# Technology M&As and Knowledge Diffusion

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ASSA 2026 Annual Meeting — Lightning Session

Jan 4$^{th}$, 2026

# Motivation: Synergy or Hoarding?

**Background Examples**

- J&J–ALZA (2001): Integrated drug-delivery tech into global distribution
- NVIDIA–Arm (2021): $40B deal blocked over restricted tech access concerns

**Competing Mechanisms**

- **Synergy:** Combined firm enhances technology value (e.g., Teece, 1986; Bena & Li, 2014)
- **Hoarding:** Strategic restrictions block diffusion (e.g., Bryan & Hovenkamp, 2020; Akcigit & Ates, 2021, 2023; Cunningham et al., 2021)

**Research Questions**

- Do tech M&As increase or reduce diffusion of target technology?
- How much do diffusion effects matter for aggregate productivity growth?

# Identification: Withdrawn Deals DiD

- **Data:** SDC M&A matched to PatentsView USPTO (1980–2021)
- **Design:** Patent-level DiD tracking non-self forward citations
- **Controls:** 63 withdrawn deals failed for exogenous reasons (e.g., macro shocks) as control group (following Seru, 2014)
- **Matching:** CEM on industry composition, timing, and pre-event citations

▸ withdrawn ▸ balance

# Empirical Findings: Acceleration of Diffusion

**Tech Acquisition Accelerates Knowledge Diffusion**

- Acquired patents experience a **significant surge** in external citations
- Impact: **1.4**$\times$ increase (0.41 $\rightarrow$ $\sim$1.0 scaled citations/year)
- Persistence: Effect remains significant for **5+ years**

**Higher Quality Follow-on Innovation**

- Average renewal rate of citing patents increases by $\sim$**20%**
- Evidence of a more promising environment for acquired technology

▸ regression ▸ dynamics ▸ quality ▸ young firms ▸ within-industry

# The Bridge: Model of Idea Flows

**Disentangle Synergy vs. Hoarding Effects** on innovation diffusion:

- Identify innovation step size via empirical citation surge:

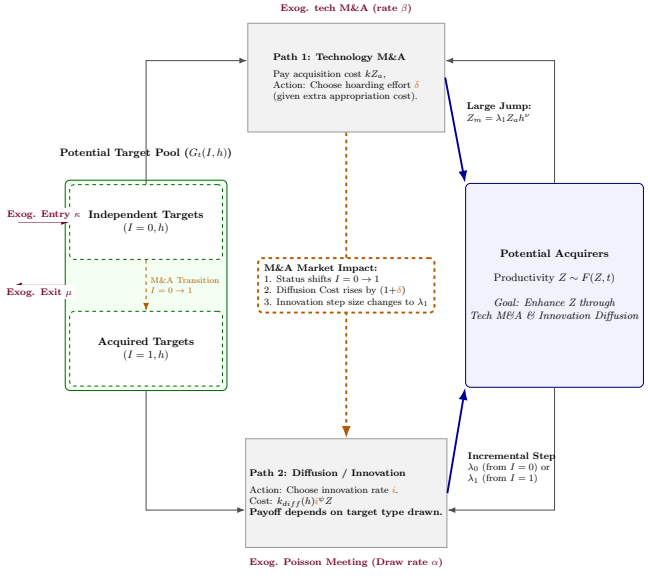
$$IRR_{10} = \frac{5 \cdot IRR_1 + 5 \cdot IRR_2}{10} = \frac{5 \times 2.41 + 5 \times 1}{10} = 1.705$$

- Approximate hoarding via self-citation rate differences (acquired vs. controls)

**Isolate the Diffusion Channel** of tech M&As' productivity impact

▸ model ▸ fit

# Model Mechanism



# Aggregate Impact on Productivity Growth

**Counterfactual Exercises**

1. **Increase Tech M&A Rate:**
   - Doubling 2015 tech M&A rate $\Rightarrow$ **+0.05 pp** annual productivity growth
   - Diffusion channel accounts for **40%** of this gain

