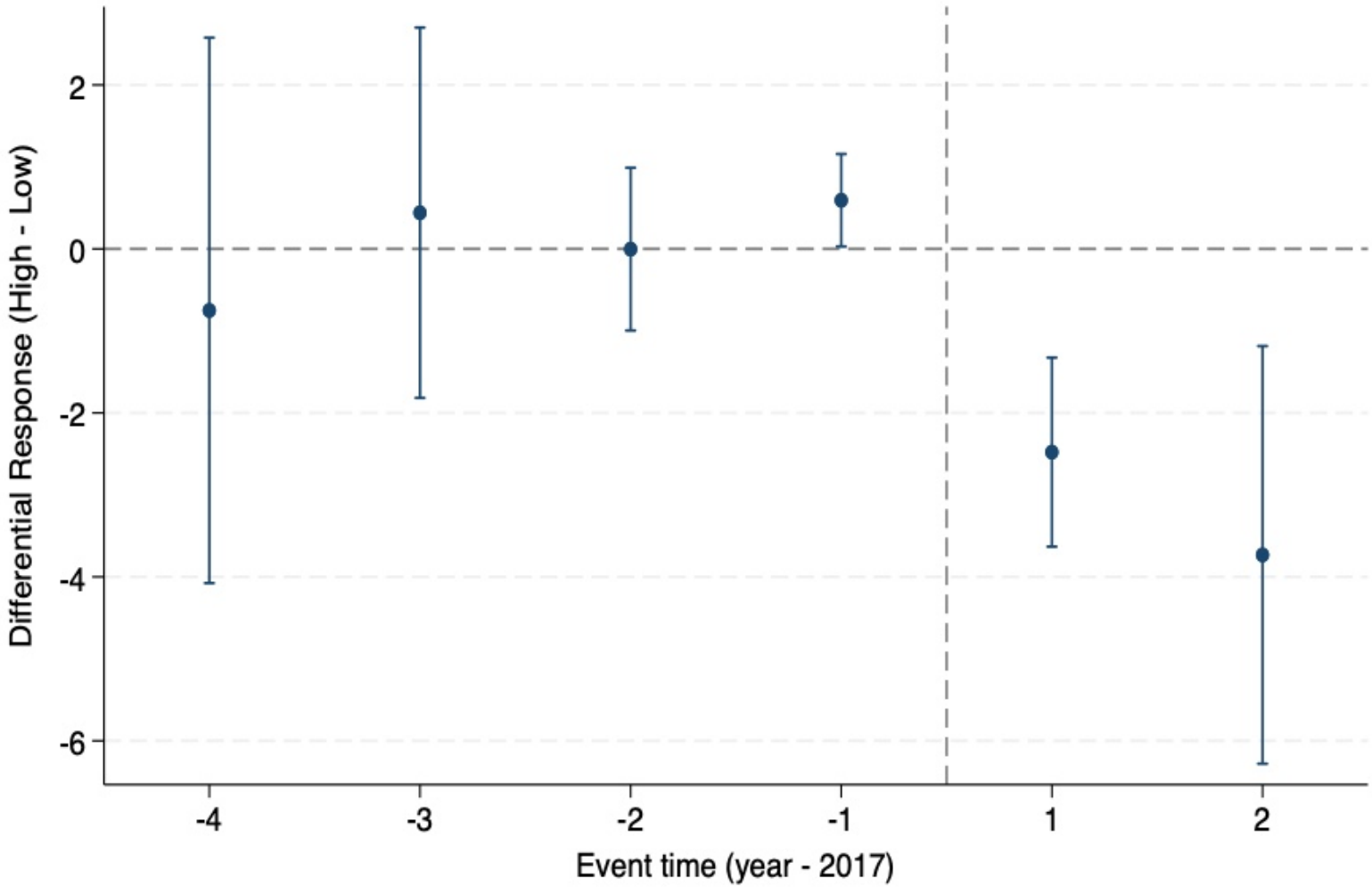
