Searching Where Ideas are Harder to Find – The Productivity Slowdown as a Result of Firms Hindering Disruptive Innovation

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Introduction

Research Question

- Productivity growth is declining across the developed world
- Patents/Scientific Publications have become less
  - disruptive (Park et al. 2023 and Funk & Owen-Smith 2017)
  - scientific (Arore et al. 20019, Poege et al. 2019)
  - creative (Kalyani 2024)
- Researcher productivity declines, yet firms still hire more (Cowen 2019, Bloom et al. 2020)
- **But why?**
  - Decline in patent quality (Olmstead-Rumsey 2024)?
  - ICT (De Ridder 2024)?
  - Technology diffusion (Akcigit & Ates 2023)?

Agenda

- Empirics: Gather stylized facts about Disruptive Innovations and its costs
- Model: Build an endogenous growth model with disruptive and incremental innovation
- Discussion: Explore under which conditions innovation becomes more incremental
- Counterfactuals: Simulate to understand effect size

Literature

- Endogenous growth (Romer 1987, 1990, Aghion & Howitt 1992, Grossman & Helpman 1991...)
  - Firms invest in R&D to reap monopoly profits
  - Closest Model: Akcigit & Kerr 2018
- Search and matching labor markets (Rogerson 2005)
  - Increased assortative matching (Abowd, Kramarz & Margolis 1999, Hagedorn, Law & Manovskii 2016,Card, Heining & Kline 2013)
- Dynamic Ineffciencies in Innovation
  - General purpose technologies (Helpman and Trajtenberg 1998, Bresnahan and Trajtenberg 1995, Comin & Mestieri 2010)
  - Firms direct research so they can appropriate benefits (Hopenhayn & Mitchell 2001, Denicoló, 2000, Scotchmer 1991, Bryan & Lemus 2017)

Empirics

Data Source

PATSTAT

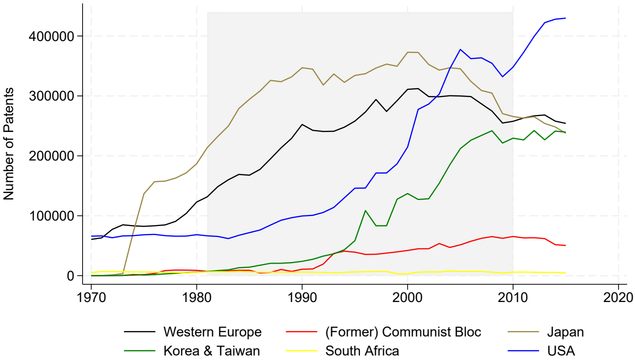
- 70+M. international patent applications
- Inventor & firm name, country, address
- Patent citations

Used Measures

- Disambiguated inventor names (PatentsView)
- Technology fields: IPC-8 classes
- 5 year Citations (Output)

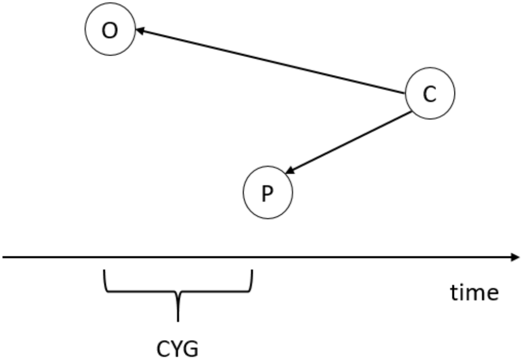
Data Source

Figure: *Overview over PATSTAT*



Notes: Number of patents in PATSTAT per region. The gray region marks the time period of data used in the event study.
Sources: PATSTAT (European Patent Office).

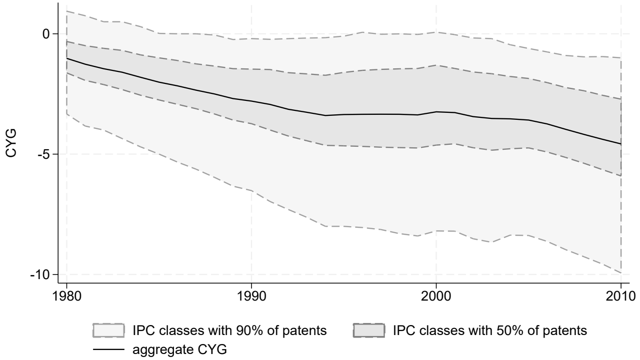
Measure of "Disruptiveness"



Notes: -

Decline of "Disruptiveness"

Figure: *Aggregate Evolution of Disruptive Innovation*



Notes: Average *CYG* per technology class over time. The *CYG* of individual IPC classes containing 50% (90%) of patents are contained in the dark (light) gray area.
Sources: PATSTAT (European Patent Office).

