Pre-Grant Patents and Innovation Diffusion

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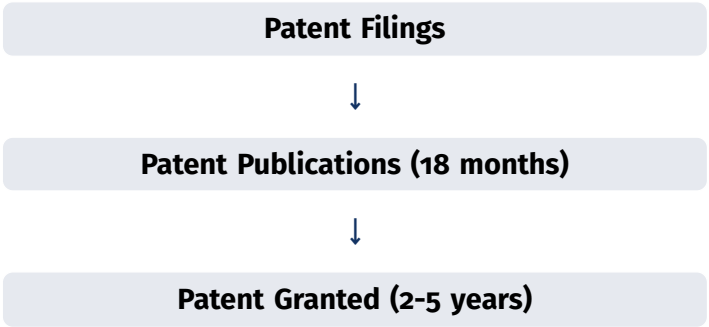
Patents & Academia - When New Knowledge Becomes Visible and Diffuses?

Patent Process	Academic Process	Meaning for Innovation Diffusion
Filed Patent	Draft Paper	Idea exists but is confidential; not yet observable by EVERYBODY.
Published Patent	Working Paper (NBER, SSRN, etc.)	Public and citable; others can access, learn, and build upon it — diffusion begins here.
Granted Patent	Published Journal Article	Formally and legally protected; diffusion has largely occurred at last stage.

Are pre-grant patents effective early signals of global technology diffusion, and how does diffusion vary across countries and sectors?

This Paper



- This paper uses **patent publications and trade exposure** to detect early foreign innovation signals and their diffusion across countries and their manufacturing (traded) sectors.

Research Gap and Contribution

1. **Pre-Grant or Granted patents?**
   - Most of the literature focuses on granted patents
   - Limited attention to **pre-grant patents as early indicators for future innovation** *(Jaffe et al., 1993; Hall et al., 2005; Bloom et al., 2013)*
   - I show that **pre-grant patents (publications)** provide earlier signals of future innovation diffusion
2. **Trade channel OR Foreign Innovation channel?**
   - **Trade**: key knowledge diffusion channel
   - **Foreign Innovation**: foreign published patents are universally citable → diffusion has started. *(Coe & Helpman, 1995; Keller, 2004; Javorcik, 2004)*
   - Foreign innovation channel mainly drives the pre-grant patent diffusion based on the stable trade relations
3. **Single-level analyses dominate**
   - Focus on main innovative country
   - Lack of a **multi-level framework** (country–sector)
     (Cascaldi-Garcia and Vukotić, 2020; Beaudry and Portier, 2006; Barsky and Sims, 2011)

Country Level Analysis

Data Overview

- **Sample:** 21 economies — Australia, Brazil, Canada, Switzerland, China, Germany, Denmark, Finland, France, United Kingdom, India, Ireland, Italy, Japan, Korea, Netherlands, Norway, Singapore, Sweden, United States, South Africa.
- **Pre-Grant Patents (1981–2019):** Patent Publication in fractional counting (*LaBelle et al., 2023)*.
- **Granted Patents (1981-2019):** European Patent Office
- **Total Factor Productivity (TFP):** Utilization-adjusted TFP from *EU KLEMS* (ISIC Rev. 2).

Foreign Innovation Channel & Trade Channel

Foreign Innovation Channel

$$Z_{i,t}^{\text{Innovation}} = \sum_{k \neq i} \omega_{ik}^{\text{Base}} \cdot \text{PreGrant}_{k,t}, \quad \omega_{ik}^{\text{Base}} = \frac{1}{5} \sum_{t=1981}^{1985} \frac{\text{Imports}_{i \leftarrow k,t}}{\sum_{K \neq i} \text{Imports}_{i \leftarrow K,t}} \tag{1}$$

Trade Channel:

$$Z_{i,t}^{\text{Trade}} = \sum_{k \neq i} \omega_{ik,t} \cdot \text{Pre}\bar{\text{G}}\text{rant}_{k}, \quad \text{Pre}\bar{\text{G}}\text{rant}_{k} = \frac{1}{5} \sum_{t=1981}^{1985} \text{PreGrant}_{k,t} \tag{2}$$

Local Projection

Innovation Channel

$$\Delta \log x_{i,t+h} = \alpha_i + \delta_t + \beta_h Z_{i,t}^{\text{Innovation}} + \Gamma_h' W_{i,t-1} + \varepsilon_{i,t+h}, \quad h = 0, \ldots, H. \tag{3}$$

Trade Channel

$$\Delta \log x_{i,t+h} = \alpha_i + \delta_t + \beta_h Z_{i,t}^{\text{Trade}} + \Gamma_h' W_{i,t-1} + \varepsilon_{i,t+h}, \quad h = 0, \ldots, H. \tag{4}$$

