Patent Hunters: Charting the Future of Innovation

Keynote Address

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HARVARD BUSINESS SCHOOL

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Motivation: The Innovation Chain

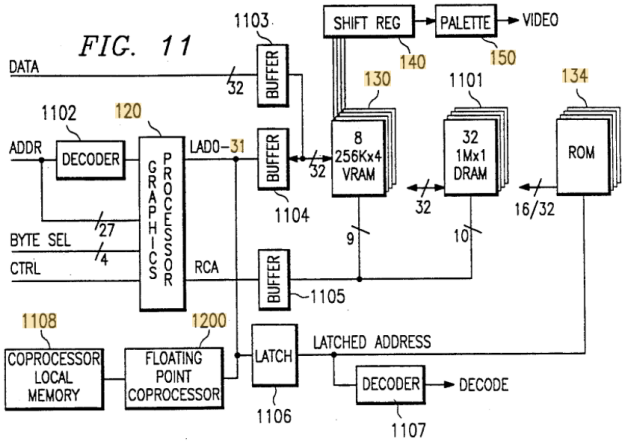
- There is a fundamental chain of experimentation, search, and implementation that underlies the innovation process.
- While each element of this chain is critical to ultimate success (of a given idea, product, or service), the literature has mainly focused on the initial, novel idea generation phase.
  - For example, basic research generation, laboratory interactions amongst private- and public-sector research teams, and most extensively through patents.
- While this has enhanced our understanding of initial conditions, our understanding of the remainder of the chain – equally important for understanding the entire innovative process – is relatively less well-understood.
- This is of particular importance as not all ideas that eventually are successful are recognized immediately. Moreover, eventual positive realizations of innovation take many divergent paths to reach that success point, often looking very different than the initial innovative idea.

Motivation: This Paper

In this paper, we aim to begin to fill precisely this gap.

- In particular, we document the first large-sample evidence on critical components of these latter stages.
  - We find that there are key agents in the innovation system that search out (or "hunt") neglected early-stage innovation and implement it in a demonstrable fashion.
  - Using millions of interconnected patents and innovators, we show that patent-hunting agents are unique and non-substitutable players in the innovation chain.
  - Moreover, the rents to "patent hunting" are substantial – often the most sizable portion of the entire innovation chain.
- Therefore, these roles – and the technology, physical, and human capital needed to implement them – should be seriously considered by all agents in the innovation chain; from those inadvertently seeding the hunters to those nearing entry at alternate stages.

Example: Patent US5025407 by Texas Instruments



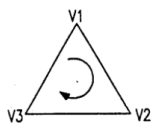


FIG. 16

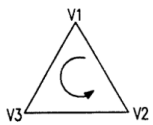


FIG. 17

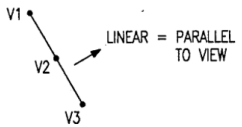


FIG. 18

FIG. 20

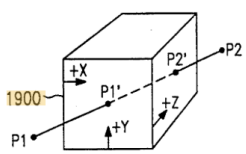


FIG. 19

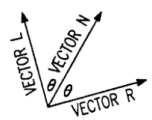
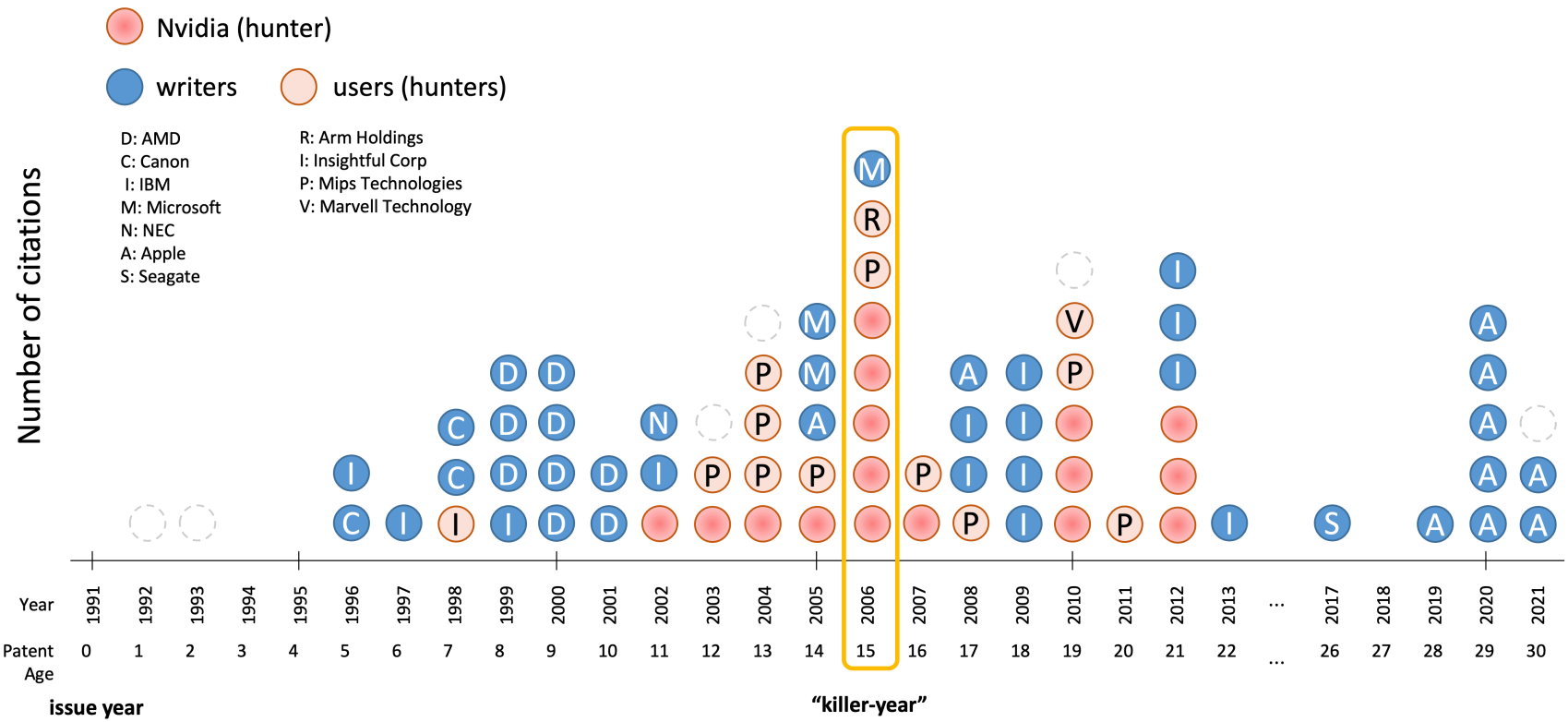


FIG. 21

- 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
- TI's core technology class was H01L Semiconductor devices.
  - This patent's technology proximity to TI's core technology is 0.13.
- This patent's technology proximity to Nvidia is 0.32.