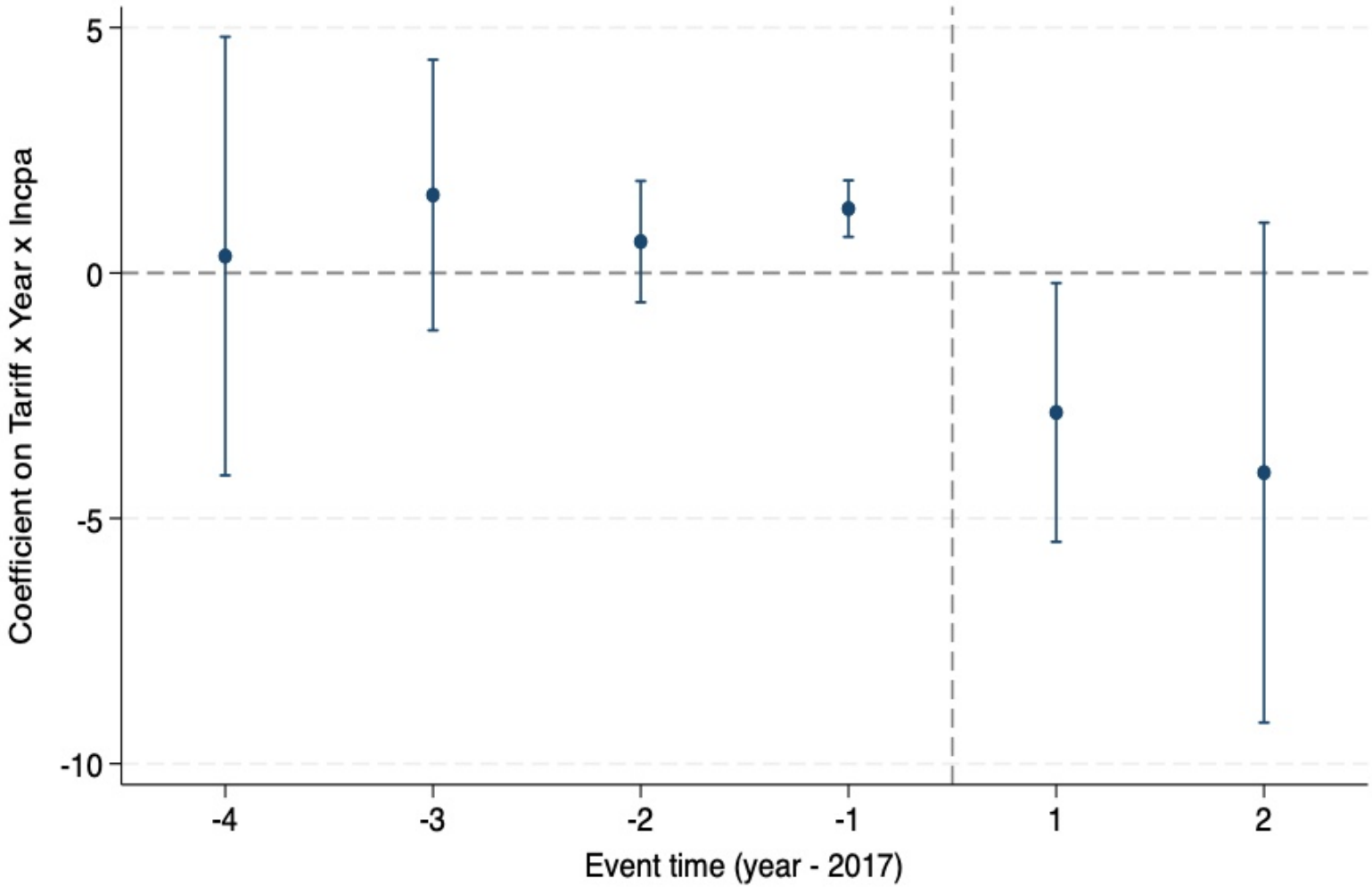
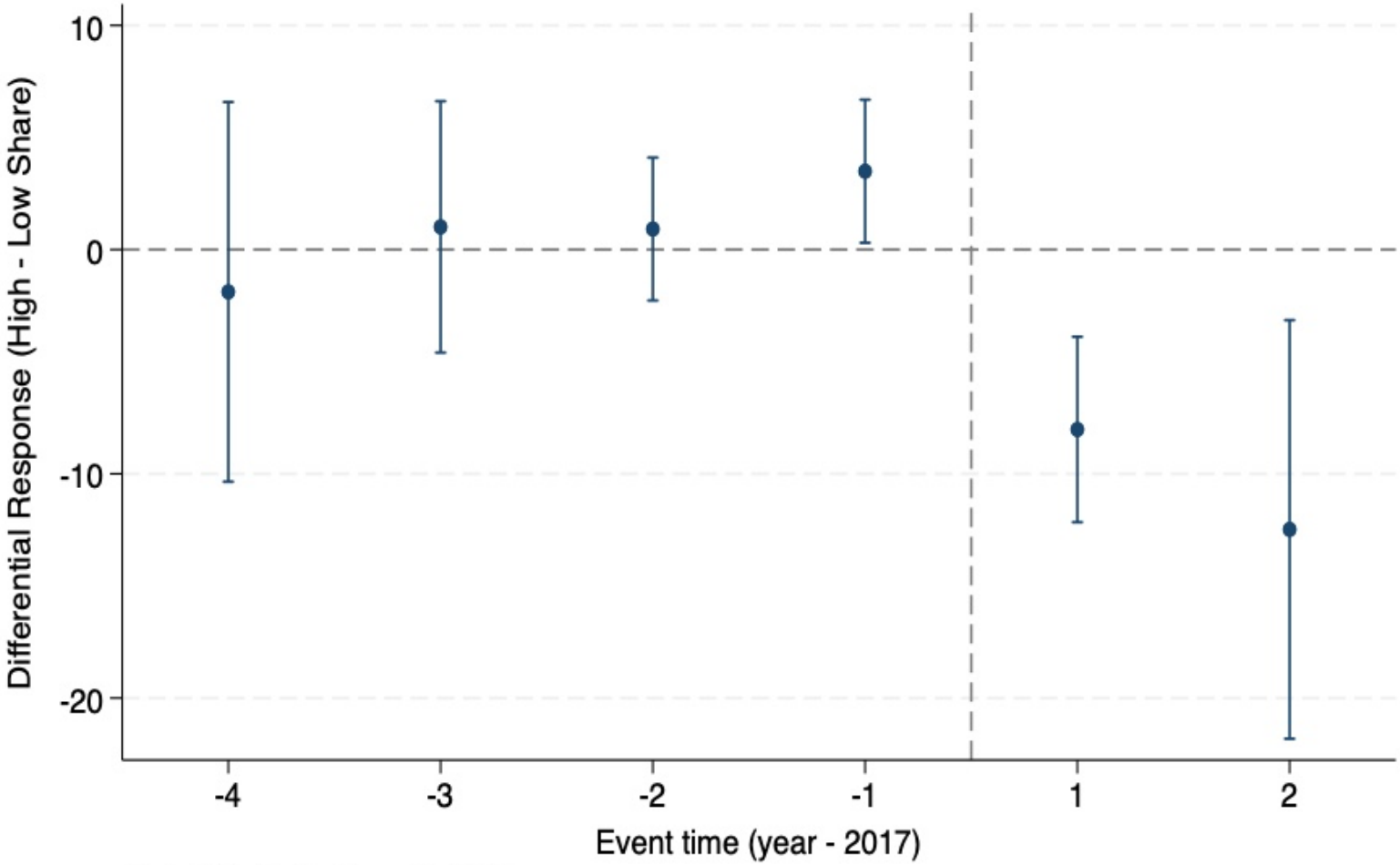
Trade War: triple DiD (binary)