- β_h: response of x to pre-grant innovation news SHOCKS.
- $\Gamma_h' W_{i,t-1}$: lagged controls (e.g., TFP, GDP).
- x: TFP

Results - TFP

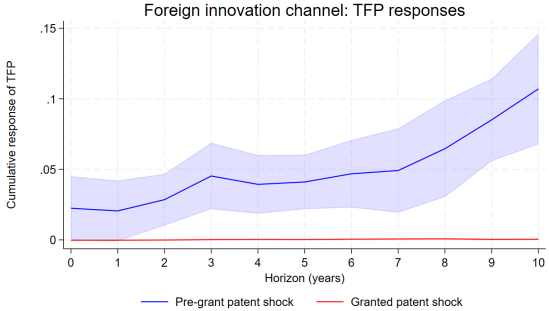


Figure: Responses of TFP to Pre-Grant and Granted Patent Shocks - Foreign Innovation Channel

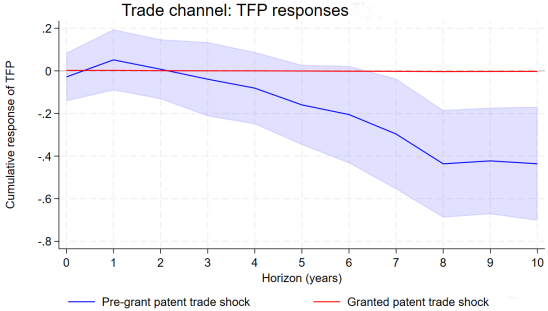


Figure: Responses of TFP to Pre-Grant and Granted Patent Shocks - Trade Channel

- **Pre-grant patents through foreign innovation channel drives forward-looking innovation diffusion based on the stable trade relations**

Sector Level Analysis

Data Overview

- **Sector Coverage:** Manufacturing sectors (ISIC Rev. 2; NACE 10–32).
- **Pre-Grant Patents (2000–2014):** Publication of patent applications by private firms (*European Commission Joint Research Centre, 2017)*.
- **R&D Capital Stock:** Country-Sector specific R&D Capital Stock (*OECD, 2016)*.
- **Manufacturing Sector TFP**: EU KLEMS

Shift-Share Identification of Global Innovation Exposure

- **Sector-level foreign innovation exposure:**

$$\text{SectorPreGrant}_{i,s,t} = \sum_{k \neq i} w_{iks,t} \cdot \text{PreGrant}_{k,s,t}$$

- **Instrument:**

$$Z_{i,s,t} = \sum_{k \neq i} \omega_{iks}^{\text{Base}} \cdot \Delta\text{PreGrant}_{k,s,t}$$

- **Shift-share structure:**
  - **Shift:** changes in foreign pre-grant patents
  - **Share:** pre-determined import weights (2000–2004)
- $Z_{i,s,t}$ instruments sector-level pre-grant patent exposure using exogenous foreign innovation shocks.

Estimation: Sector-Level Local Projections

$$\Delta \log y_{i,s,t+h} = \alpha_i + \gamma_s + \delta_t + \beta_h \cdot \overbrace{\text{SectorPreGrant}}^{IV}_{i,s,t} + + \Gamma_h' W_{i,s,t-1} + \varepsilon_{i,s,t+h} \tag{5}$$

Notation:

- $y_{i,s,t}$: Outcome variable (e.g., sectoral TFP or capital stock of R&D)
- β_h: response of y to country-sector pre-grant patent shocks.
- $\Gamma_h' W_{i,t-1}$: lagged controls (e.g., TFP, GDP).
- α_i: Country fixed effects
- γ_s: Sector fixed effects
- δ_t: Year fixed effects

Results - Capital Stock of R & D (Manufacturing)

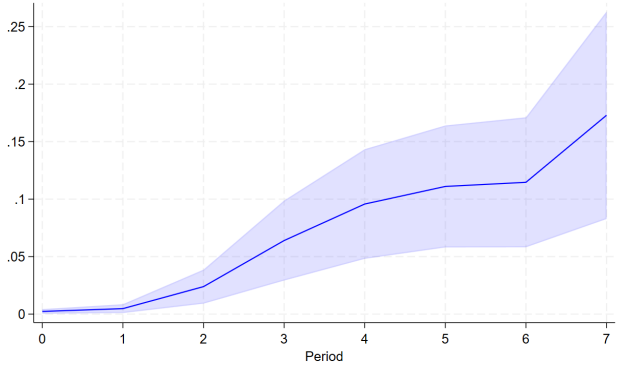


Figure: Response of Capital Stock of R & D to Sectoral News Shocks (Manufacturing)

Sectors expand research capacity in anticipation of future technological adoption.