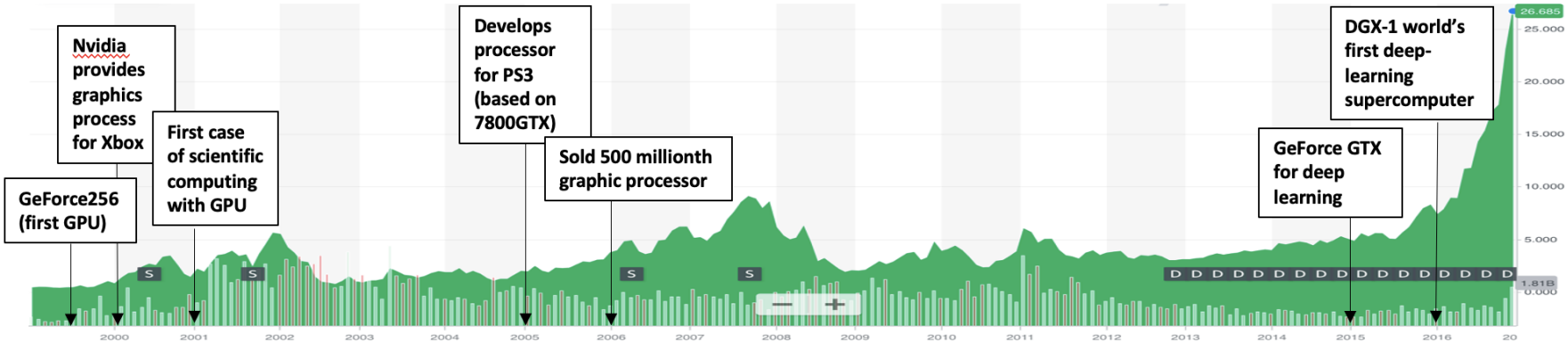
Example: Patent US5025407 and Nvidia Corp.

- The patent was on graphics floating point coprocessor having matrix capabilities.
- Early citations are from developers of CPU (not GPU).
- Nvidia started citing it intensely around 2006 related to GPU computing.

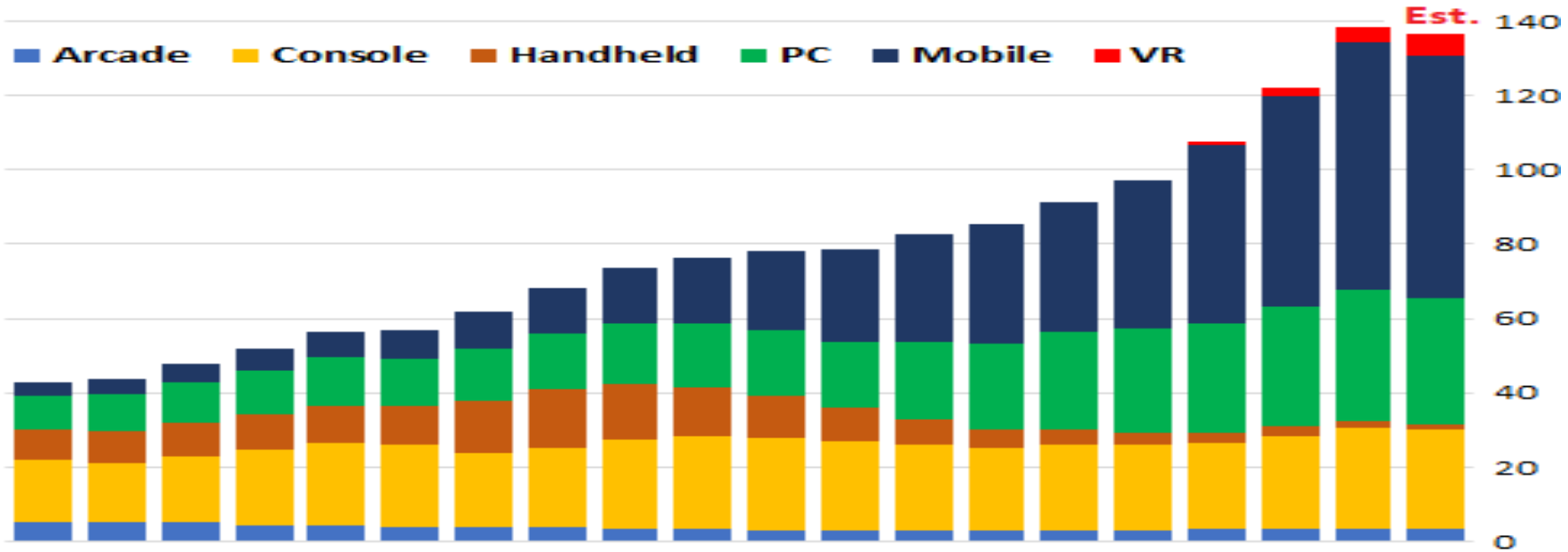


Example: Nvidia Corp.

- Nvidia stock prices, 2000-2017



- Video game industry revenues, $ billion, 2002-2019



Findings

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- Patent hunting **rents** come with those new markets.
  - Patent hunters' sales growth, Tobin's Q, and the number of new products increase.
  - Patent hunters' benefits exceed original patent writers' benefits, on average.

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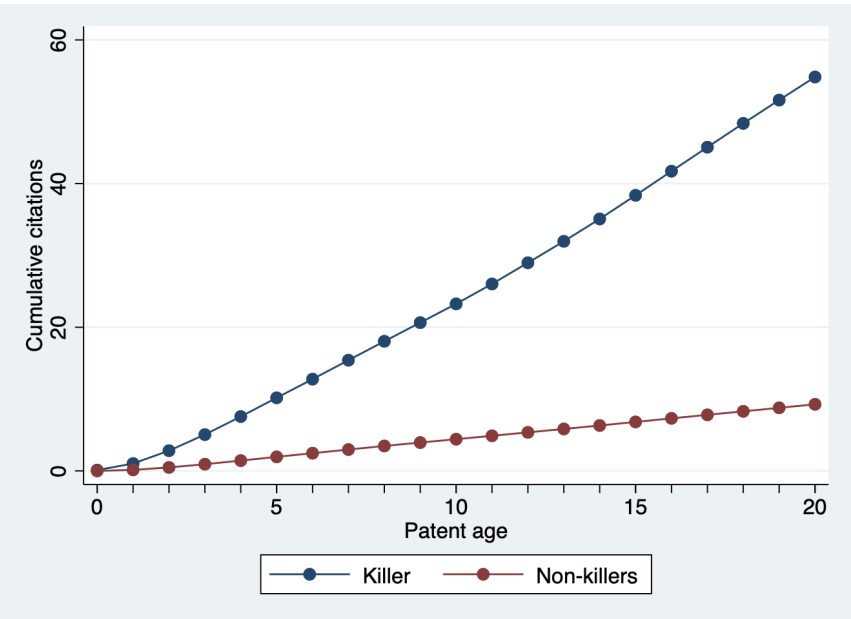
- In rationalizing the equilibrium, the initially neglected patents which are 'hunted':
  - Are peripheral to the core technology of the writers.
  - Are not in currently competitive spaces (so lack time pressure).
- We find that having both writers of neglected patents and their hunters can be optimal.

