Patent Hunters

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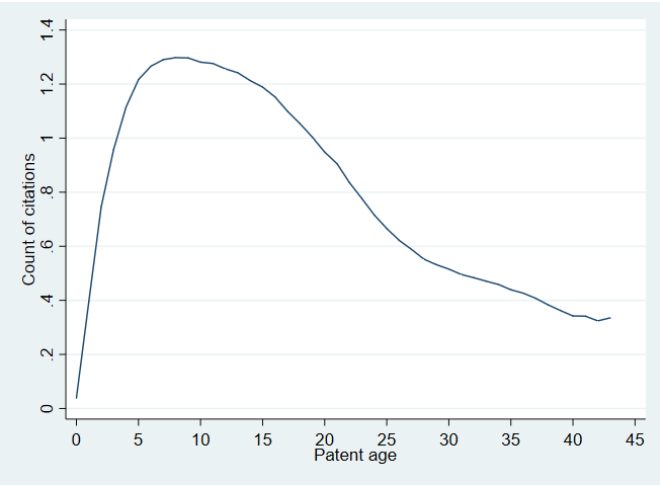
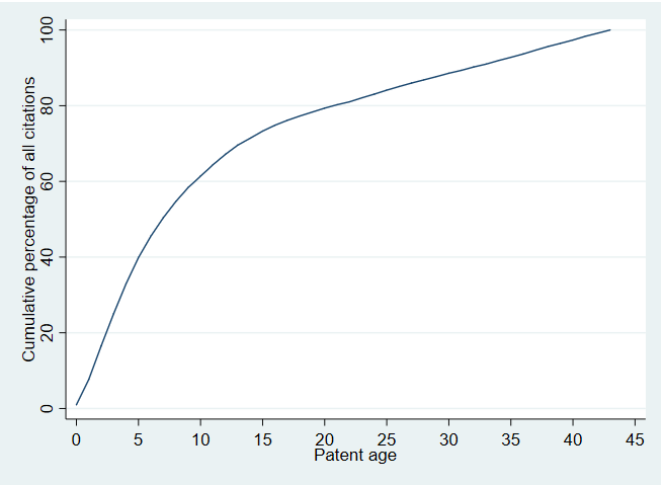
How is innovation generally recognized?