Results - Responses of TFP (Manufacturing)

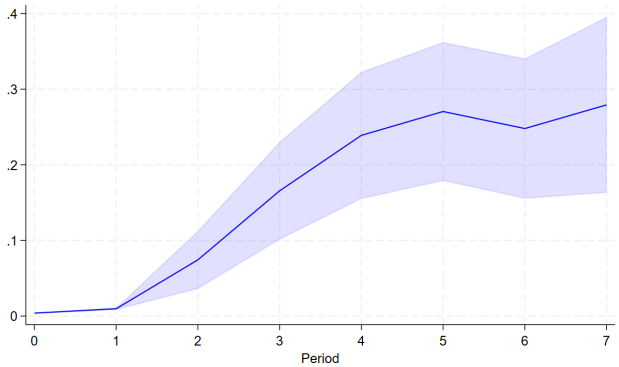


Figure: Response of TFP to Sectoral Pre-Grant News Shocks (Manufacturing)

Sectors require a clear preparation period before productivity gains materialise.

Heterogeneous Diffusion in Manufacturing sectors Across Countries?

- **R&D intensity ⇒ whether countries with higher R&D intensive manufacturing sectors have higher productivity gains to pre-grant patent shocks.**

R&D Intesnsity - Interaction Terms

$$\begin{aligned}\Delta \log TFP_{i,s,t+h} = \alpha_k &+ \beta_{1,t} \cdot \widehat{\text{SectorPreGrant}}_{i,s,t} \\ &+ \beta_{2,t} \left(\widehat{\text{SectorPreGrant}}_{i,s,t} \times RDIntensity_{i,s}\right) \\ &+ \gamma X_{i,s,t} + \varepsilon_{i,s,t+h}\end{aligned}$$

$RDIntensity_{i,s}$: Country-Sectors (i, s) specific time average R & D Intensity.

- $\hat{\beta}_{1,t}$: Direct effect of Sectoral Patent-based news shocks on Sectoral TFP
- $\hat{\beta}_{2,t}$: Conditional effect of Sectoral Patent-based news shocks with R & D Intensity on Sectoral TFP
- I trace both $\hat{\beta}_{1,0}$ and $\hat{\beta}_{2,0}$ with $RDIntensity_{i,s}$ as Marginal Effects:

$$\hat{\beta}_{1,0} + \hat{\beta}_{2,0} \cdot RDIntensity_{i,s}$$

Marginal Effects of Sectoral Pre-Grant Patent Shocks - Manufacturing

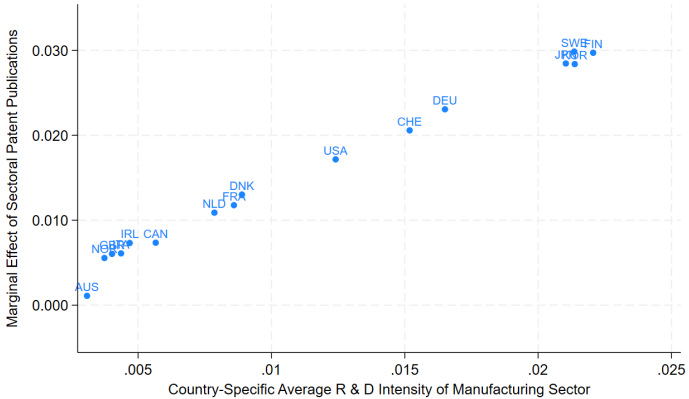


Figure: Marginal Effects of Sectoral Pre-Grant Patent Shocks on TFP (Manufacturing)

Greater R&D capacity → higher productivity gains.

Conclusion

- **Country Level:** Innovation diffusion is primarily driven by global knowledge creation rather than changes in trade intensity.
  However, stable trade relationships remain essential for transmitting these foreign innovation signals.
- **Sector Level:** Pre-grant patent shocks lead to a gradual adjustment process: firms first build R&D capacity, which enhances absorptive capacity and ultimately translates into higher productivity.
- **Key Insight:** Innovation diffusion begins earlier than previously measured and depends on both early information signals and the ability of firms to respond.

Policy Implications

- **Absorptive capacity is critical:** Trade exposure alone is insufficient — countries benefit from foreign innovation only when domestic R&D capability allows them to absorb and apply it.
- **Targeted support for high-potential sectors:** R&D-intensive manufacturing sectors are better positioned to convert early innovation signals into productivity gains, highlighting the role of sector-specific policies.
- **Complement trade with industrial policy:** Maintaining open and stable trade relationships is essential, but should be paired with targeted R&D investment and industrial upgrading to capture global innovation spillovers.
- **Timing matters:** Pre-grant patents provide early signals — policy should support firms in responding early, rather than waiting for technologies to mature.

Thanks for listening!

All comments and advice are welcomed!

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