Data construction

- We use the universe of USPTO patents (1.7 million) from 1976 through 2019.
- 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 exclude approximately 0.45% with no technology class information.
- We later focus on public firms for firm outcome regressions using the sample between 1976 and 2019.
  - Merge with Compustat for financial variables.
  - Merge with new product data from Mukerjee et al. (2022) for commercialization proxies.

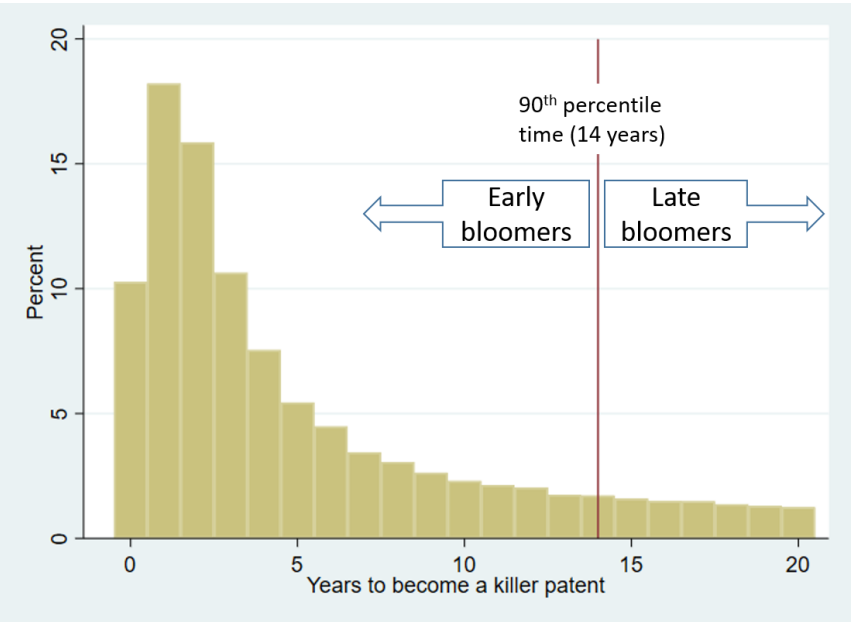
What are killer patents?

- Killer patents are those patents that are extremely impactful, as measured by the number of cumulative citations they received from outside innovators and patents.
  - 95th percentile cumulative forward citations (net of self-citations)
  - within the cohort of the same CPC class and grant year
  - over the first 20-years of patent age
- We have 213,772 killer patents that are granted between 1976 and 1999.

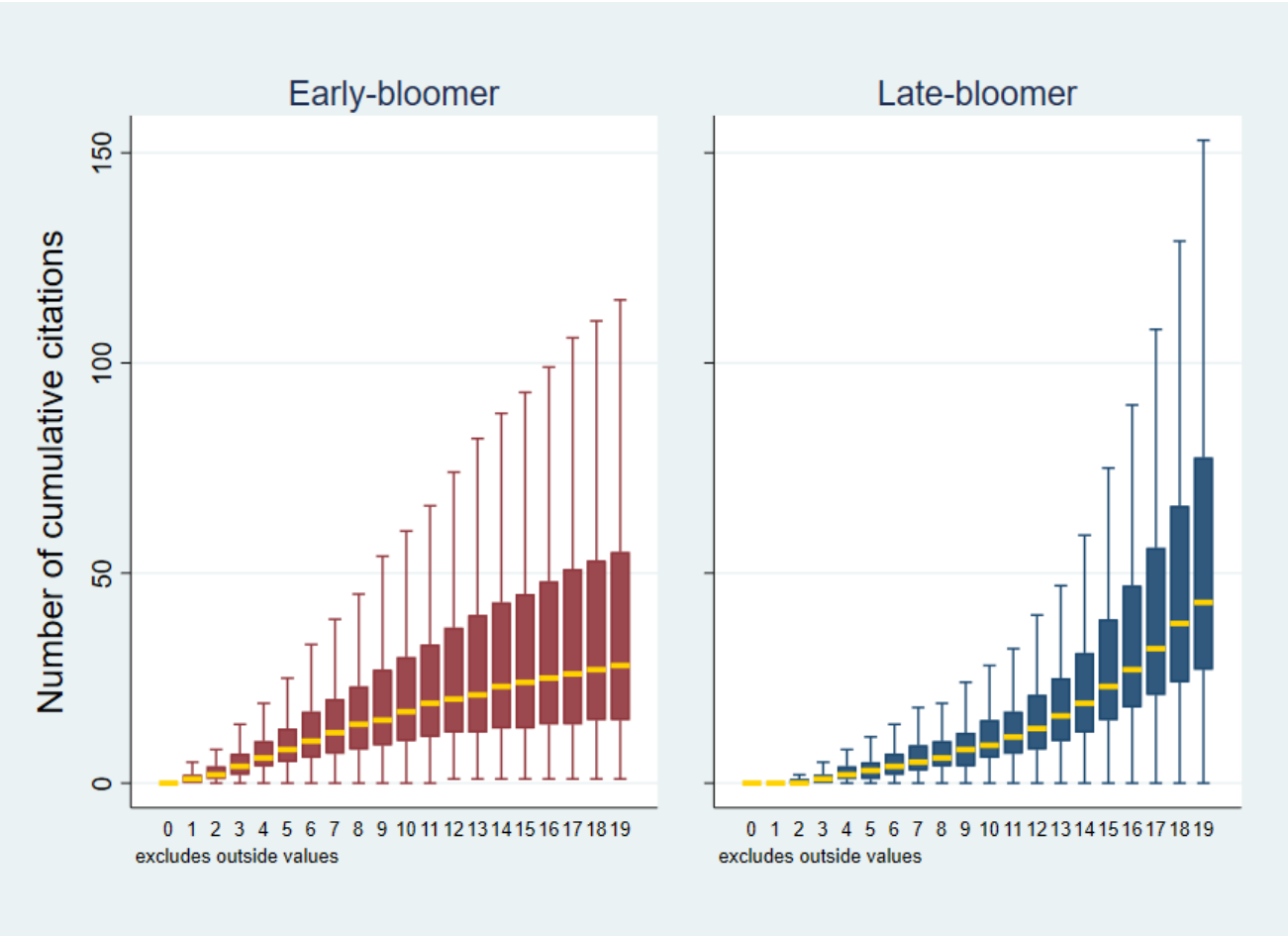


Early bloomers vs. Late bloomers

- We further classify killer patents into late- and early-bloomer patents by the time it took to become a killer patent.
- A **late-bloomer** patent is somewhat neglected early-stage innovation (N=21,960).
- An **early-bloomer** patent immediately attracts interest from users (N=191,812).