2. **Reduce Knowledge Hoarding Cost:**
   - Enhancing acquirer's appropriation ability **need not reduce** aggregate productivity
   - Reason: Higher acquisition value $\Rightarrow$ more innovation based on independent targets

▸ M&A rate ▸ hoarding

# Takeaways

**Main Findings**

- Tech M&A **catalyzes diffusion** with measurable productivity impact
- **Policy:** Account for positive diffusion effects; balance acquirer incentives against diffusion of acquired innovation

**Future Directions**

- Richer modeling of acquirer–target dynamics
- Consider competition and market structure heterogeneity

website & paper

# Appendix

# Appendix A: Sample Statistics

**Table A1:** Summary Statistics for M&A Sample

| | Full M&A Sample | Tech M&As | Tech Share |
|---|---|---|---|
| *Deal Characteristics* | | | |
| Number of deals | 32,917 | 3,692 | 11.21% |
| Total deal value ($ mi) | – | – | 42.76% |
| Average deal value ($ mi) | 406.21 | 1,553.08 | 382.3% |
| Same-industry deals (%) | 48.07 | 44.66 | – |
| *Target Characteristics* | | | |
| Private targets (%) | 75.50 | 38.60 | – |
| High-tech industry (%) | 43.41 | 61.16 | – |
| *Patent Portfolio* | | | |
| Total patents | 5,422 | 3,689 | 68.04% |
| Patents per target (mean) | 2.6 | 4.1 | 157.69% |
| Patents per target (median) | 1.0 | 1.5 | 150% |
| Citations per patent per year | 0.656 | 0.664 | 101.22% |

*Note:* Tech M&As defined as acquisitions where target has patents granted within 7 years before deal announcement.

# Appendix B: Withdrawn Deal Breakdown

**Table A2:** Classification of Qualified Withdrawn Deals

| **Failed Reason** | **Count** | **Share** | **Cumulative** |
|---|---|---|---|
| Acquiror issue not related to tech<br>(Unexpected funds issue, negative shocks) | 21 | 33.33% | 33.33% |
| Regulation | 18 | 28.57% | 61.90% |
| Target rejection not related to target tech | 11 | 17.46% | 79.37% |
| Other exogenous reasons<br>(Macro shocks, adverse market conditions) | 8 | 12.70% | 92.06% |
| Competing offers | 3 | 4.76% | 96.83% |
| Management disagreement | 2 | 3.17% | 100% |
| **Total** | **63** | **100%** | |

# Appendix C: CEM Matching Balance

Patent characteristics do not predict treatment status in the matched sample.

**Table A3:** Logistic Regression of Treatment Prediction

| | **Dep. Var: Treatment** Coefficient (SE) |
|---|---|
| Originality | −0.655 (0.544) |
| Breadth | −1.154 (1.053) |
| New word | 0.066 (0.082) |
| RETech | −0.049 (0.040) |
| Num claims | −0.005 (0.007) |
| Observations | 1,976 |

*Note:* Logistic regression with matched strata FE. Robust SEs in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

# Appendix D: Full Regression Tables

Significant raw (>2.5×) and scaled (1.4×) citation increase after Tech M&As

**Table A4:** Diffusion Effects on Non-Self Follow-on Patents

| | Raw Citations | | | Scaled Citations | | |
|---|---|---|---|---|---|---|
| Dep. var: # non-self follow-on | (1) | (2) | (3) | (4) | (5) | (6) |
| D(acquired)×D(Post) | 1.323*** | 1.284*** | 1.162*** | .884*** | .891*** | .822** |
| | (.298) | (.259) | (.240) | (.327) | (.309) | (.352) |
| Tech_class F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Patent F.E. | Yes | No | Yes | Yes | No | Yes |
| Age F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Year F.E. | No | No | Yes | No | No | Yes |
| Year×Strata F.E. | Yes | Yes | No | Yes | Yes | No |
| Observations | 16,492 | 23,001 | 16,909 | 16,492 | 23,001 | 16,909 |

*Note:* Estimated by Poisson pseudo-maximum likelihood method. Outcome winsorized at 99%. Robust SEs clustered at target firm. Pre-event mean: 0.34 (raw), 0.41 (normalized).