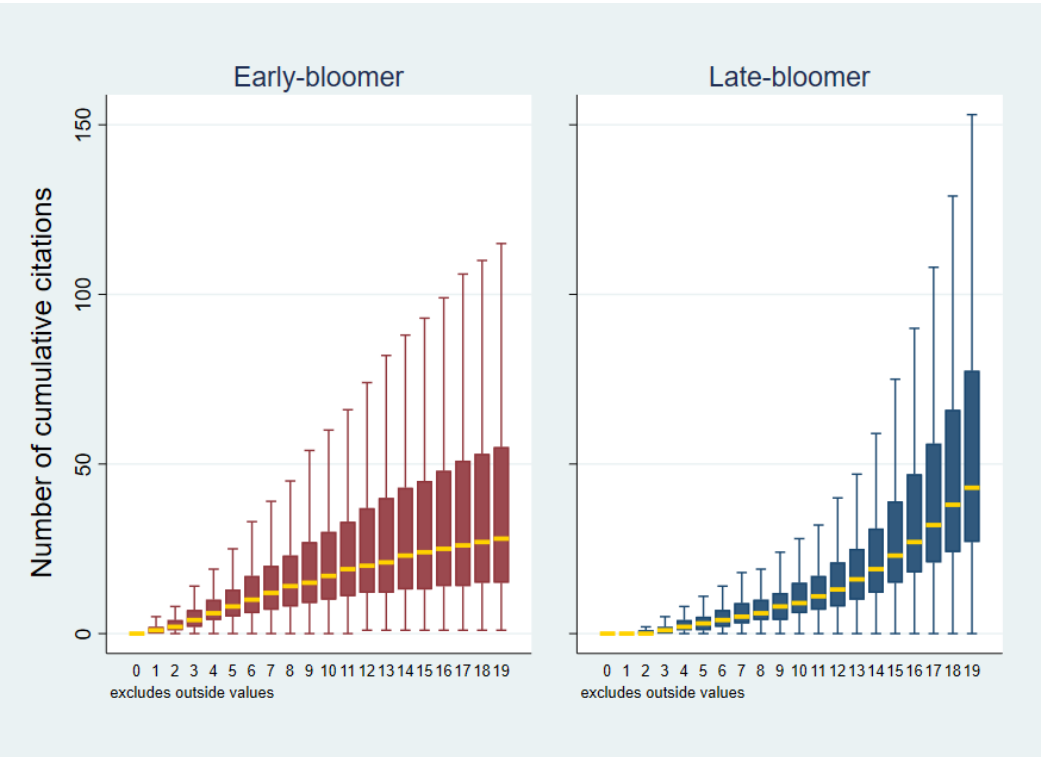


(a) Annual citation count

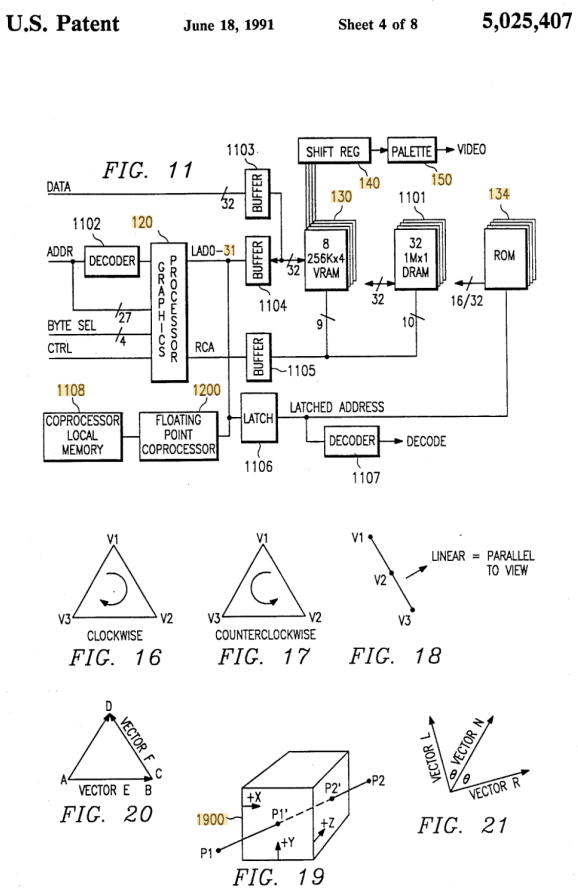


(b) Cumulative percent citation

Some most influential patents do not following the pattern



Example: Patent US5025407 by Texas Instruments



- Granted to Texas Instruments in 1991.
- Became the top 5% cited patent in 2006 (bloomed late).
- Technology class:
  - G06F Electric digital data processing
  - G06T Image data processing
- This technology is distant to TI's core technology (semiconductor devices) with the proximity score of 0.13.
- This technology is closer to Nvidia three times more at 0.32.

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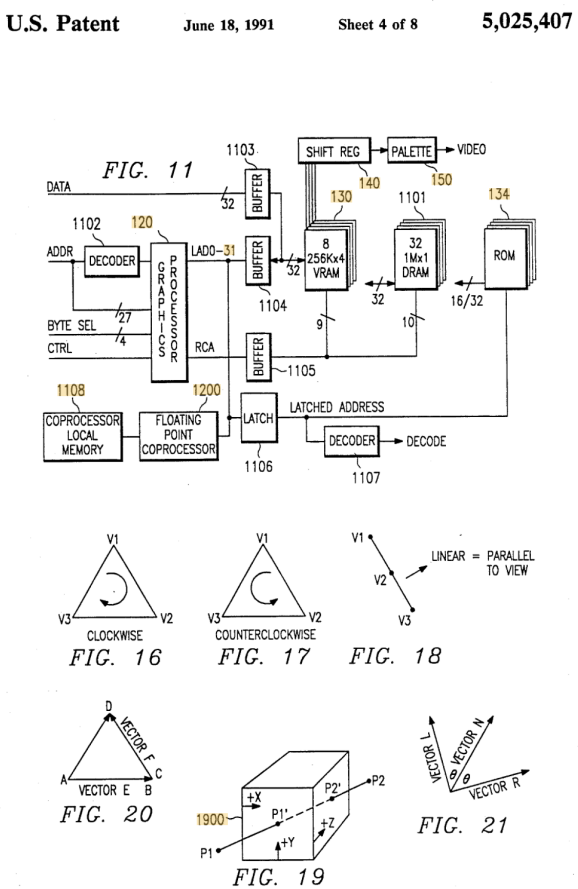

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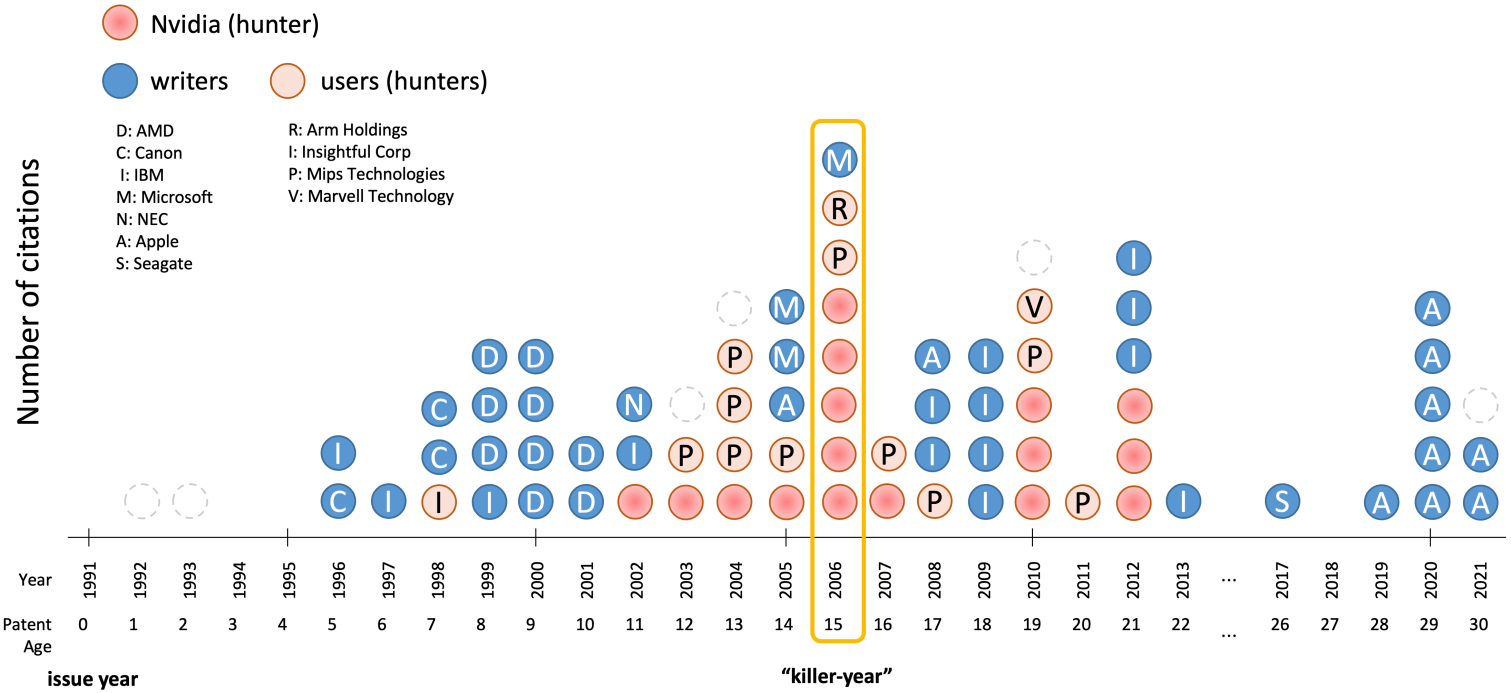
Title: **"Graphics floating point coprocessor having matrix capabilities"**

Example: Patent US5025407 and Nvidia Corp.

