Mini Course on: Economics of Ideas and Innovation-Led Growth

Part 1

Ufuk Akcigit
University of Pennsylvania & NBER

July 23, 2013 - Bilkent University

Introduction

Ideas and innovations are the engines of long-run economic growth.

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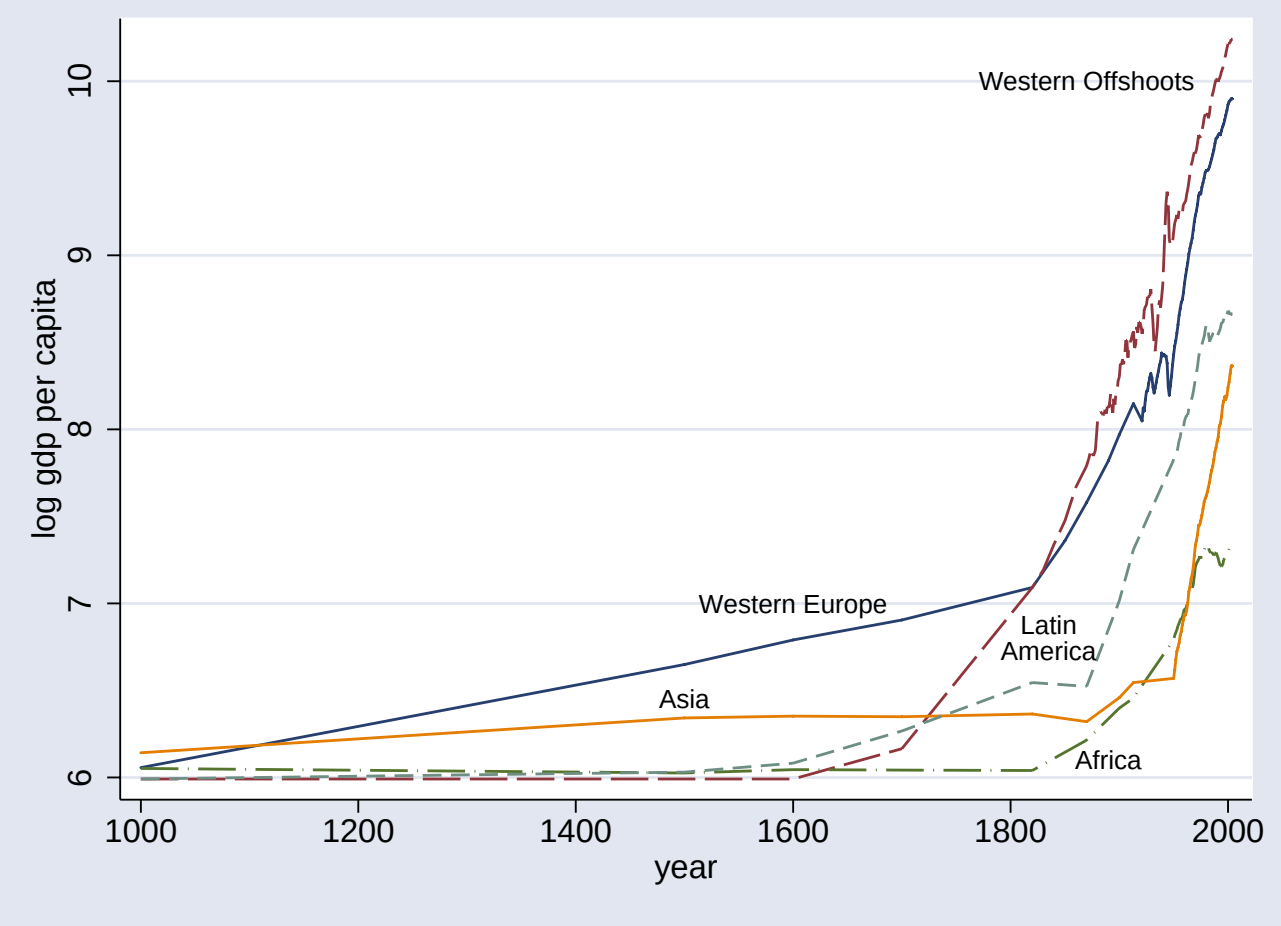
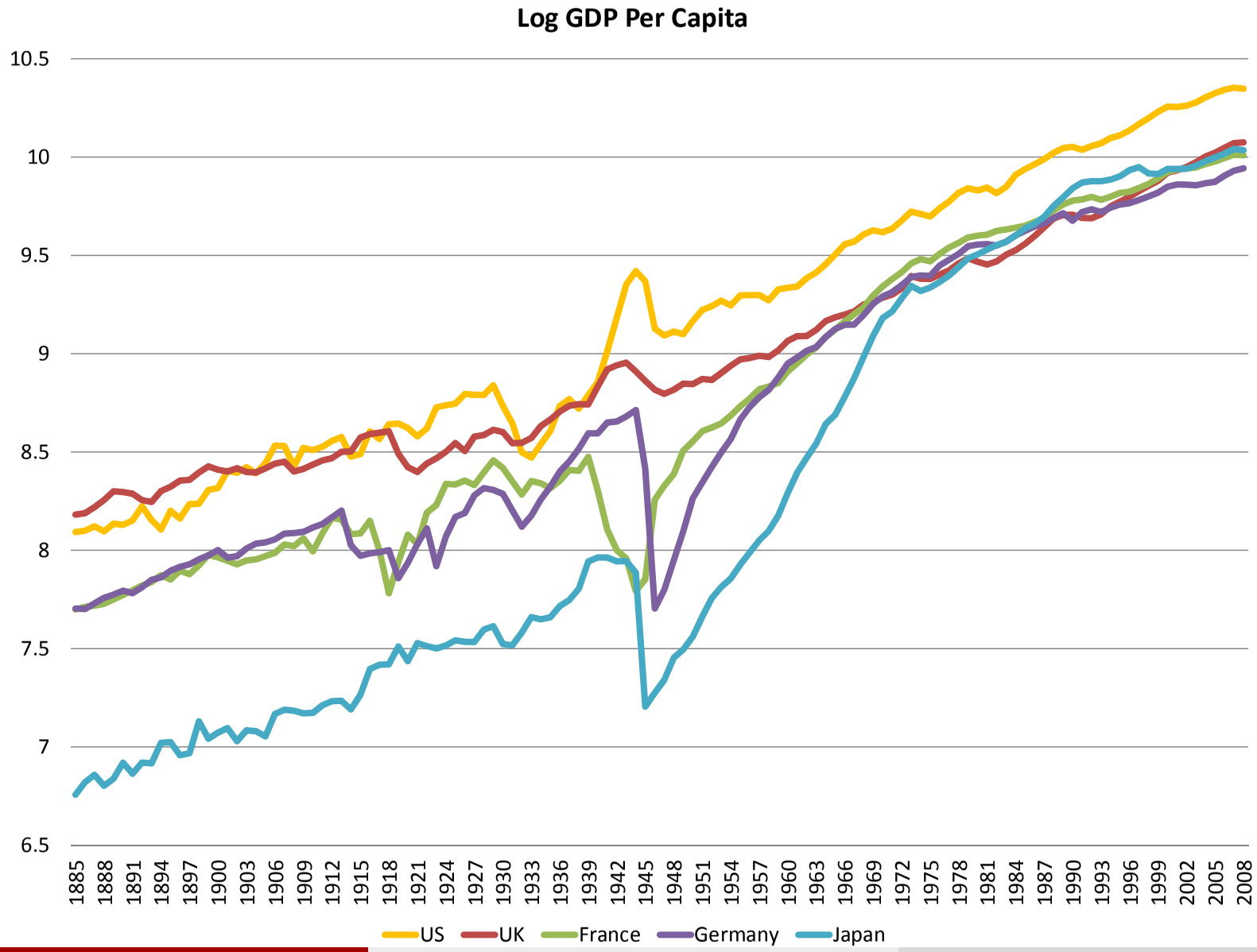
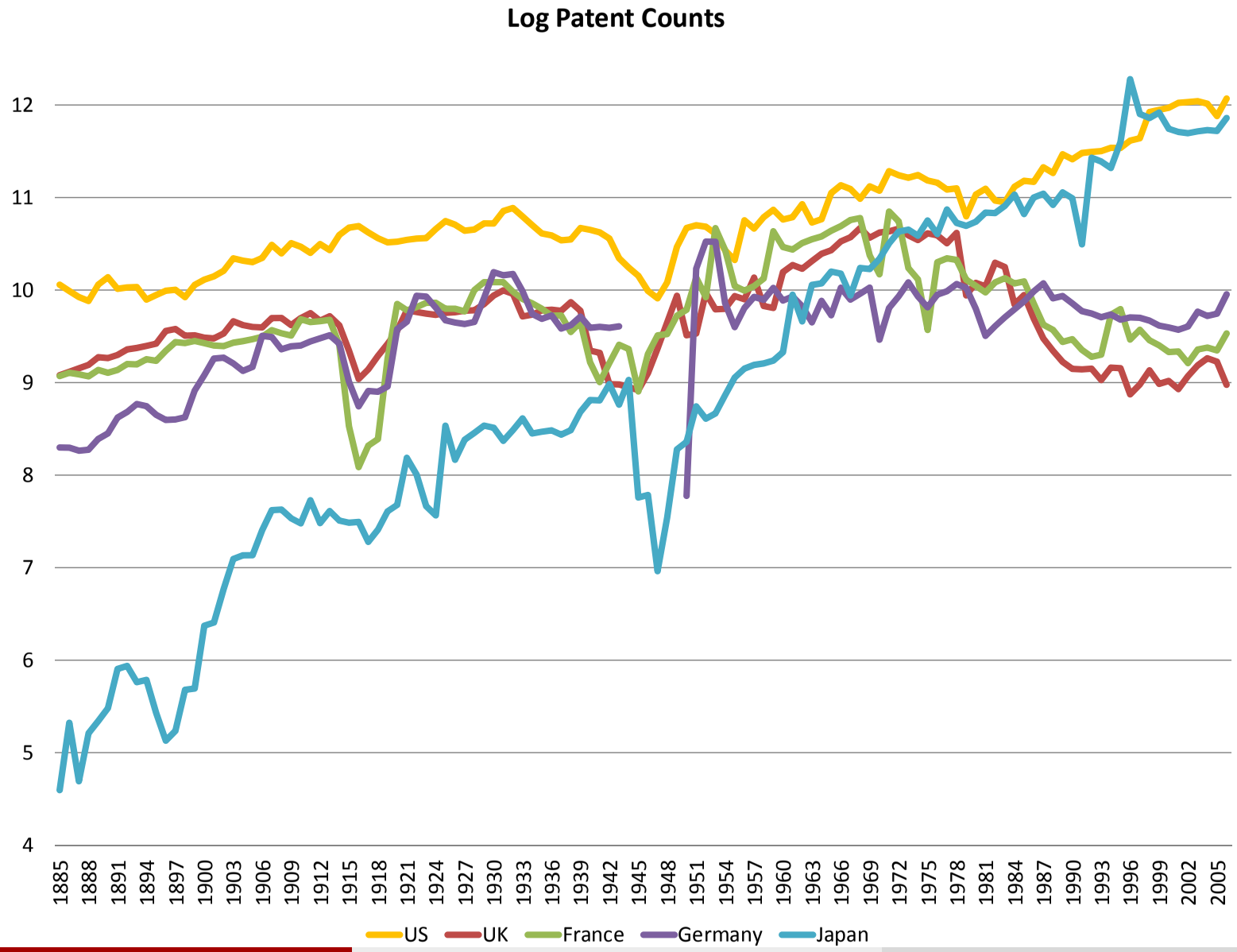