Matching Disrupted and Undisrupted IPC classes

- To understand the impact of a disruptive innovation
- IPC Disruption: $\geq 50\%$ of citations for disruptive patents
- Nearest Neighbor matching on
  - Citation year gap: CYG_{T-4}, CYG_{T-3}, CYG_{T-2}, CYG_{T-1}
  - Citations: $nr_{citations}(T)$, $nr_{citations}(T-1)$, $nr_{citations}(T-2)$
  - Citations of established Inventors: $cum.nr_{citations}^{cohort T-5}(T-1)$

$$y_{t^r;i} = \sum_{r=-5}^{r=15} \beta^{t^r} t_i^r + \Theta_i + u_{t^r;i} \quad (1)$$

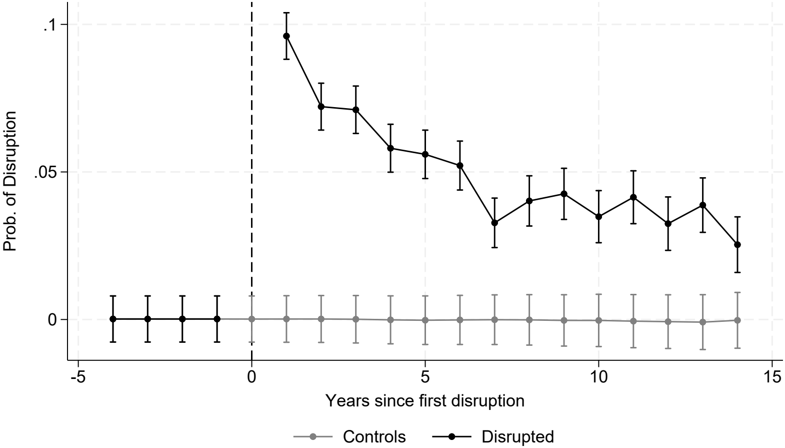
Matching Disrupted and Undisrupted IPC classes

Table: *Summary Statistics on IPC classes before and after Matching*

	Panel 1: Before Matching			Panel 2: After Matching		
	Controls	Disrupted	Difference	Controls	Disrupted	Difference
CYG_{T-1}	-5.585	-3.441	2.144***	-4.031	-3.917	0.114
	(4.231)	(3.821)	(0.044)	(2.996)	(3.205)	(0.109)
CYG_{T-2}	-5.485	-3.742	1.743***	-3.907	-3.843	0.064
	(4.148)	(3.919)	(0.048)	(3.006)	(3.230)	(0.109)
CYG_{T-3}	-5.386	-4.008	1.378***	-3.813	-3.783	0.029
	(4.067)	(3.903)	(0.052)	(3.048)	(3.266)	(0.111)
CYG_{T-4}	-5.278	-4.105	1.174***	-3.752	-3.662	0.090
	(3.976)	(3.866)	(0.057)	(3.213)	(3.368)	(0.115)
$nr_{citations}(T)$	4.820	5.322	0.502	24.855	22.311	-2.544***
	(65.112)	(8.486)	(0.317)	(25.414)	(27.623)	(0.929)
$nr_{citations}(T-1)$	4.820	3.186	-1.634***	23.901	22.973	-0.928
	(65.112)	(7.374)	(0.317)	(22.709)	(23.086)	(0.802)
$nr_{citations}(T-2)$	4.391	2.544	-1.847***	21.021	20.265	-0.755
	(59.560)	(6.494)	(0.290)	(20.732)	(20.128)	(0.716)
$cum.nr_{citations}^{cohortT-5}(T-1)$	1.187	0.999	-0.188**	7.306	7.484	0.178
	(16.565)	(2.975)	(0.081)	(8.650)	(9.222)	(0.313)
Observations	1,477,476	42,283	1,519,759	1,631	1,631	3,262