- Zero citations for the first five years.
- Most early citations are from CPU developers.
- Nvidia started citing it intensely around 2006 related to GPU computing.

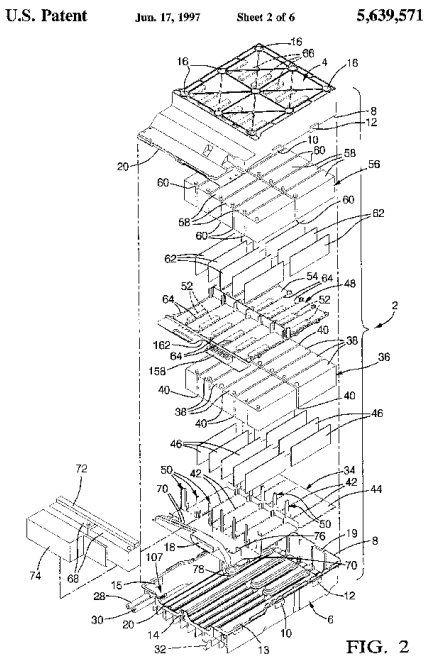


Other Examples

Battery pack

DirecTV 1997, No. 5639571
Tesla citing extensively from 2012

A battery pack for easy access to, and uniform cooling/heating of, the individual battery modules thereof. The pack comprises stackable housing parts (i.e., top and bottom) housing multiple tiers of battery modules supported by underlying trays having openings/holes therein aligned with gaps/spaces between adjacent battery modules through which cooling/heating air is uniformly flowed in parallel between the modules from an underlying plenum. The battery modules are compressively immobilized in the housing by resilient foam pads which bear down on the tops of the modules.

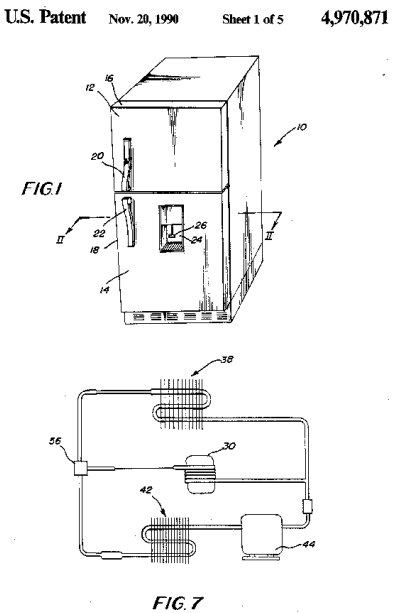


Other Examples

Carbonator refrigeration system

Coca-Cola 1990, No. 4970871
Whirlpool citing extensively from 2000

A carbonator refrigeration system for use in a conventional refrigerator for dispensing a chilled carbonated liquid such as water or a beverage from the front door of the refrigerator. The system includes a compressor, an evaporator, a condenser, a carbonator and a valve member wherein the valve member is responsive to conditions detected within the refrigerator for selectively directing a source of cooling fluid to or away from a heat exchange device provided in connection with the carbonator. The carbonator refrigeration system enables cooling of the carbonator for home dispensing use in a time-share manner with the remaining mechanical refrigeration components.



Motivation

- Because not all successful ideas are immediately recognized,
- Search and implementation are fundamental components of the innovation process.
- Yet, the literature has been mainly focusing on the initiation of innovation. (*i.e.*, patent grants, grant-year stock reaction)
- Search and implementation processes are relatively less understood.
- In this paper, we aim to fill this gap.

This paper

- We identify eventually successful patents that are not immediately recognized ("late-bloomer patents").

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- We identify eventually successful patents that are not immediately recognized ("late-bloomer patents").
- We show that there are important economic agents in the innovation chain who deliberately and persistently search out for the late-bloomer patents and add value to them ("patent hunters").
- We show there are rents from patent hunting, which accrue to patent hunters, exceeding those to original writers.
  - The rents are larger if patent hunters are more experienced (learning).
  - The rents are smaller if they face greater search costs.

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  - The rents are larger if patent hunters are more experienced (learning).
  - The rents are smaller if they face greater search costs.
- Patent hunting has both the firm and inventor-level components.
- Patent hunting rents are causal with an IV analysis.

Data construction

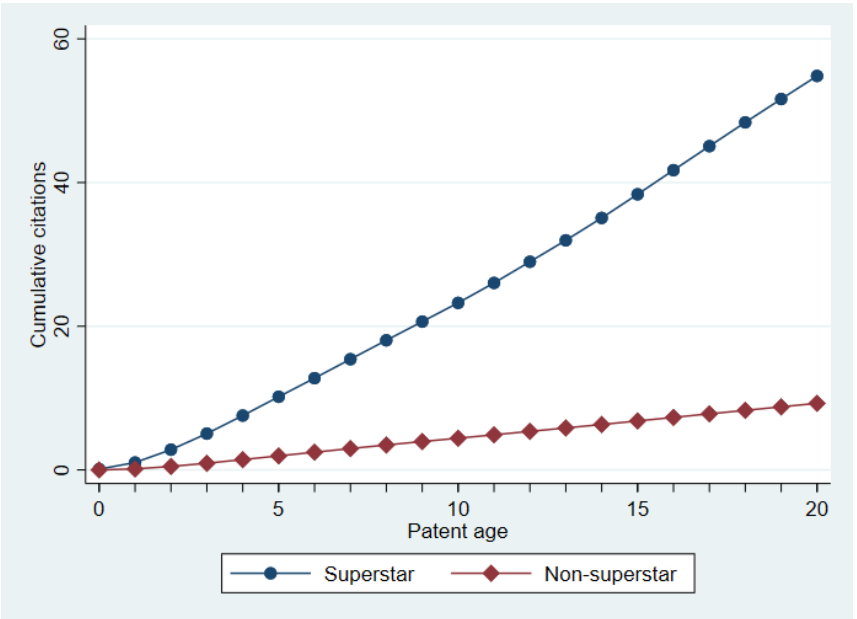
We use the universe of USPTO patents (1.7 million) from 1976 to 2020.

