

# Creative Destruction and Strategic Protection<sup>1</sup>

## Evidence from Drug Patent Citations

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# Outline

- Motivation
- Theoretical considerations
- Data
- Results

# Motivation

## Follow-on patenting

- 1984 Hatch-Waxman
  - ANDAs eliminate requirement of clinical trials for generics
- Loophole: follow-on patenting
  - If any patents are still in force, incumbent may file suit against generics
  - Automatic 30 month stay triggered at FDA per patent
  - Incentives to “stockpile” and “time release” patents
  - AKA “evergreening”
- Loophole reduced in 2003 (Medicare Act)
  - Only one stay allowed

# Motivation

## Innovation

- In addition to direct incentive, may also be an additional strategic incentive to extend patent protection
- Incumbents may strategically extend patent protection through follow-on patenting
  - Fencing/fenceposts v. Thickets (Hall and Ziedonis, 2001)
- Entrants may strategically target weaker patents or fertile patents that are not sufficiently fenced
  - Schumpeter's creative destruction
  - Intra-molecule v. inter-molecule, within therapeutic class
- Entrants may avoid heavily patented areas to avoid lawsuits (Lerner 1995, biotechnology)

# Overview of this paper

- Investigate follow-on patenting behavior of pharma firms
  - Timing of follow-on patenting by incumbents *and* patenting (citations) by competitors
  - Parametric and non-parametric hazard estimation
- Results
  - Follow-on patenting appears to be characterized by strategic substitution *at the product level*
  - Cannot speak to R&D/patenting at the firm level, which could still be strategic complements

# Theoretical considerations

## Theoretical models of R&D

- Strategic substitutes (SS) and strategic complements (SC) (Bulow, Geanakoplos, and Klemperer, 1985)
- When faced with entry, incumbents have more at stake and may do more R&D than entrants in order to protect monopoly rents (Gilbert and Newberry 1982)...*strategic substitution (SS)*
  - Or, intra-chemical innovation shared through licensing (incumbent cannot be worse off)
- In typical patent race models, R&D may be characterized by *strategic complementarity (SC)* (Reinganum 1983)
  - Or, direct effect dominates and the area is fruitful for research

# Empirical Tests

- Lots of theoretical predictions, but few empirical tests
  - Dewo, Gans, and Hirschberg (2005)—little evidence for incumbent reaction to entrant R&D
  - Cockburn and Henderson (1994)—find little evidence of racing
  - Sundaram, John, and John (1996)—find zero average effect, but separate SS from SC
- This paper provides a test for SS v. SC at the product level in pharma
- Pharma patents are a useful area
  - Product market level—*location* of R&D (Lerner 1995, Ziedonis 2004). Makes use of FDA requirement to list patents on drug applications (NDAs)
  - Patenting heavily used... is patenting a proxy for R&D?
  - Can make use of precise dates of patenting activity (application v. grant date)

# Data

## Sample

- (Historical) Orange Book data plus current update
- All patents for (almost) all NDAs 1970-2009 (patents 1968-2009)
  - Several NDAs per drug (different forms/doseages may have different NDAs)
  - Several patents per NDA
  - Matched by first listed patent (chemical substance patent, NCE)
  - OB listed patents are follow-on patents
- Merge with NBER (2006) patent datafile
  - Drop pre-1976 and post-2006

# Data

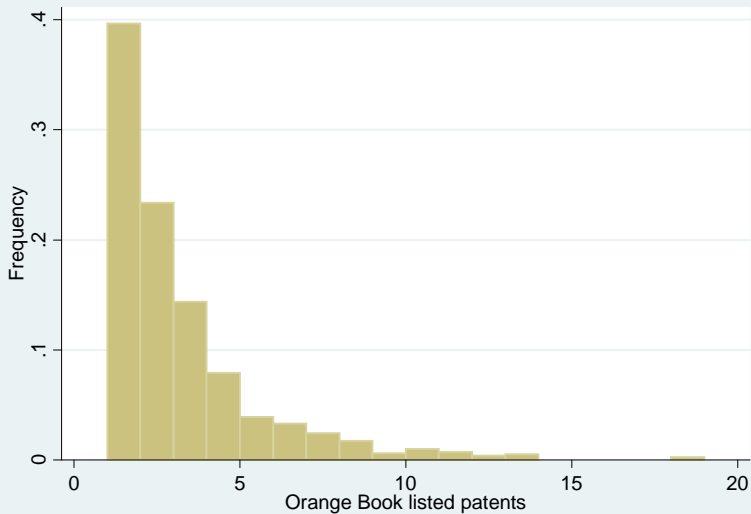
## Sample

- Sample
  - 822 first patents (drugs), 2214 OB, 19,437 citations
- Technology, by International Patent Classification