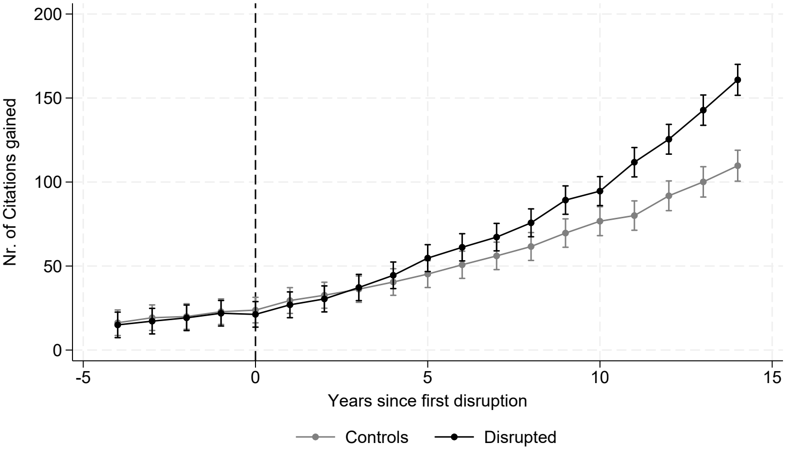
Notes: Unit of observation: harmonized IPC class first disrupted in year T. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. *CYG* measures how disrupted a technology is. It is worth noting that matching mainly works for larger, well cited IPC classes and the matched sample reduces substantially.

Subsequent Disruptions



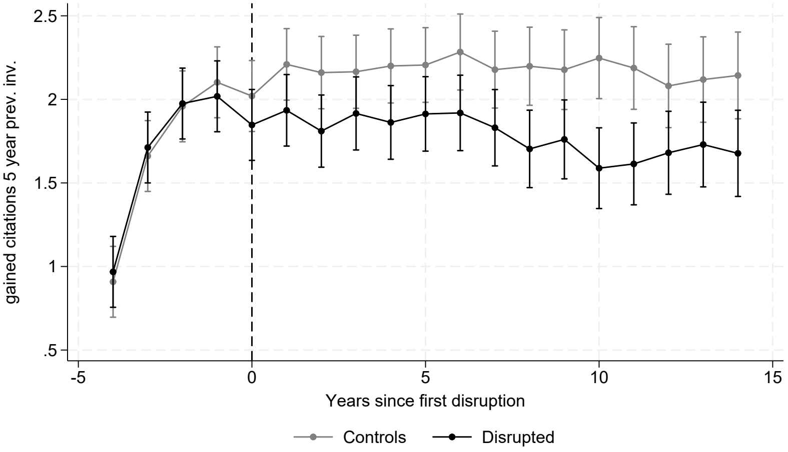
Sources: PATSTAT (European Patent Office).

Citations



Sources: PATSTAT (European Patent Office).

Citations of Established Inventors



Sources: PATSTAT (European Patent Office).

Model

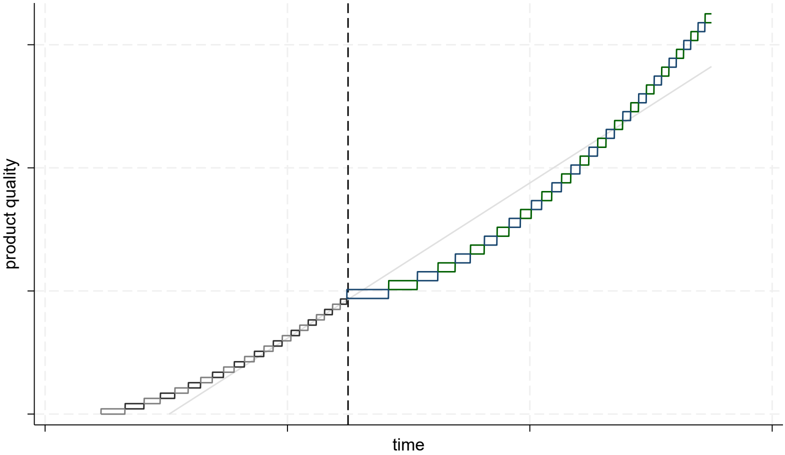
Model Overview

- Model Technological Progress as a function of the resistance to disruption
  - Progress is "normally"' the result of investment
  - But: Progress produces losers
  - Historically, these losers often inhibited growth
- Exogenously fixed decisions not in focus
  - Price setting/Employment
  - Supply of Inventors