Early bloomers vs. Late bloomers



- **Late-bloomer** patents are slow to accumulate citations earlier in patent age.
- However, they accumulate substantially larger number of citation compared to the early-bloomer patents towards the end of 20 years.

Summary statistics: patent-level

Panel A: Killer patents vs. non-killer patents

	Non-killer patents			Killer patents			
	mean	p 50	sd	mean	p50	sd	Difference
Cum. citations at age 20	9.31	6.00	12.17	54.26	30.00	76.22	-44.95***
Count class	1.83	2.00	1.07	2.06	2.00	1.29	-0.23***
Count claims	12.27	10	10.17	15.85	12.00	13.98	-3.58***
Avg. claim word count	76.45	61.44	57.10	77.70	62.75	56.40	-1.25***
Backward citation	9.39	7	10.52	12.13	8.00	15.82	-2.74***
Public	0.39	0	0.49	0.46	0.00	0.50	-0.07***
KPSS value	9.08	3.26	23.56	11.28	3.90	31.45	-2.19***
Number of patents	1,499,277			213,772			

Panel B: Early-bloomer patents vs. late-bloomer patents

	Early-bloomer patents			Late-bloomer patents			
	mean	p 50	sd	mean	p50	sd	Difference
Cum. citations at age 20	52.53	28.00	77.20	69.80	49.00	64.73	-17.27***
Count class	2.05	2.00	1.28	2.17	2.00	1.39	-0.12***
Count claims	15.83	12.00	13.96	16.02	13.00	14.13	-0.19**
Avg. claim word count	78.11	63.00	56.66	74.01	60.12	53.84	4.09***
Backward citation	12.09	8.00	15.61	12.41	8.00	17.64	-0.32***
Public	0.46	0.00	0.50	0.46	0.00	0.50	0.01**
KPSS value	11.29	3.85	31.65	11.15	4.31	29.61	0.14
Number of patents	191,812			21,960			

- Economically small differences suggest that killer and late/early-bloomer patents cannot be predicted by the patent characteristics at issuance.

Summary statistics: citing patents

Panel C: Citing patents of early-bloomer patents vs. and late-bloomer patents

	Early-bloomer citing patents			Late-bloomer citing patents			
	mean	p50	sd	mean	p50	sd	Difference
Cum. citations at age 20	23.21	10.00	47.37	35.99	16.00	69.11	-12.77***
Count class	2.00	2.00	1.31	2.22	2.00	1.54	-0.22***
Count claims	17.26	15.00	13.43	19.56	17.00	15.54	-2.30***
Avg. claim word count	70.34	57.30	73.48	64.91	53.45	109.04	5.43***
Backward citation	43.96	16.00	113.79	96.89	31.00	195.04	-52.94***
Individual inventor	0.01	0.00	0.08	0.01	0.00	0.08	0.00**
Public	0.41	0.00	0.49	0.40	0.00	0.49	0.01***
KPSS value	13.65	4.51	38.77	16.34	5.81	42.47	-2.69***
Number of patents		2,797,100			790,936		

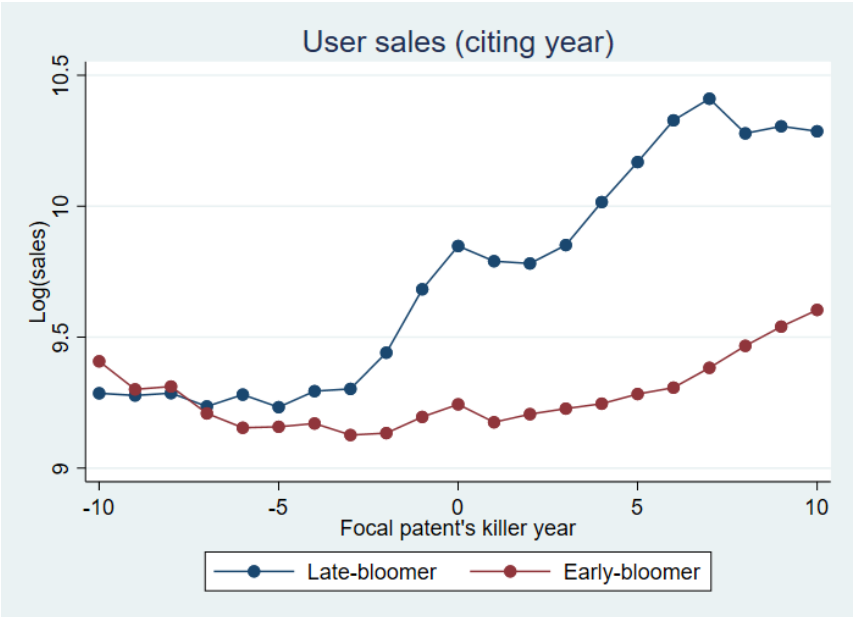
- Citing patents amass fewer citations compared to the killer patents they cite, on average.
- That said, *late-bloomer* citing patents (users) make a substantially broader search of patents, e.g., significantly more backward citations.
- We further closely examine
  - who writes late-bloomer patents and
  - how late-bloomer users discover and extract benefits from the neglected early-stage innovation.