59%	A61K	Preparations for medical, dental, or toilet purposes
11%	C07D	Heterocyclic compounds
5%	A61F	Filters implantable in to blood vessels; prostheses; ban
11%	Other A	Human necessities
11%	Other C	Chemistry; Metallurgy
3%	Other	

# Data

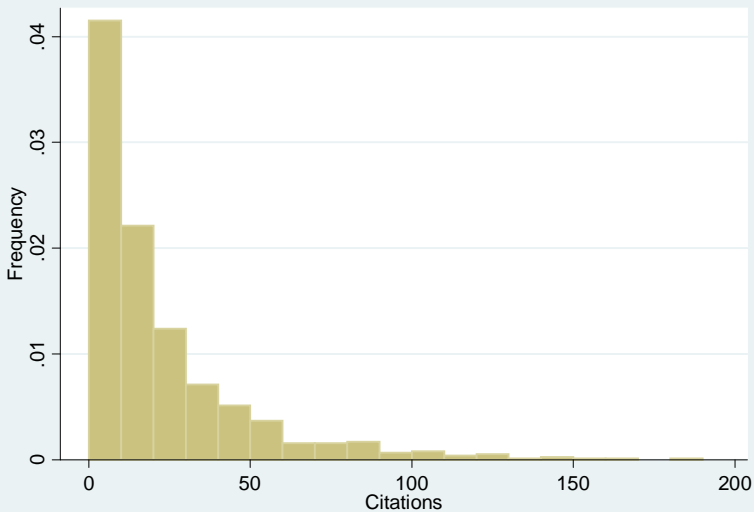
## Histogram of Orange Book listed patents per drug



822 drugs

# Data

## Forward patent citations per drug



766 drugs

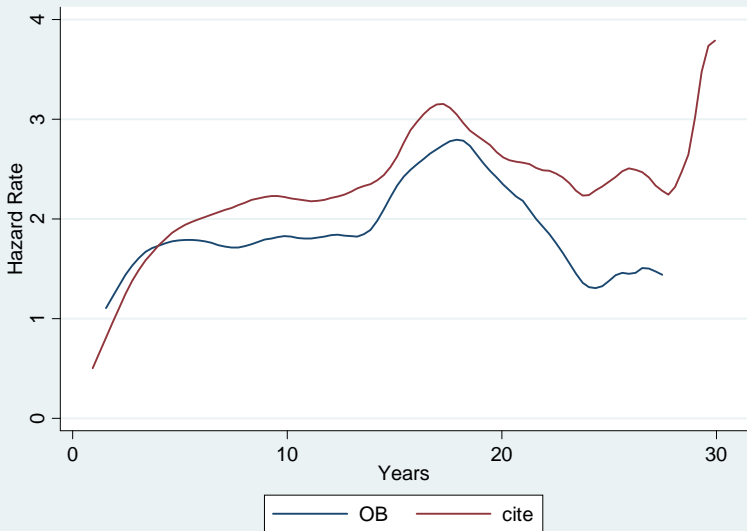
# Estimation

## Hazard Estimation

- Too large for individual content analysis of citing patents
- Non-parametric Kaplan-Meier
- Can control by type of citation
  - Orange Book v. citation
  - Self-citation
  - Technology