- For patent classification, we use patents granted between 1976 and 1999.
  - Some patent variables merged from PatentsView start in 1976.
  - We require full 20-year citations for the classification.
- We later focus on public firms for firm outcome regressions.
  - Merge with Compustat for financial variables.
  - Merge with the new product offerings data from Mukherjee, Thornquist, and Žaldokas (2022) for commercialization proxies.

We focus on the extremely successful patents

Superstar patents are exceptionally impactful patents based on:

- the number of citations received (net of self-citations)
- within the same CPC class and grant year cohort
- over the initial 20-year patent lifespan
- in the top 5% of the cumulative forward citation distribution (Trajtenberg, 1990; Sampat and Ziedonis, 2004)

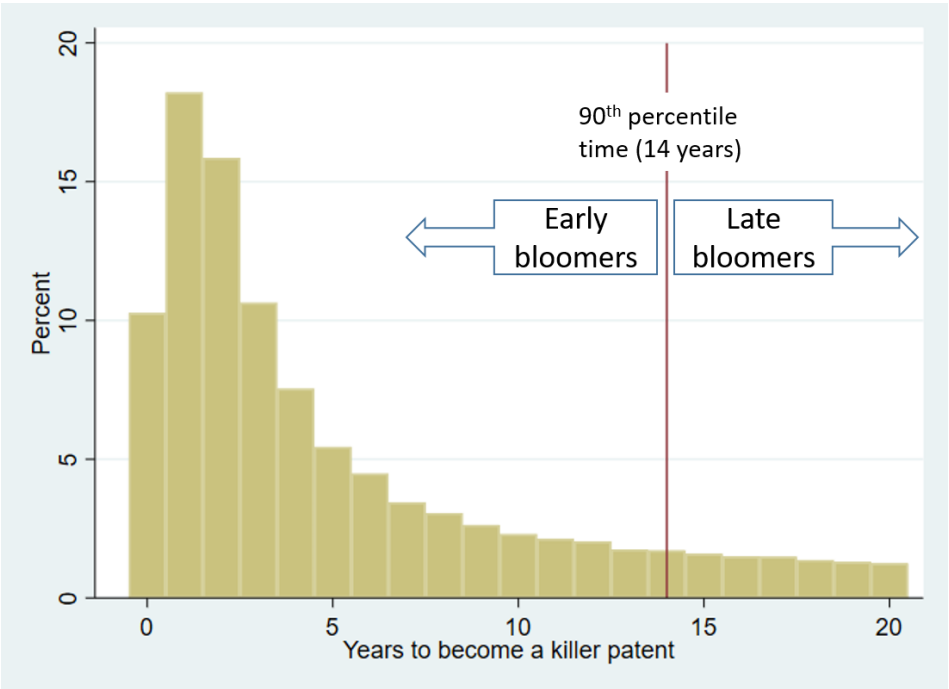


We have 213,772 superstar patents granted between 1976 and 1999.

Superstar patents take different paths to success

We classify superstar patents into late-bloomer (LB) and early-bloomer (EB) by the time it took to become a superstar patent.

- The cutoff point is the 90th percentile of the duration (14 years).



Summary statistics

- **Characteristics at the time of patenting?**

	Early-bloomers	Late-bloomers	
	mean	mean	Difference
Cum. citations at age 20	52.53	69.80	-17.27***
Count class	2.05	2.17	-0.12***
Count claims	15.83	16.02	-0.19**
Backward citation	12.09	12.41	-0.32***
KPSS value	11.29	11.15	0.14
Number of patents	191,812	21,960	

- LBs accumulate a substantially larger number of citations compared to EBs towards the end of 20 years.
- Economically small differences suggest that EB and LB cannot be predicted by the characteristics at patenting.

Summary statistics

- **Who are the users, then?**

	Early-bloomer citing patents	Late-bloomer citing patents	
	mean	mean	Difference
Cum. citations at age 20	23.21	35.99	-12.77***
Count class	2.00	2.22	-0.22***
Count claims	17.26	19.56	-2.30***
Backward citation	43.96	96.89	-52.94***
KPSS value	13.65	16.34	-2.69***
Number of patents	2,797,100	790,936	

- LB users have significantly more backward citations, implying a substantially broader search of patents.
- LB users themselves write patents with higher value.
- Motivated by these patterns, we focus on answering
  - Who are these LB users?
  - Why do LB users discover neglected innovation (benefits to hunting)?

LB writers vs. users (age-matched)

With a strong assumption of exclusivity for this comparison only:

- **Writers: produce at least one LB and possibly also cite them.**
  - Writers are old, big, value firms with a larger stock of patents and citations and bigger R&D spending.
- **Users: cite LBs but do not produce them.**
  - Users are younger (by 4-5 years), smaller, growth firms with more products per patent, greater consumer dependence, and comparable R&D spending.