Late bloomer writers vs. users

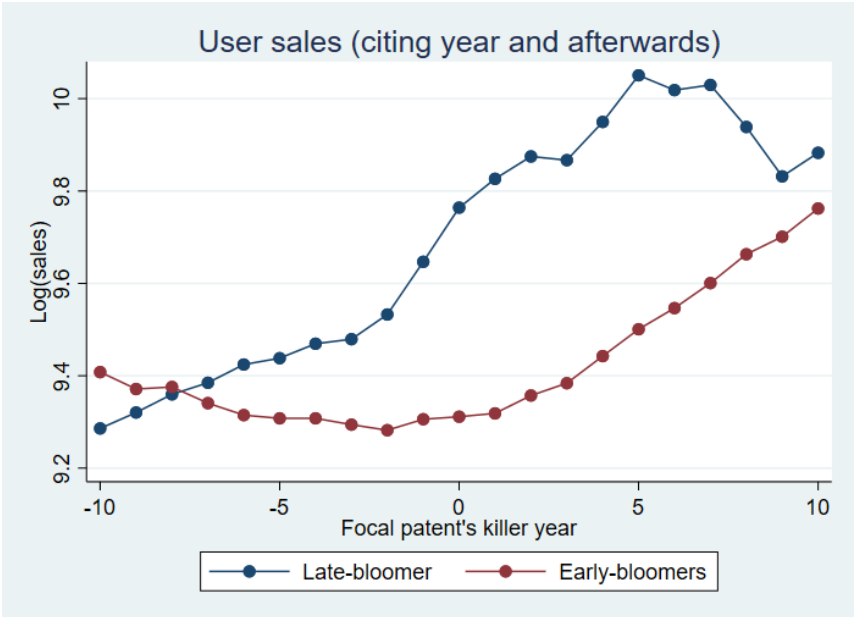
	Writers	Users	ATE	SE
no. patents per year	29.71	2.840	26.87***	3.234
no. external cites per year	63.91	4.135	59.78***	6.330
no. external cites/no. patents	2.450	1.517	0.933***	0.112
no. new products/no. patents	0.181	0.256	-0.0749***	0.0271
log_asset	5.212	4.665	0.546***	0.0827
tobinq	2.495	2.523	-0.0281	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
consumer dependent	0.231	0.256	-0.0250**	0.0116

- Writers produce at least one LB and possibly also use/cite LBs.
  - Writers are big, value firms with larger stock of patents and citations and bigger R&D spending.
  - Examples: U.S. Surgical, Johnson and Johnson, IBM, General Electric
- Users use/cite LBs but do not produce LB.
  - Users are smaller firms with more products per patents, greater consumer dependency, and comparable R&D spending.
  - Examples: Tivo, Parkervision, Affymetrix, Lennox Intl

User benefits from hunting (LB vs. EB)



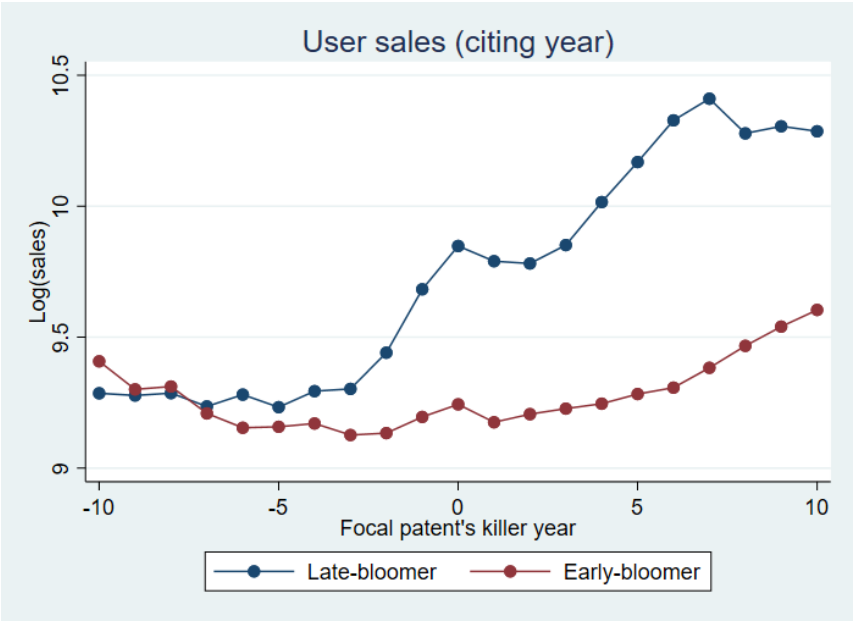
(a) User Sales



(b) User Cumulative Sales

- The benefits from hunting LB, measured by firm sales, are significantly larger than those from hunting EB.
- Such LB hunting benefits last over time (panel b).

User vs. writer benefits



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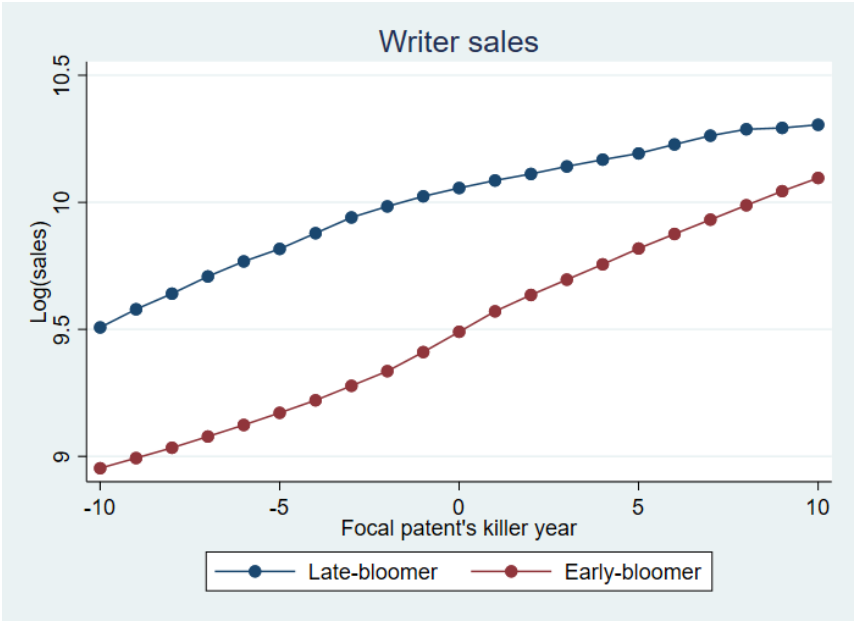


(c) Writer Sales

- There are also benefits from writing LBs.
- Writer benefits are relatively smaller given the larger size of writing firms.
- Writers appear to have more benefits from writing EB than writing LB.

User Benefits from Hunting LB (relative to writer)

	New product/Total Assets	
user × $killeryear_{post}$		0.000271***
		(0.000116)
user	0.000466***	0.000201***
	(0.0000441)	(0.000092)
$killeryear_{post}$		-0.000238***
		(0.000056)
LB pre-*killeryear* outcome mean	0.0017	0.0018
Focal patent FE	Y	Y
Observations	2405083	2405083
Adjusted R^2	0.180	0.180

- The dependent variable is the number of new products scaled by asset.
- There are sizable and statistically significant user benefits from hunting LB after the focal patent becomes a killer patent.
  - The post-killyear number of new product increases by 15% (t=2.33), which translates into 3.5 new products for a median-size firm.