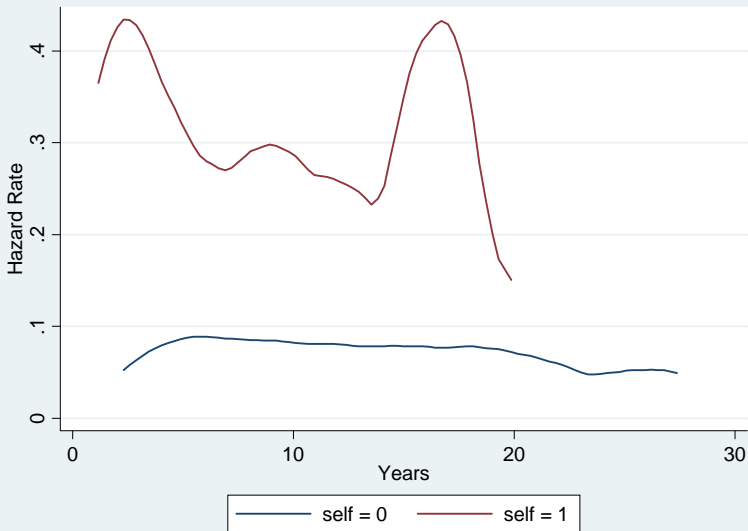
# Kaplan-Meier Estimation

Orange book v. other citations



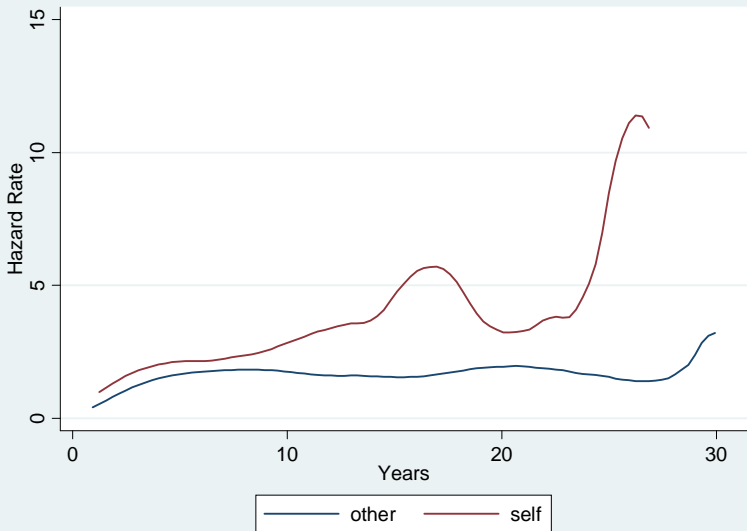
# Kaplan-Meier Estimation

Orange book patenting



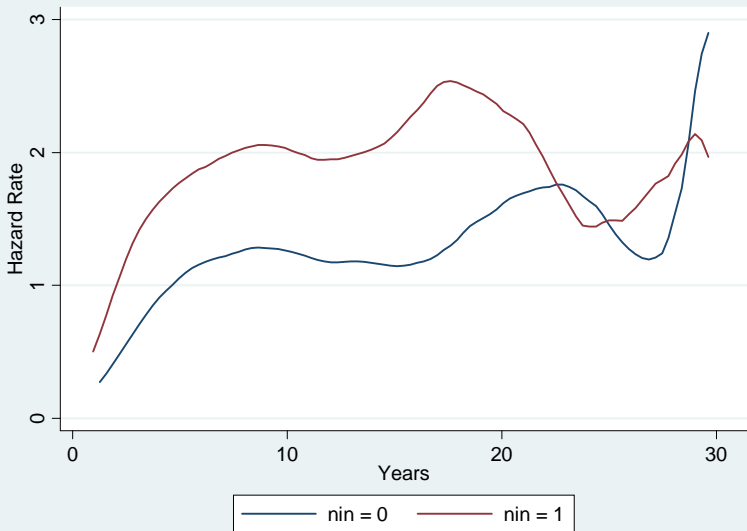
# Kaplan-Meier Estimation

Citation



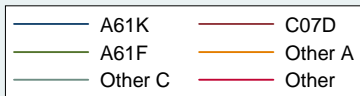
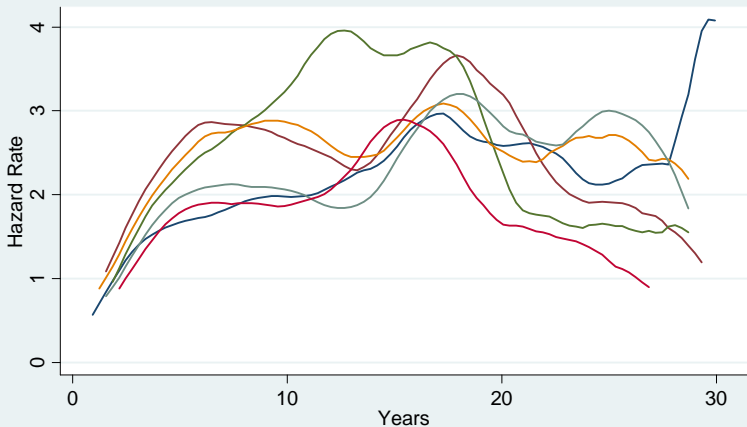
# Kaplan-Meier Estimation

Non-self citation, by inside v. outside



# Kaplan-Meier Estimation

All citation, by IPC



# Estimation

## Hazard Estimation

- Hazard estimation
  - Estimate *frequency* of dependent variable (hazard rate)
  - Maximum likelihood estimation
- Non-parametric and parametric estimation
  - Non-parametric Kaplan-Meier (no independent variables)
  - Parametric: Weibull, Frailty

# Estimation

## Weibull frailty estimation

	[1]	[2]	[3]
	Follow-on	Self-citation	Citation
Cumulative Counts	Patenting		
Follow-on	2.389 *** (12.57)	1.014 (0.23)	0.728 *** (-9.62)
In force	1.085 *** (7.30)	1.034 *** (14.38)	1.013 *** (21.16)
Self	0.959 * (-1.75)	1.062 *** (9.72)	0.970 *** (-3.16)
Citations	0.943 *** (-5.77)	0.951 *** (-6.89)	1.013 *** (5.89)
Claims	1.010 *** (3.26)	1.023 *** (5.03)	1.017 *** (6.10)
Year dummies	Y	Y	Y
rho (Weibull)	0.939 * (-1.84)	1.389 *** (16.36)	1.843 *** (57.09)
theta (frailty)	0.639 *** (-3.34)	2.045 *** (9.01)	0.924 (-1.24)
obs	12531	12531	12531
drugs	696	696	696
failures	931	2563	8227

\*\*\* significant at the 0.01 level. \*\* significant at the 0.05 level. \* significant at the 0.10 level.