	Writers	Users	ATE	SE
no. patents per year	29.71	2.840	26.87***	3.234
no. external cites per year	63.91	4.135	59.78***	6.330
no. external cites/no. patents	2.450	1.517	0.933***	0.112
no. new products/no. patents	0.181	0.256	-0.0749***	0.0271
consumer dependent	0.231	0.256	-0.0250**	0.0116
log_asset	5.212	4.665	0.546***	0.0827
tobinq	2.495	2.523	-0.0281	0.0698
salegr	0.167	0.157	0.00998	0.0102
rnd_asset	0.101	0.0849	0.0161***	0.00498
adv_asset	0.0109	0.0111	-0.000197	0.00102
d_dv	0.425	0.384	0.0414***	0.0143

Writer/user persistence

Now relaxing the exclusivity assumption:

- We consider a transition matrix among:
  - Strict LB Writer: write LBs but never cite an LB.
  - Flexible LB Writer/User: write LBs and also cite LBs.
  - Strict LB User: cite LBs but never write an LB.

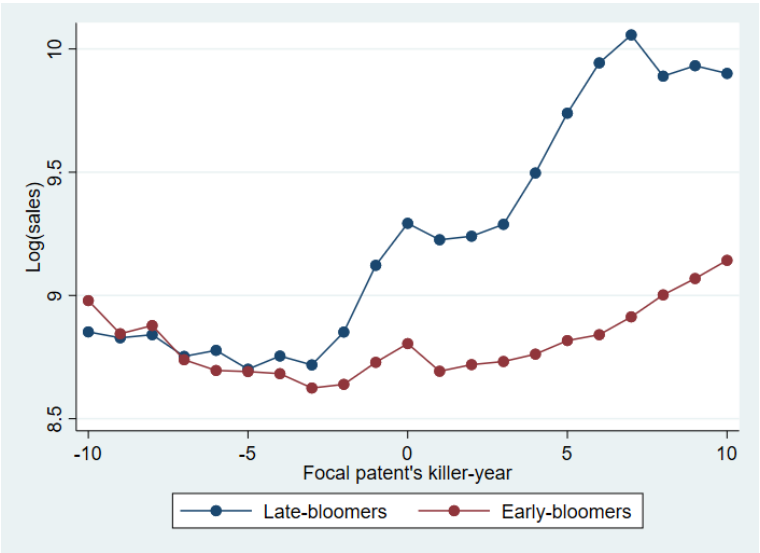
- We find that 50.82% of strict users remain as strict users next year.

	Status at $t+1$				
Status at t	Strict Writer	Flexible Writer/User	Strict User	Not Writer, not User	Total
Strict Writer	113 13.12%	148 17.19%	184 21.37%	416 48.32%	861 100%
Flexible Writer/User	46 1.65%	1,709 61.12%	788 28.18%	2,53 9.05%	2,796 100%
Strict User	118 2.97%	832 20.94%	2,019 50.82%	1,004 25.27%	3,973 100%
Not Writer, not User	444 6.07%	379 5.18%	1,308 17.88%	5,185 70.87%	7,316 100%
Total	721 4.82%	3,068 20.53%	4,299 28.76%	6,858 45.89%	14,946 100%

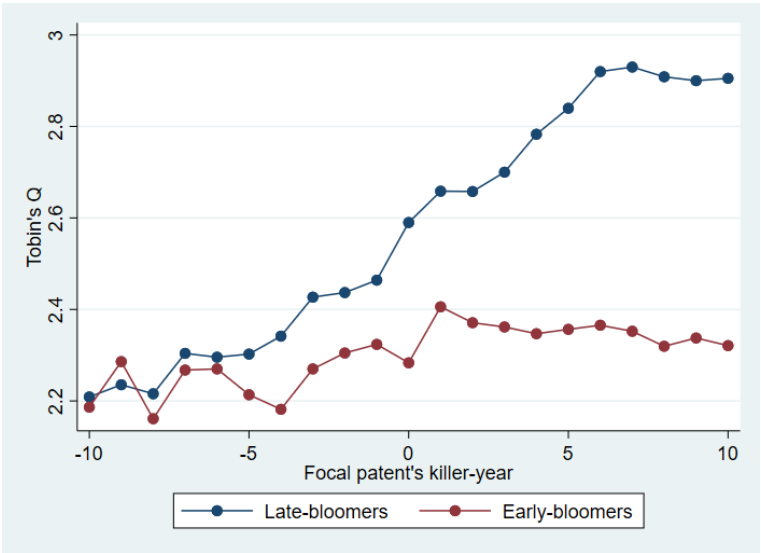
Main results

User benefits

The utilization of LB vs. EB is sharply different.



(a) User Sales



(b) User Value

- The benefits of using LB (hunting), measured by firm sales and value, are significantly larger than those of using EB.

User benefits regressions (firm-year level)

$$Y_{t,t+4} = b_1 log(1 + LBhunting)_{jt} + b_2 log(1 + EBhunting)_{jt} + \gamma_j + \eta_t$$

	Sales growth (1)	Avg Tobin's Q (2)
log(1+LBhunting)	0.0831***	0.0658***
	(0.0275)	(0.0168)
log(1+EBhunting)	-0.0962***	-0.0217**
	(0.0181)	(0.00866)
Mean	0.901	2.080
$H_0 : LB = EB$ (p-value)	0.000	0.000
Firm FE	Y	Y
Year FE	Y	Y
Observations	75589	98776
Adjusted R^2	0.350	0.719

- User sales growth and Tobin's Q increase by 6.4% and 2.2% from the means with doubling the number of LB hunting.

User benefits from LB hunting (patent-year level)

We consider user vs. writer and the superstar year additionally.