Technology Structure

- Each Product is equivalent to a technology field
- Each technology field is split into technology clusters
  - An exogenous amount of inventors enter the field
  - These enter the most recent technology cluster
- Exogenous amount of disruptive inventors also enter
- All inventors draw a random (incremental) firm to match
  - Match is permanent, even if not working together
  - Nash Bargaining over match output

Technology Structure



Product Markets

- Final goods sector that converts intermediate goods into final goods

$$Y(t) = \frac{1}{1-\beta} L_c^{\beta}(t) \int_0^1 q_j^{\beta} z_j^{1-\beta} dj \tag{2}$$

- Profits of a monopolist producer:

$$\pi^*_{mon} = L_c(t) * (1-\beta) * \beta^{\beta}(1-\beta)^{1-2\beta} * q_j = \pi * q_j \tag{3}$$

- Patents represent a stream of future profits

$$r * V^{Patent} = \pi \omega^c \tag{4}$$

Value Function

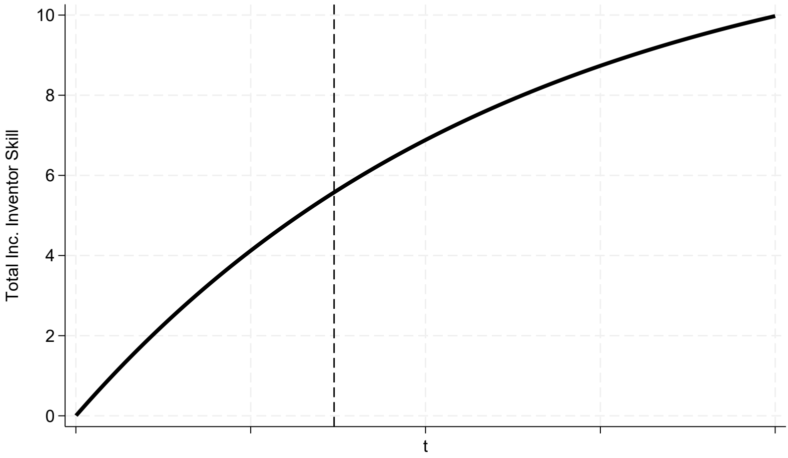
- Inventors represent a stream of future patents

$$rV_f^{inv}(1, \lambda_f^{dis}, X^{inc}) = \underbrace{\frac{\pi}{r}\omega^c * \alpha}_{\text{new patents net of inv. wages}} - \underbrace{\delta V_f^{inv}(1, \lambda_f^{dis}, X^{inc})}_{\text{inv. exit}}$$

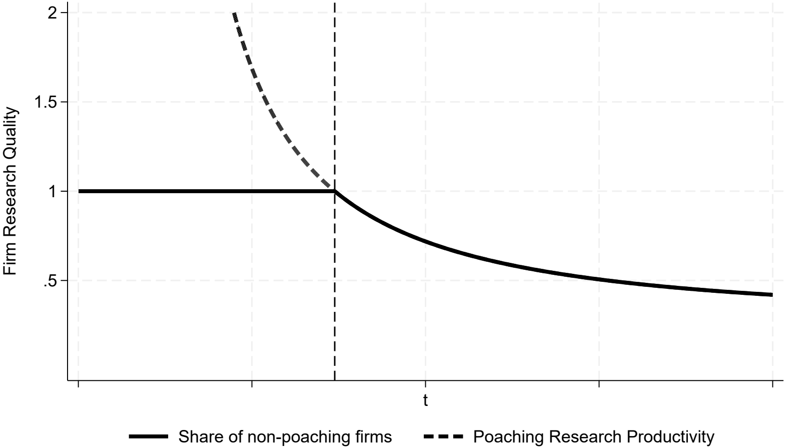
$$- \underbrace{\Lambda_{max}^{dis} \frac{\gamma\omega\pi * V_f^{inv}(1, \lambda_f^{dis}, X^{inc})}{V_f^{inv}(1, \lambda_f^{dis}, X) * X^{inc}}}_{\text{disruption risk}}$$

$$- \underbrace{\lambda_f^{dis} V_f^{inv}(1, \lambda_f^{dis}, X^{inc})}_{\text{wages to poached inv.}} + \underbrace{\frac{\partial V_f^{inv}(1, \lambda_f^{dis}, X^{inc})}{\partial X^{inc}}(H^{inc} - \delta X^{inc})}_{\text{increase in poaching by others}} \quad (5)$$