Trade War: triple DiD (continuous)



Trade War: market share event study



Controls for Tariff x Year x High Spillover.

Trade War: heterogeneity table

	High spillover (binary)		Accumulated CpP		Citation per patent	
	(1)	(2)	(3)	(4)	(5)	(6)
Import tariff × Post18	-0.019**	-0.026***	-0.049***	-0.050***	-0.051***	-0.053***
	(0.008)	(0.007)	(0.011)	(0.007)	(0.014)	(0.008)
Import tariff × Post18 × High spillover	-0.027***	-0.024***				
	(0.007)	(0.005)				
Import tariff × Post18 × Accumulated CpP			-0.037**	-0.031***		
			(0.015)	(0.007)		
Import tariff × Post18 × Citation per patent					-0.043*	-0.047***
					(0.023)	(0.011)
Observations	8875	8131	8875	8131	8875	8131
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes

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Trade War: market share amplification (full table)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Import tariff × Post18	-0.008	-0.015	-0.019	-0.028**	-0.014	-0.043***	-0.047***
	(0.014)	(0.016)	(0.012)	(0.012)	(0.010)	(0.008)	(0.008)
Import tariff × Post18 × High share	-0.025**	-0.023*					
	(0.012)	(0.013)					
Import tariff × Post18 × Firm share			-0.101**	-0.083**	-0.091***	-0.100***	-0.116***
			(0.043)	(0.040)	(0.034)	(0.033)	(0.030)
Import tariff × Post18 × High spillover					-0.028***		
					(0.007)		
Import tariff × Post18 × Accumulated CpP						-0.040***	
						(0.009)	
Import tariff × Post18 × Citation per patent							-0.066***
							(0.011)
Observations	7998	7252	7970	7246	7246	7246	7246
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	Yes	Yes	Yes

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Trade War: robustness with state-year FE

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Import tariff × Post18	-0.038***	-0.049***	-0.032***	-0.050***	-0.055***	-0.016	-0.032***	-0.026***	-0.045***
	(0.008)	(0.009)	(0.008)	(0.007)	(0.008)	(0.016)	(0.009)	(0.009)	(0.007)
Import × Post18 × High spillover			-0.017***					-0.017**	
			(0.006)					(0.007)	
Import × Post18 × Accumulated CpP				-0.027***					-0.028***
				(0.007)					(0.008)
Import × Post18 × Citation per patent					-0.043***				
					(0.010)				
Import × Post18 × High share						-0.022*			
						(0.012)			
Import × Post18 × Firm share							-0.052	-0.053	-0.058
							(0.039)	(0.037)	(0.036)
Observations	8033	6706	8033	8033	8033	8033	8026	8026	8026
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State×Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

All specifications include **firm FE + state-year FE** (controls for time-varying state shocks). ◂ Back

Trade War: high vs. low spillover sectors

Ranked by accumulated $\ln(\text{cit/patent})$, pre-trade-war.

Group	NAICS	Sector Description
	3391	Medical Equipment and Supplies
	3152	Cut and Sew Apparel
Highest	3122	Tobacco Manufacturing
	3255	Paint, Coating, Adhesive
	3399	Other Miscellaneous Manufacturing
	3169	Other Leather & Allied Products
	3363	Motor Vehicle Parts
Lowest	3231	Printing & Related Support
	3362	Motor Vehicle Body & Trailer
	3366	Ship & Boat Building

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GE feedback (Proposition 2)

- *Proposition 2.* Lower (higher) trade costs increase (reduce) innovation iff

$$\frac{\frac{(1-\sigma)\tau^{1-\sigma}}{1+\tau^{1-\sigma}} + \frac{1}{\theta}(A_\tau + A_{d\tau} + A_{x\tau})}{(\sigma-1)(1-\nu\rho) - \frac{\alpha}{\beta}(1-\rho) - \frac{1}{\theta}(A_d + A_x)} < 0.$$

- Numerator: direct demand and markup channels.
- Denominator: spillover, diffusion, GE feedback through P and $\bar{a}$.