User benefits from hunting (LB vs. EB, relative to writer)

	Diff(Sales growth)	Diff(Tobin's Q)
latebloomer × $killeryear_{post}$	1.593***	0.276***
	(0.00294)	(0.0336)
latebloomer	-0.00158	-0.0629*
	(0.00248)	(0.0380)
$killeryear_{post}$	0.00673***	-0.0280**
	(0.00105)	(0.0112)
LB pre-*killeryear* outcome mean	0.035	0.325
Killer year FE	Y	Y
Observations	10428295	10687503
Adjusted R^2	0.051	0.027

- The dependent variable is the difference in the outcome variable between users and writers: $y_{user} - y_{writer}$.
- There are sizable and statistically significant user benefits from hunting LB over EB particularly after the focal patent becomes a killer patent.
- The gap between user and writer in terms of
  - sales growth increases by 36.4% (t=4.44)
  - and Tobin's Q increases by 85% (t=8.23).

Do killer patents generally create user benefits?

Killer vs. non-killer

	Diff(Sales growth)	Diff(New products)	Diff(Tobin's Q)
killerpat $\times$ $killeryear_{post}$	0.00247	-0.202	-0.00813
	(0.00156)	(0.243)	(0.0148)
killerpat	0.00668***	1.205***	0.196***
	(0.00144)	(0.225)	(0.0167)
$killeryear_{post}$	0.00751***	-2.727***	0.0501***
	(0.00126)	(0.200)	(0.0135)
Killer year FE	Y	Y	Y
Controls	Y	Y	Y
Observations	10805288	9570460	11069516
Adjusted R^2	0.051	0.071	0.026

- No, benefits are specific to hunting LB and not any killer patents.
- The user benefits around the peak of citations are statistically indistinguishable between killer and nonkiller.

User benefits from hunting LB over non-killer patents

Late-bloomer vs. non-killer

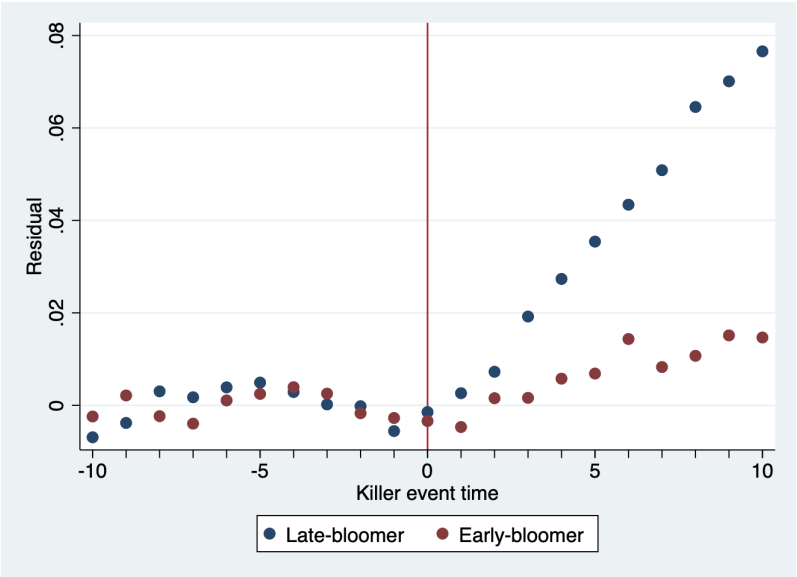
	Diff(Sales growth)	Diff(New products)	Diff(Tobin's Q)
latebloomer × $killeryear_{post}$	0.0143***	1.275***	0.210***
	(0.00283)	(0.402)	(0.0299)
latebloomer	0.00444**	1.244***	0.133***
	(0.00209)	(0.309)	(0.0226)
$killeryear_{post}$	0.00564***	-2.944***	0.0254*
	(0.00129)	(0.213)	(0.0140)
Killer year FE	Y	Y	Y
Observations	2115307	1523151	2167795
Adjusted R^2	0.039	0.090	0.043

Early-bloomer vs. non-killer

	Diff(Sales growth)	Diff(New products)	Diff(Tobin's Q)
earlybloomer × $killeryear_{post}$	-0.0000402	-0.0401	-0.0406***
	(0.00157)	(0.244)	(0.0148)
earlybloomer	0.00661***	0.844***	0.178***
	(0.00157)	(0.249)	(0.0220)
$killeryear_{post}$	0.00696***	-3.168***	0.0138
	(0.00124)	(0.197)	(0.0132)
Killer year FE	Y	Y	Y
Observations	9066974	8366591	9283734
Adjusted R^2	0.053	0.069	0.021

- The user benefits from hunting LB persist using non-killer patents as the comparison group but are **absent** when hunting EB.

How do users create value?



(d) De-trended proximity

- In general, the technology proximity between the focal and citing patents decreases over time. i.e. focal patent technology gradually becomes obsolete or broadly applied.
- For LB patents, the proximity stabilizes when the focal patent becomes a killer patent.
- The stabilizing technology proximity is suggestive of the rising demand for LB technology by a new group of focused users.

Creation of new markets

	Log(Patent counts in tech-class groups)			
	Focal patent tech-class group		Citing patent tech-class group	
latebloomer × $killeryear_{post}$	0.145***	0.151***	0.0607***	0.0721***
	(0.00494)	(0.00489)	(0.0207)	(0.0215)
$killeryear_{post}$	-0.132***	-0.139***	0.386***	0.382***
	(0.00201)	(0.00196)	(0.0411)	(0.0350)
Sample	Full	up to *killyear* + 20	Full	up to *killyear* + 20
Focal patent FE	Y	Y	Y	Y
Observations	696851	565484	9300908	7382756
Adjusted R^2	0.409	0.405	0.697	0.735

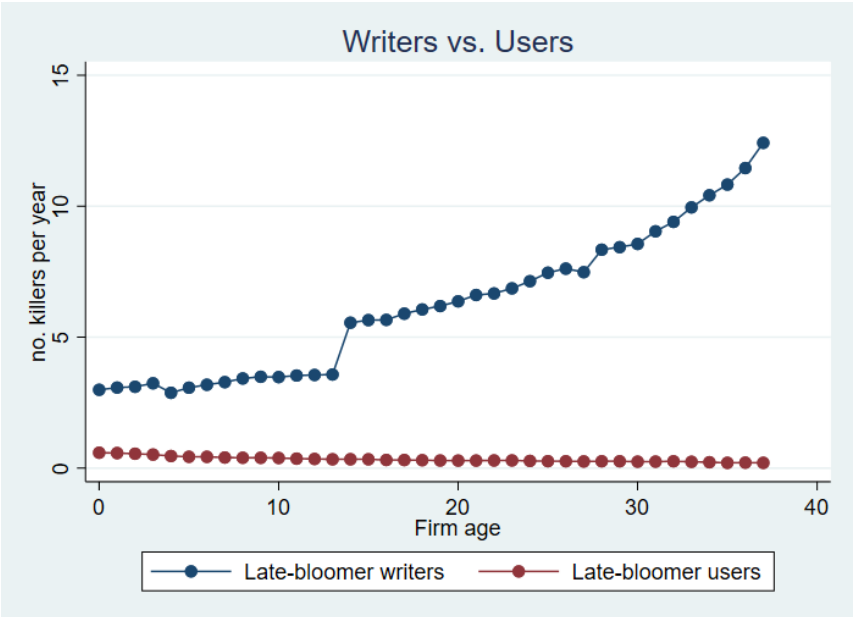
- The new demand for LB technology creates a new market by the users around the killer year.
- There is an increase in the number of new patents granted in
  - the LB patents' own technology space by 15.6% (t=29.4)
  - the new overlapping technology classes among LB user patents by 6.2% (t=2.93).