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# Appendix E: Dynamic Plot

Dynamic results under Poisson regression with binned patents $\geq$5 years old.

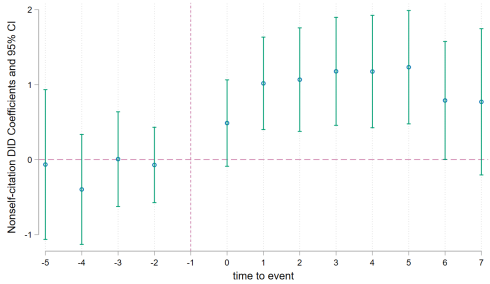


**Figure A1:** Event study on non-self follow-on patents (CEM matched)

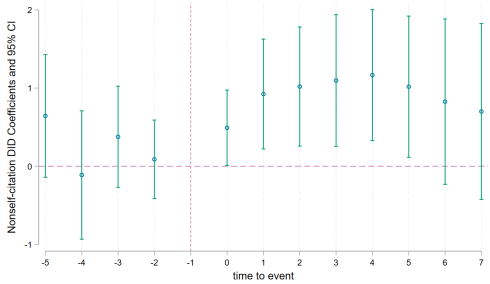


**Figure A2:** Event study on mean-citation normalized measures (CEM matched)

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# Appendix F: Quality Increase

A more promising environment for acquired technology.

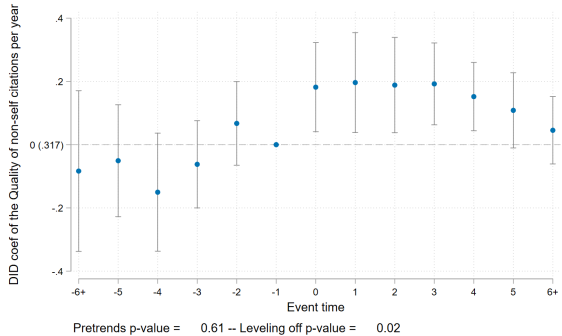


**Figure A3:** DiD coefficient of citing patents average renewal rate

# Appendix G: The Firm's Problem

**Firm's Problem (Potential Acquirers)**

Firm expected value function satisfies the following HJB equations:

$$rV(Z,t) = \left\{ Z + \alpha \left[ \int_h g_0(h,t) \Delta V^{meet-ind} dh + \int_h g_1(h,t) \Delta V^{meet-acq} dh \right] + \beta \int_h \frac{g_0(h,t)}{\text{prob}(h \text{ from ind target})} [\Delta V^{acq}] dh + \frac{\partial V(Z,t)}{\partial t} \right\} \qquad (*)$$

- $\Delta V^{meet-ind} = \max_{i_{ind}} \left[ i_{ind}(V(\lambda_0 Z, t) - V(Z,t)) - k_{diff}(h) i_{ind}^{\psi} Z \right]$
- $\Delta V^{meet-acq} = \max_{i_{acq}} \left[ (i_{acq} V(\lambda_1 Z, t) - V(Z,t)) - (1+\tilde{\delta}) k_{diff}(h) i_{acq}^{\psi} Z \right]$
- $\Delta V^{acq} =$
  $\max_{\delta} \{\delta[V(\lambda_1 Z h^{\nu}, t) - V(Z,t)] - I_{imp}(\delta) Z\} + V(\lambda_1 Z h^{\nu}, t) - V(Z,t) - kZ$

# Appendix H: Model Fit (Non-Targeted Moments)

Model provides reasonable fit to long-run US growth and citation patterns (1980–2015).