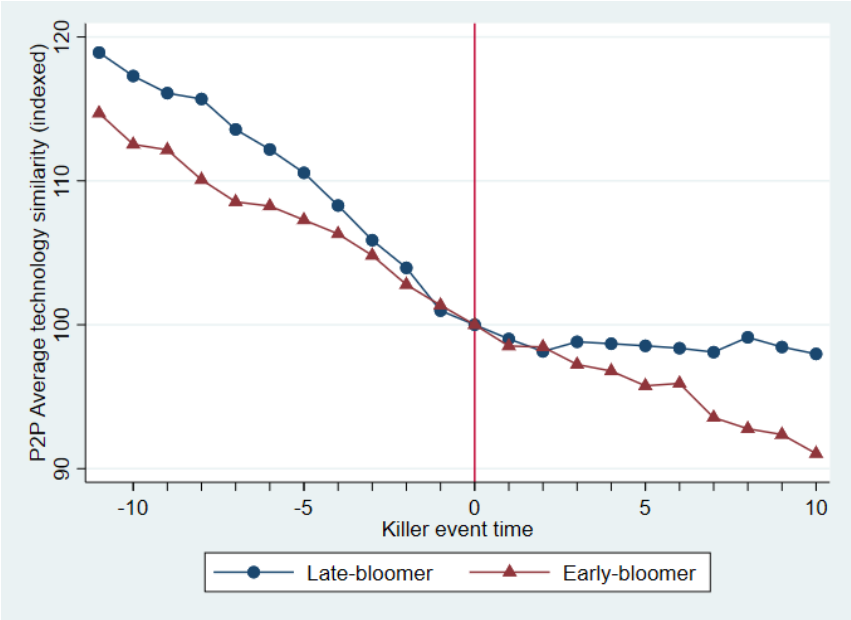
$$Y_{ijpt} = b_1 user_{ijp} + b_2 ssyear_{pt}^{post} + b_3 user_{ijp} \times ssyear_{pt}^{post} + \gamma_{ij} + \eta_t$$

	Sales growth (1)	Tobin's Q (2)
user × ssyear$_{post}$	0.00730***	0.0179**
	(0.00125)	(0.00816)
user	0.0143***	0.0644***
	(0.000923)	(0.00525)
ssyear$_{post}$	-0.00146	-0.000481
	(0.00145)	(0.00625)
Cited patent FE	Y	Y
Year FE	Y	Y
Observations	1523717	1534074
Adjusted R^2	0.226	0.386

- LB user benefits exceed those of writers, particularly after LB is recognized.
- These benefits are NOT prevalent to other patents (EB or non-superstar).

New demand by focused users: Patent applicability

We now consider the tech proximity between the focal and citing patents.



- In general, the tech proximity between the focal and citing patents decreases over patent age (Kuhn et al. 2020) – *i.e.*, gradually becoming obsolete.
- For LB, the proximity sharply stabilizes when it is recognized.
- The stabilizing tech proximity suggests the rising demand for LB technology by a new group of focused users.

Creation of new markets: New innovation space

	Log(Patent counts in tech-class groups)		Log(1+new product)
	Focal CPC	Citing CPC	LB hunting only
	(1)	(2)	(3)
latebloomer×ssyear$_{post}$	0.145***	0.0398**	
	(0.00495)	(0.0198)	
user× ssyear$_{post}$			0.0472***
			(0.00842)
Focal patent FE	Y	Y	Y
Year FE	N	N	Y
Observations	696851	1274268	1201198
Adjusted R^2	0.410	0.458	0.626

- LB patents define new technology spaces with significantly more patenting after being hunted.
  - LB patents' own tech space by 16%.
  - New overlapping tech classes among user patents by 5%.
- The new demand creates a new market by the users.
  - LB users' new product launches (Mukerjee et al., 2022) increase by 5%.

Why do writers neglect some patents?

	Late-bloomers	
	(1)	(2)
tech-class dist to core	0.0143**	0.0142**
	(0.00534)	(0.00551)
ln(competing patent stock)	-0.00561***	-0.00543***
	(0.00131)	(0.00135)
fin_const (KZ)	-0.00695**	
	(0.00293)	
equity_const (LW)		-0.00936
		(0.00776)
debt_const (LW)		-0.00165
		(0.00770)
Writer FE	Y	Y
Grant year FE	Y	Y
Observations	94889	86801
Adjusted R^2	0.033	0.033

- LBs exist possibly due to
  - Writers' intellectual capacity constraints: LBs are peripheral to their core.
  - Low competitive threat at the time of patenting.
- Financial constraints are not the reason. Rather, writers are less constrained to work on innovation not in immediate use.

Moderating factors of benefits

	Sales growth (1)	Avg Tobin's Q (2)	Sales growth (3)	Avg Tobin's Q (4)
complexity	-0.000675	-0.0191***		
	(0.00174)	(0.00387)		
competition			-0.00251***	-0.00795***
			(0.000925)	(0.00209)
Focal patent FE	N	N	N	N
Focal patent class FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	95841	116692	108953	135942
Adjusted R^2	0.117	0.220	0.117	0.212

- Given searching,
  - LB' complexity could decrease benefits through processing/integration costs.
  - Severe competition for a given LB's technology space could decrease benefits.

Patent hunting has inventor-level component

	Sales growth (1)	Tobin's Q (2)
inventor move × user × ssyear$_{post}$	0.0371***	0.115***
	(0.00567)	(0.0388)
Cited patent FE	Y	Y
Year FE	Y	Y
Observations	1501145	1510968
Adjusted R^2	0.228	0.397