Which patents are hunted by users?

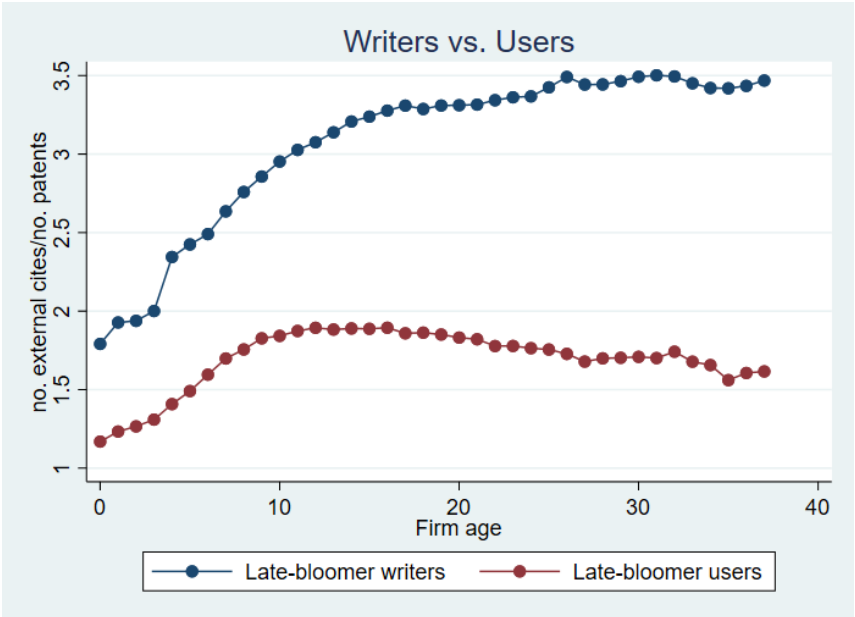
	latebloomer			
	(1)	(2)	(3)	(4)
techclass weight	-0.0432***	-0.0478***		
	(0.0145)	(0.0146)		
techclass dist to core			0.0143**	0.0159***
			(0.00534)	(0.00551)
log(competing patent stock)	-0.00556***	-0.00505***	-0.00561***	-0.00512***
	(0.00135)	(0.00133)	(0.00131)	(0.00130)
fin_const (KZ)	-0.00701**		-0.00695**	
	(0.00296)		(0.00293)	
fin_const (WW)		-0.0337		-0.0341
		(0.0851)		(0.0846)
Writer FE	Y	Y	Y	Y
Grant year FE	Y	Y	Y	Y
Observations	94889	90936	94889	90936
Adjusted R^2	0.033	0.032	0.033	0.032

- LB patents come about possibly due to **intellectual capital or capacity constraints** of writers or **low competitive threat**.
- They are likely a **failed or peripheral technology** to writers' core technology.
- Writers have the ability to create valuable patents and are not financially constrained but just not willing or able to focus on every innovation they create.
  - techclass weight: the fraction of patents in the CPC class of a given patent in all patents of its assignee over the entire sample period.
  - tech class dist to core: the class-to-class proximity between the CPC class of a given patent and the core CPC class of its assignee.
  - log(competing patent stock): the log of the number of all US public firm patents in the same tech class up to the grant year.

Are LB Writers and Users persistently different?



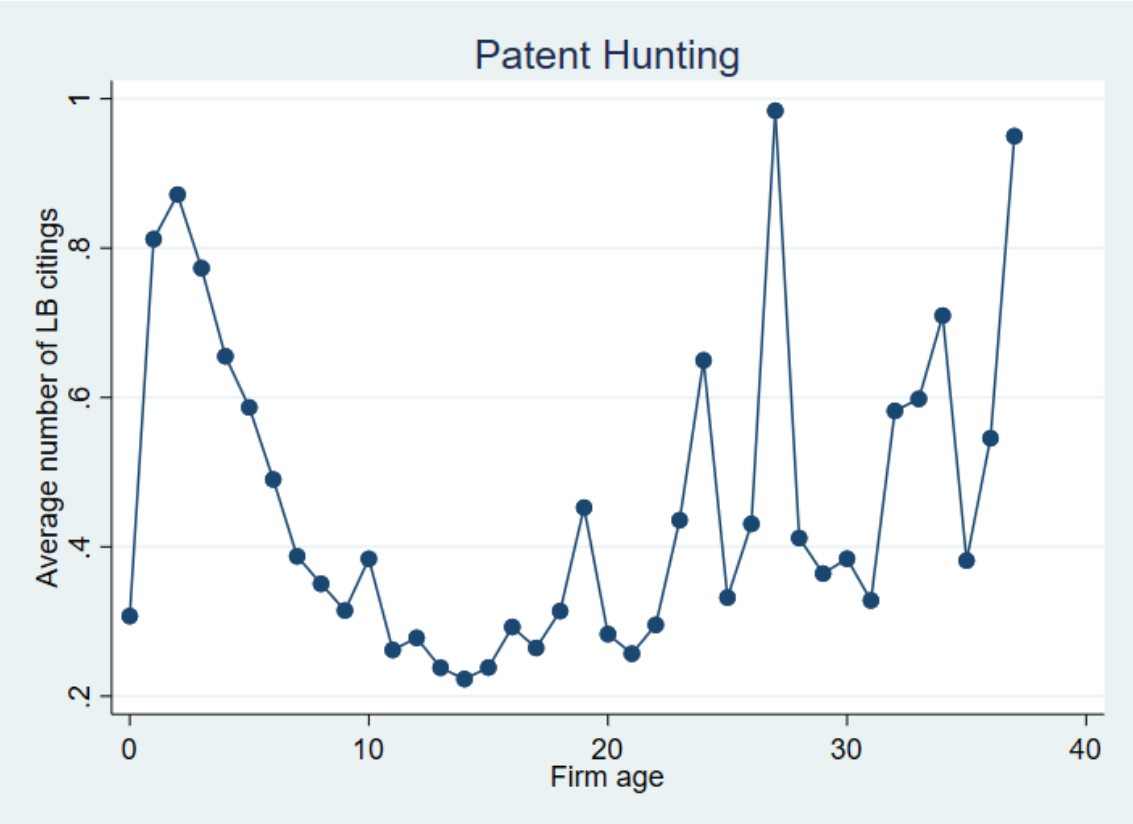
(e) Number of Patents per Year



(f) Number of External Cites per Patent

- LB writers are persistently more active in writing (killer) patents over 40-year firm age than users.
- LB writers also write persistently more influential patents than users.