**Table A5:** Model Validation Against Non-Targeted Moments

| Non-Targeted Moments | Model | Data |
|---|---|---|
| TFP growth rate | 0.75% | 1.1% |
| Annual external citations for independent targets (range) | 1.2 | 0.2–1.4 |
| Annual external-citing patents for potential acquirers (range) | 8 | 4–12 |
| Acquired intangibles amortization intensity (range) | 0.17% | 0.13%–0.57% |

# Appendix I: Counterfactual on Knowledge Hoarding

Post-merger knowledge hoarding may not harm aggregate growth.

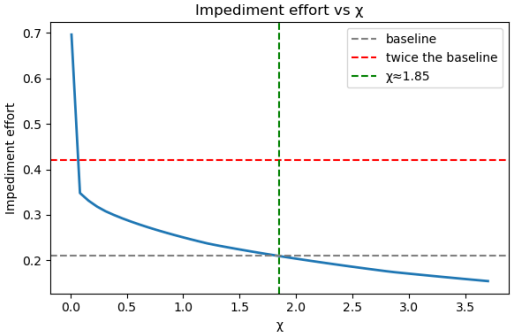


**Figure A4:** Impediment effort vs. $\chi$

**Table A6:** Hoarding Counterfactual

| Case | Diffusion | TFP Growth |
|---|---|---|
| Baseline | 1.21 | 0.7217% |
| Double hoarding effort | 1.21 | 0.7218% |

- Diffusion growth: 0.02%→0.018% (**−10%**)
- Offset by higher innovation on independent targets

# Appendix J: Counterfactual on Tech M&A Rate

Diffusion channel plays a measurable role in productivity growth.

**Table A7:** Counterfactual Analysis: Varying Tech M&A Rates

| **Scenario** | **M&A Rate ($\beta$)** | **Growth Rate ($\gamma$)** | **Diffusion** |
|---|---|---|---|
| Low M&A Rate (half) | 0.00065 | 0.70% | 1.20 |
| **Baseline** | **0.0013** | **0.72%** | **1.21** |
| High M&A Rate (double) | 0.0026 | 0.77% | 1.22 |

**Key Result (High M&A Rate):**

- Diffusion growth: 0.02% $\rightarrow$ 0.04% (contributes **40%** of total increase)

# Appendix K: Diffusion to Young Firms

Citations from young US assignees (though fewer in number) also increase after acquisition.

**Table A8:** Diffusion Effect from US Young Assignees

| Dep. var: # non-self follow-on patents | **Poisson** | | **OLS** | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| D(acquired)·D(Post) | 1.449** | 1.161*** | .028* | .027* |
| | (.621) | (.386) | (.015) | (.014) |
| Tech_class F.E. | Yes | Yes | Yes | Yes |
| Patent F.E. | Yes | No | Yes | No |
| Age F.E. | Yes | Yes | Yes | Yes |
| Year×Strata F.E. | Yes | Yes | Yes | Yes |
| Observations | 2,927 | 14,757 | 23,841 | 23,841 |

*Note:* Outcome winsorized at 99%. Robust SEs clustered at target firm. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

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# Appendix L: Within-Industry Effects

Within-industry effects and potential defensive strategy by patenting acquirers.

**Table A9:** Diffusion Effect Conditional on Patenting Acquirer

| Dep. var: # non-self follow-on | **Within-industry citations** | | **All citations** | |
|---|---|---|---|---|
| patents | (1) | (2) | (3) | (4) |
| D(acquired)·D(Post) | .725* | .763** | .773* | .816** |
| | (.408) | (.380) | (.409) | (.371) |
| Tech_class F.E. | Yes | Yes | Yes | Yes |
| Patent F.E. | Yes | No | Yes | No |
| Age F.E. | Yes | Yes | Yes | Yes |
| Year×Strata F.E. | Yes | Yes | Yes | Yes |
| Observations | 8,306 | 10,703 | 8,439 | 10,718 |

*Note:* Estimated by Poisson pseudo-maximum likelihood method. D(acquired) = 1 for treated patents. D(Post) = 1 after acquisition year. Outcome winsorized at 99%. Robust SEs clustered at target firm. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

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