Standard errors clustered by drug.

# Estimation

## Inside and outside citations

Hazard of: Specification:	[1]		[2]		[3]		[4]	
	Follow-on patenting		Self citation		Inside citation		Outside citation	
	Weibull		Weibull		Weibull		Weibull	
	frailty/normalized		frailty/normalized		frailty/normalized		frailty/normalized	
Follow-on	2.389	***	1.016		0.759	***	0.727	***
	12.57		0.26		-6.52		-6.77	
In force	1.085	***	1.034	***	1.018	***	1.012	***
	7.30		14.34		17.78		14.05	
Self	0.960	*	1.063	***	1.014		0.926	***
	-1.71		9.87		1.10		-5.33	
Inside	0.949	***	0.995		1.026	***	0.989	*
	-3.02		-0.39		4.84		-1.81	
Outside	0.934	***	0.886	***	0.967	***	1.072	***
	-2.62		-7.36		-3.32		10.08	
Claims	1.010	***	1.021	***	1.016	***	1.017	***
	3.20		4.62		4.90		5.18	
_cons	0.000	***	0.004	***	0.030	***	0.024	***
	-7.37		-12.67		-12.42		-11.05	
Year dummies	Y		Y		Y		Y	
rho	0.940	*	1.398	***	1.797	***	1.836	***
	-1.83		16.74		40.52		37.13	
theta	0.638	***	2.086	***	1.209	***	1.242	***
	-3.35		9.29		2.75		2.89	

# Discussion

- Main result: follow-on patenting characterized by strategic substitution
- Extensions
  - Welfare consequences: Is there delay in developing substitutes or cumulative innovation because of fencing?
  - Control for therapeutic classes across drugs (requires additional data)
  - Use patent application dates (only available for 1997-2006)
  - More work on the small sample (separate paper), including prices and revenues (separate paper)