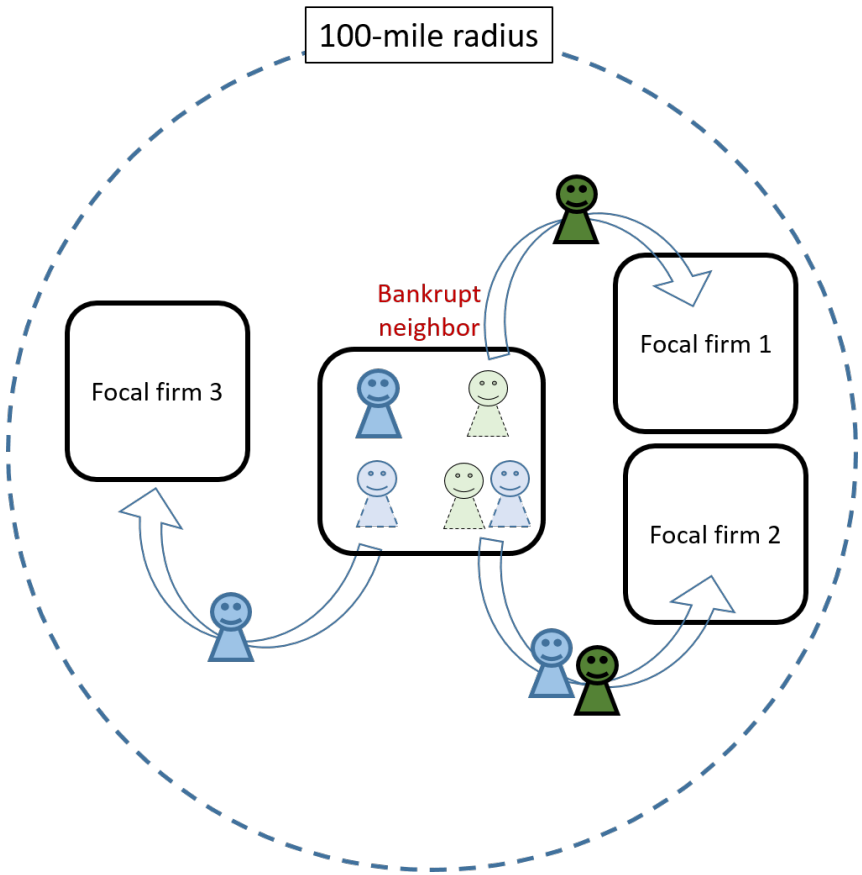
- When inventors move from writers to users, the user benefits are greater.

	𝟙(LB hunting) next firm (1)	no.(LB hunting) next firm (2)
𝟙(LB hunting) current firm	0.0681***	
	(0.00606)	
no.(LB hunting) current firm		0.136***
		(0.0224)
Current employment FE	Y	Y
Work start year FE	Y	Y
Observations	51544	51544
Adjusted R-squared	0.053	0.062

- Hunting inventors keep hunting after job switch.

Identification - IV regressions

We exploit the forced inventor moves from bankrupt neighboring firms.



- We only look at focal firms that have bankrupt neighbors.
- The intensity of hunting inventors in bankrupt neighbors is the treatment. ⏩ Stat
- The intensity of hunting inventors in bankrupt neighbors could make focal firms hunt more with labor spillovers, but is not directly related to focal firms' future sales growth.

Identification - IV regressions

	First-stage	Second-stage
	Log(1+LB hunting)	Sales growth
	(1)	(2)
bankrupt neighbor hunting intensity	0.454***	
	(0.0982)	
instrumented log(1+LB hunting)		2.475***
		(0.955)
First-stage F-stat	21.41	
Firm FE	Y	Y
Year FE	Y	Y
Observations	25874	25874
Adjusted R-squared	0.776	0.135

- There is a strong IV effect on nearby firms' LB hunting (a strong instrument).
- The 2nd-stage coefficients are positive and significant.
- The results suggest that the benefits of hunting LB are causal.

Nothing is a sideshow here

- The cited patent was important to its user. ⏩ evidence1
  - LB's technology was closer to users' technology than any other cited patents.
  - LB's technology booms after being hunted by the user.
- Citing LB was essential. ⏩ evidence2
  - LB is more likely to be referenced by inventors as an in-text citation and less likely to be added by examiners.

Takeaways

- The paper is the first to examine initially neglected but becoming extremely influential innovation.
- We provide new insight into *search and *implementation beyond the initiation of innovation.
  - We find that patent hunters amass significant rents from searching out neglected patents.
  - Patent hunting is persistent and deliberate and requires skills.
- "Patent hunters" play a critical role in innovation by creating attention and developing new technology areas in the spaces of neglected ideas.

Appendix

Is the hunting benefit prevalent in any superstar patents?

Superstar vs. non-superstar

	Diff(Sales growth)	Diff(Tobin's Q)
	(1)	(2)
superstar $\times ssyear_{post}$	0.00247	-0.00813
	(0.00156)	(0.0148)
superstar	0.00668***	0.196***
	(0.00144)	(0.0167)
$ssyear_{post}$	0.00751***	0.0501***
	(0.00126)	(0.0135)
SSyear FE	Y	Y
Observations	10805288	11069516
Adjusted R^2	0.051	0.026