Is patent hunting persistent?



- LB users who ever cite LB patents at least once during our sample period continue to find out neglected early-stage innovation and cite them (approximately 1 hunting every other year on average).

Is patent hunting persistent?

- We consider transition matrix among:
  - Strict LB writers: write LBs but never cite an LB.
  - Flexible LB writers: write LBs and also cite LBs.
  - Strict LB users: cite LBs but never wrtie 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	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	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%

Is patent hunting an inventor effect?

	Sales growth (1)	Tobin's Q (2)
Inventor_move × user × $killeryear_{post}$	0.0465***	0.551***
	(0.00875)	(0.198)
User × $killeryear_{post}$	0.0188***	0.173***
	(0.00300)	(0.0342)
$killeryear_{post}$	-0.0153***	0.0810***
	(0.00194)	(0.0203)
Inventor_move × user	0.0124	0.115
	(0.0122)	(0.136)
Inventor_move × $killeryear_{post}$	-0.0381***	-0.156**
	(0.00643)	(0.0608)
Inventor_move	0.0256***	0.138*
	(0.00615)	(0.0789)
User	0.0174***	0.179***
	(0.00220)	(0.0265)
Firm Controls	Y	Y
Patent-pair FE	Y	Y
Observations	3525900	3573959
Adjusted R^2	0.098	0.323

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

Is patent hunting an inventor effect?

	Next firm		Next 3 firms	
	𝟙(LB User)	LB User Avg. Num	𝟙(LB User)	LB User Avg. Num
𝟙(LB user)	0.0681***		0.0738***	
	(0.00836)		(0.00786)	
𝟙(Killer User)	0.0189***		0.0181***	
	(0.00440)		(0.00376)	
LB user avg. num		0.136***		0.155***
		(0.0242)		(0.0245)
Killer user avg. num		0.00672**		0.00776**
		(0.00301)		(0.00326)
gender	-0.00696	0.0130	-0.0107	0.00915
	(0.00860)	(0.0108)	(0.00951)	(0.0123)
inv_npat	0.00236***	0.00131***	0.00257***	0.00137***
	(0.000402)	(0.000301)	(0.000415)	(0.000319)
inv_nfirms	-0.0178***	-0.0108***	-0.0154***	-0.00475
	(0.00337)	(0.00353)	(0.00331)	(0.00327)
Firm Controls	Y	Y	Y	Y
Observations	51544	51544	51544	51544
Adjusted R-squared	0.053	0.062	0.062	0.062

- Hunting inventors keep hunting after job switch ($\backsim$ 9% more likely).
- Hard to distinguish
  - inventors self-selecting patent hunting firms
  - inventors bringing hunting skills to new firms

Is there an advantage being an early-hunter?

	Late-bloomer only		Early-bloomer only	
	Diff(Sales Growth)	Diff(New Product Growth)	Diff(Sales Growth)	Diff(New Product Growth)
	(1)	(2)	(3)	(4)
early-hunter	0.592**	1.324**	-0.205	0.486*
	(0.255)	(0.606)	(0.249)	(0.257)
diff(log_asset)	-0.373***	1.056***	-0.611***	1.063***
	(0.0630)	(0.185)	(0.126)	(0.0770)
diff(log_age)	-2.058***	0.995***	-0.845***	1.788***
	(0.416)	(0.381)	(0.125)	(0.148)
diff(roa)	-10.05***	8.222***	-9.512***	7.850***
	(2.951)	(2.257)	(3.211)	(0.882)
diff(leverage_b)	1.249*	4.049**	-2.816**	4.114***
	(0.750)	(1.852)	(1.169)	(0.849)
Focal patent FE	Y	Y	Y	Y
Observations	49839	7258	213938	43434
Adjusted R^2	0.350	0.487	0.990	0.561

- The early hunters who used the late-bloomer patent before the advent of the new market show larger sales and new product growths over the ten years from the citing year.

Are there any costs to hunting LBs?

	Diff(10-year sales growth)			
	(1)	(2)	(3)	(4)
first5hunting	-1.624*			
	(0.874)			
highnumpat_f		-0.796***		
		(0.170)		
highnumpat_c			-0.565***	
			(0.139)	
avgncompetitor				-0.0840***
				(0.0262)
Cited patent FE	Y	Y	Y	Y
Observations	49839	39257	47888	49839
Adjusted R^2	0.350	0.467	0.371	0.350

- The user benefits are relatively smaller if:
  - **Less experienced** in hunting (first5hunting)
  - **Too many** same technology class focal patents to search from (highnumpat_f)
  - **Too many** same technology class user patents (highnumpat_c) or firms (avgncompetitor) exploiting the focal patent
- LB hunting may not be viable or profitable for every innovative agent.

Takeaways

- We use the universe of patents granted over the past five decades to provide new insight into the fundamental chain of experimentation, search, and implementation that underlies the innovation process.
- Namely, we find that patent hunters amass significant rents from hunting out neglected patents - in terms of new products, sales growth, and Tobin's Q (market value).
- The patents they search out tend to be closer to their core (and more peripheral to the writers), along with being in - at that moment - less competitive idea and innovation spaces.
- Patent hunting is persistent, and has a learning component. It also appears to have inventor-level components: as hunted-patents are more valuable when tied with inventors, along with patent hunting inventors continuing across work-places.
- This patent hunting process also appears to have spillovers for the system in terms of creating more attention, innovation, and new product development in the hunted patent idea spaces.

Next Steps: Moving Forward

- This is a rich area, on the frontier of explosion for future research.
- We're just beginning to scratch the surface on what goes on in this complex but critical bridge in the innovation system. Indeed the winners and losers have yet to be fully identified or understood.
- Moreover the **times**, **industries**, and **competitive environments** in which certain players and certain strategies win relative to others, has yet to be explored and unearthed. And yet critically must be.

Next Steps: Moving Forward - Final Thoughts

- You are all far better researchers than I... we need you(!)
- Everyone should drop everything and start researching the innovation chain too.
- ...
- Have you started yet?
- What are you waiting for?

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Now let's dive into Q&A!