IV strength (first-stage F)

	(1) OLS	(2) IV	(3) IV (High)	(4) IV (Low)
lnpa_d	0.309^{***}	0.306^{***}	0.357^{***}	0.258^{***}
	(0.0282)	(0.0372)	(0.0525)	(0.0452)
Observations	1951	1951	1018	933
First-stage F-stat		1000.5	593.3	543.0

Bartik instrument: lagged spillover $\times$ national knowledge growth.

Productivity validation (China)

	Dep. var.: ln TFP		
	Levels $\ln N$	First diff. $\Delta \ln N$	Lagged $L.\ln N$
	(1)	(2)	(3)
lnN	0.047***		
	(0.009)		
(log) age	0.006		-0.068**
	(0.019)		(0.027)
(log) total assets	0.496***		0.303***
	(0.026)		(0.038)
D.lnN		0.043***	
		(0.013)	
L.lnN			0.035***
			(0.013)
(log) initial age		0.006	
		(0.012)	
D.lnta		0.472***	
		(0.090)	
Observations	14212	3963	10196
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Sector-year FE	Yes	Yes	Yes

Productivity validation (U.S.)

	Dep. var.: productivity proxy			
	Lagged R&D			First diff.
	base	+ emp.	+ age	$\Delta \ln$ RD
	(1)	(2)	(3)	(4)
L.lnRD	0.181***	0.149**	-0.022	
	(0.068)	(0.074)	(0.043)	
L2.lnRD	0.001	0.004	0.022	
	(0.056)	(0.054)	(0.034)	
D.lnRD				0.202***
				(0.044)
(log) total assets	0.145	0.063	0.022	
	(0.106)	(0.155)	(0.062)	
lne		0.140		
		(0.112)		
D.lnta				-0.056
				(0.049)
Observations	5373	5312	4239	4898
Firm fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

Trade War: with-entry sample (robustness)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Import tariff × Post18	-0.033***	-0.038***	-0.054***	-0.051***	-0.022**	-0.002	-0.012**	-0.004
	(0.009)	(0.008)	(0.015)	(0.012)	(0.008)	(0.004)	(0.006)	(0.004)
Retaliatory tariff × Post18	0.006	0.014**	-0.000	0.011	-0.018	-0.003	-0.009	0.001
	(0.009)	(0.007)	(0.013)	(0.012)	(0.011)	(0.007)	(0.007)	(0.007)
Observations	9096	8298	7687	6933	8074	7528	7016	6431
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Includes all firms (post-2018 new entrants kept). Main slides use no-entry sample. ◂ Back

Trade War heterogeneity: with-entry sample

	High spillover (binary)		Accumulated CpP		Citation per patent	
	(1)	(2)	(3)	(4)	(5)	(6)
Import tariff × Post18	-0.020**	-0.026***	-0.049***	-0.049***	-0.051***	-0.053***
	(0.008)	(0.007)	(0.011)	(0.007)	(0.014)	(0.008)
Import tariff × Post18 × High spillover	-0.027***	-0.024***				
	(0.007)	(0.005)				
Import tariff × Post18 × Accumulated CpP			-0.037**	-0.031***		
			(0.015)	(0.007)		
Import tariff × Post18 × Citation per patent					-0.042*	-0.046***
					(0.023)	(0.011)
Observations	9096	8298	9096	8298	9096	8298
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes

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Trade War market share: with-entry sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Import tariff × Post18	-0.008	-0.015	-0.019	-0.028**	-0.014	-0.043***	-0.047***
	(0.014)	(0.016)	(0.012)	(0.012)	(0.010)	(0.008)	(0.008)
Import tariff × Post18 × High share	-0.025**	-0.023*					
	(0.012)	(0.013)					
Import tariff × Post18 × Firm share			-0.101**	-0.083**	-0.091***	-0.100***	-0.116***
			(0.043)	(0.040)	(0.034)	(0.033)	(0.030)
Import tariff × Post18 × High spillover					-0.028***		
					(0.007)		
Import tariff × Post18 × Accumulated CpP						-0.040***	
						(0.009)	
Import tariff × Post18 × Citation per patent							-0.066***
							(0.011)
Observations	7998	7252	7970	7246	7246	7246	7246
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	Yes	Yes	Yes

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Productivity validation (U.S., with-entry)

	Dep. var.: productivity proxy			
	Lagged R&D			First diff.
	base	+ emp.	+ age	$\Delta \ln$ RD
	(1)	(2)	(3)	(4)
L.lnRD	0.183***	0.152**	-0.045	
	(0.068)	(0.074)	(0.043)	
L2.lnRD	0.002	0.003	0.048	
	(0.056)	(0.054)	(0.034)	
D.lnRD				0.206***
				(0.043)
(log) total assets	0.144	0.063	0.024	
	(0.106)	(0.155)	(0.061)	
lne		0.140		
		(0.112)		
D.lnta				-0.065
				(0.049)
Observations	5491	5419	4307	4976
Firm fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes

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WTO: with-entry sample (robustness)

	(1) Binary	(2) lncpc	(3) lncp	(4) lncpa
Tariff × Post01	0.111***	0.080***	0.068**	0.081***
	(0.030)	(0.029)	(0.029)	(0.029)
Tariff × Post01 × High spillover	-0.044			
	(0.029)			
Tariff × Post01 × Accum. CpP (dep.)		-0.021***		
		(0.008)		
Tariff × Post01 × Current CpP			-0.020***	
			(0.006)	
Tariff × Post01 × Accum. CpP				-0.021**
				(0.008)
Observations	55050	55050	55050	55050
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Broader sample: all firms patenting at any point during 1998–2007 (not just pre-shock), $N = 55{,}050$. Main spec restricts to firms with patents *before* the shock ($N \approx 23$k). ◂ Back

WTO: market share regression (full table)

	(1)	(2)	(3)	(4)	(5)	(6)
Tariff × Post01	-0.042	-0.031	0.013	-0.049	0.019	0.006
	(0.035)	(0.038)	(0.045)	(0.034)	(0.050)	(0.041)
Tariff × Post01 × High share	0.176***	0.170***		0.167***		
	(0.023)	(0.026)		(0.024)		
Tariff × Post01 × Firm share			0.039***		0.038***	0.037***
			(0.006)		(0.007)	(0.006)
Tariff × Post01 × High spillover		-0.020			-0.015	
		(0.029)			(0.033)	
Tariff × Post01 × Accum. CpP				-0.016*		-0.013
				(0.009)		(0.009)
Observations	23138	23138	23050	23138	23050	23050
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

High-market-share firms: significantly larger innovation gains, even controlling for spillover.

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WTO market share: with-entry sample

	(1)	(2)	(3)	(4)	(5)	(6)
Tariff × Post01	0.045	0.061**	0.069**	0.035	0.080***	0.060**
	(0.030)	(0.027)	(0.032)	(0.028)	(0.030)	(0.030)
Tariff × Post01 × High share	0.064***	0.055***		0.054***		
	(0.020)	(0.019)		(0.019)		
Tariff × Post01 × Firm share			0.016***		0.013***	0.012***
			(0.004)		(0.004)	(0.004)
Tariff × Post01 × High spillover		-0.035			-0.027	
		(0.028)			(0.029)	
Tariff × Post01 × Accum. CpP				-0.019**		-0.016**
				(0.008)		(0.008)
Observations	54697	54697	54448	54697	54448	54448
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

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