Late-bloomer vs. non-superstar

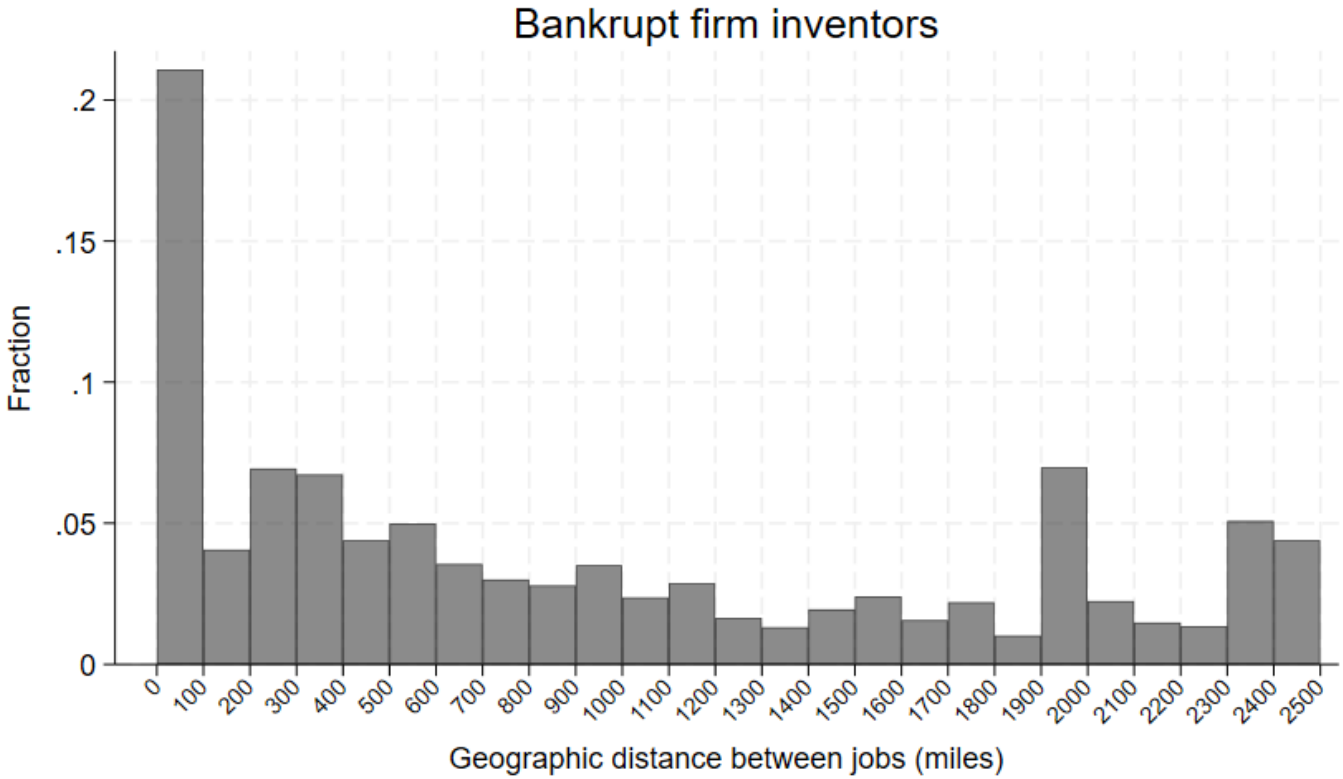
	Diff(Sales growth)	Diff(Tobin's Q)
	(1)	(2)
latebloomer × $ssyear_{post}$	0.0143***	0.210***
	(0.00283)	(0.0299)
latebloomer	0.00444**	0.133***
	(0.00209)	(0.0226)
$ssyear_{post}$	0.00564***	0.0254*
	(0.00129)	(0.0140)
SSyear FE	Y	Y
Controls	Y	Y
Observations	2115307	2167795
Adjusted R^2	0.039	0.043

Early-bloomer vs. non-superstar

	Diff(Sales growth)	Diff(Tobin's Q)
	(1)	(2)
earlybloomer × $ssyear_{post}$	-0.0000402	-0.0406***
	(0.00157)	(0.0148)
earlybloomer	0.00661***	0.178***
	(0.00157)	(0.0220)
$ssyear_{post}$	0.00696***	0.0138
	(0.00124)	(0.0132)
SSyear FE	Y	Y
Observations	9066974	9283734
Adjusted R^2	0.053	0.021

Back

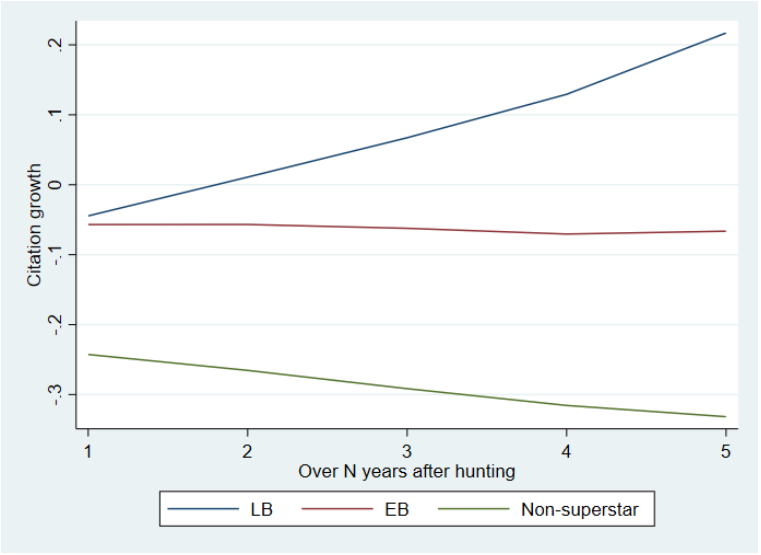
Inventor moves are geographically restricted but flexible across industries



- About 20% of inventors move within a 100-mile distance, unconditionally.
- About 50% (60%) of inventors (from bankrupting firms) move across firms outside 1-digit SIC. Back

LB technology is not a sideshow

- *LB* patent technology booms after being hunted.



- LBs are technologically closer to hunter's patents than EBs.

	Technology Proximity (1)
LB	0.00795***
	(0.00192)
Comparison group	EB, non-superstar
Citing patent FE	Y
Tech class FE	Y
Observations	2938358
Adjusted R^2	0.523

Back

Citing LB is not a sideshow

- Patent hunting is deliberate: LBs are more likely to be referenced by inventors as an in-text citation but less likely to be cited by examiners.

	Late-bloomers (1)	Non-late-bloomers (2)	(1)-(2) (3)
$\mathbb{1}$(in-text cited)	0.0552	0.0446	0.0106***
No.(in-text mentions)	0.0676	0.0558	0.0117***
Sent(in-text mentions)	0.373	0.329	0.0438***
$\mathbb{1}$(examiner cited)	0.178	0.285	-0.184***

- There is learning: Experienced hunters reap larger benefits. (based on the cited LB fraction in the past 5 years)

	Experienced		Less experienced	
	Sales growth (1)	Tobin's Q (2)	Sales growth (3)	Tobin's Q (4)
user × ssyear_{post}	0.0160***	0.0993***	0.00405***	-0.0384***
	(0.00404)	(0.0282)	(0.00123)	(0.00734)
Cited patent FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	241937	247010	1281769	1287061
Adjusted R^2	0.222	0.410	0.241	0.424

Back