Behavior of a Sector



Behavior of a Sector



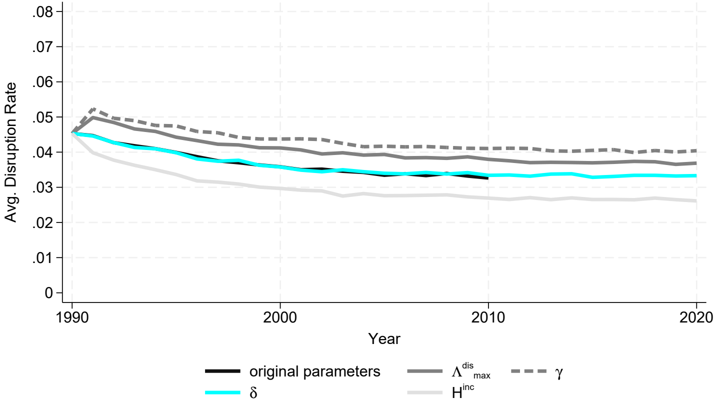
Social Planner's Perspective

- Social Planner wants to prevent/delay decline in disruptiveness
- increase γ: increase the expected first mover advantage
- increase ω : but it is a technology parameter?
- decrease y^{max}: if there are no high value incremental firms, they cannot hinder disruption
- increase $\frac{H^{dis}}{H^{inc}}$: increase ration of disruptive to incremental inventors
- make labor market for disruptive inventors less efficient

Counterfactual Simulation

Policy Implications

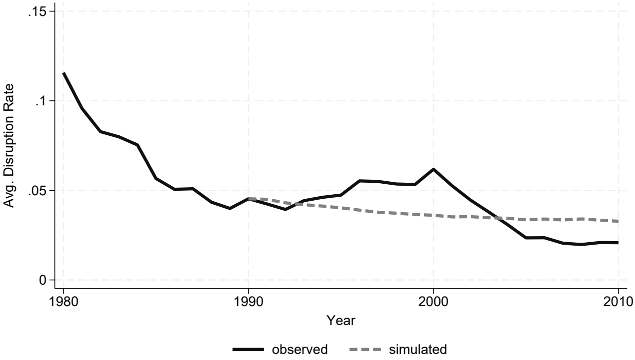
Figure: *Effect of Parameter Changes*



Notes: Effects of 10% changes to selected parameters.
Sources: PATSTAT (European Patent Office).

Behavior the Economy – Simulation vs. Reality

Figure: *Decline in Disruption predicted by the Model*



Notes: Graph shows the evolution of the rate of disruptions in IPC classes with more than 50 patents per year – actual vs. predicted rate of disruptions.
Sources: PATSTAT (European Patent Office).

Conclusion

Conclusion

- Include an inventor labor market into endog. growth. model
  - allows firms to slow down each others' innovation
  - creates an additional asset that firms protect
- Firms deliberately poach inventors to slow down competition
- Technological progress happens because
  - refrain from hindering other firms
  - "aggregate aging" explains half of the decline in disruptions

Appendix

Endogenous growth

- Romer 1987, 1990, Aghion & Howitt 1992, Grossman & Helpman 1991...
  - Firms invest in R&D to reap monopoly profits
  - Steady state growth rate
- Helpman and Trajtenberg 1998, Bresnahan and Trajtenberg 1995, Comin & Mestieri 2010
  - General purpose technologies can lead to waning and waxing growth
  - Cycles of technology invention and adoption
  - Adoption of technologies is as important as invention
- Akcigit & Kerr 2018
  - Technology clusters in an endogenous growth framework
  - Fitting model against firm behavior (Patent data)
- Contribution: Insert a labor market to endogenize key parameters and test vs. data

Inefficiencies in dynamic innovation

- Hopenhayn & Mitchell 2001, Denicoló, 2000, Scotchmer (1991)
  - Firms underinvest in research that spawns new research
- Hopenhayn & Squintani 2016
  - Firms over-invest in high value projects
- Bryan & Lemus 2017
  - Firms direct research so they can appropriate benefits
- Contribution: I insert these insights into an endogenous growth model

Search and matching labor markets

- Abowd, Kramarz & Margolis 1999,..., Hagedorn, Law & Manovskii 2016
  - Separate worker and firm productivity out from wages paid in a match
  - Assume match production is additive
- Mendes et al. 2010; Card, Heining & Kline 2013
  - Document rising assortative matching between workers and firms
- Contribution: Transfer to endogenous growth and loosen the additivity restriction (a bit)