Figure: The evolution of average GDP per capita

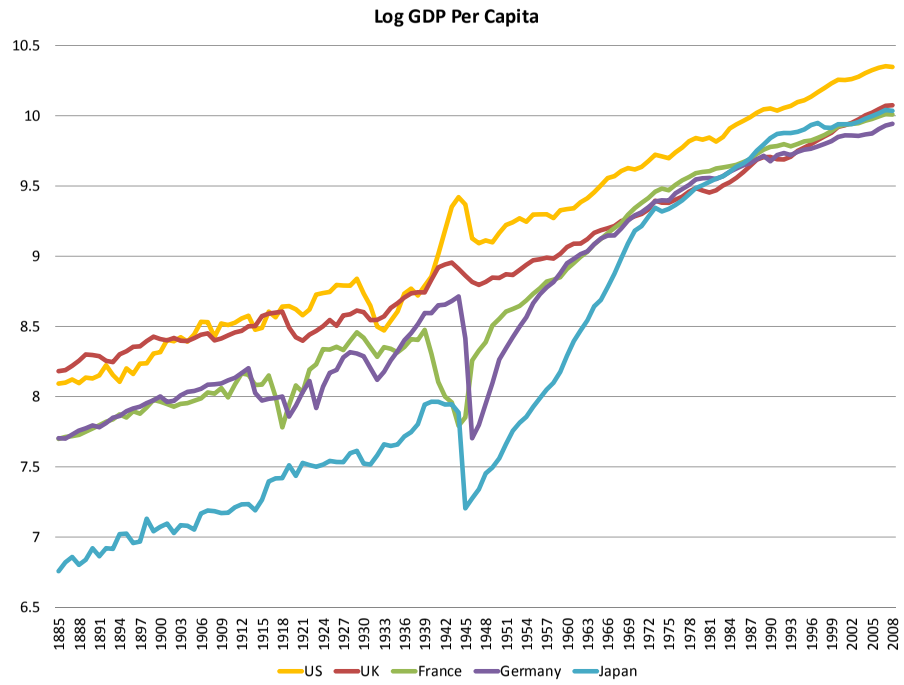
Introduction

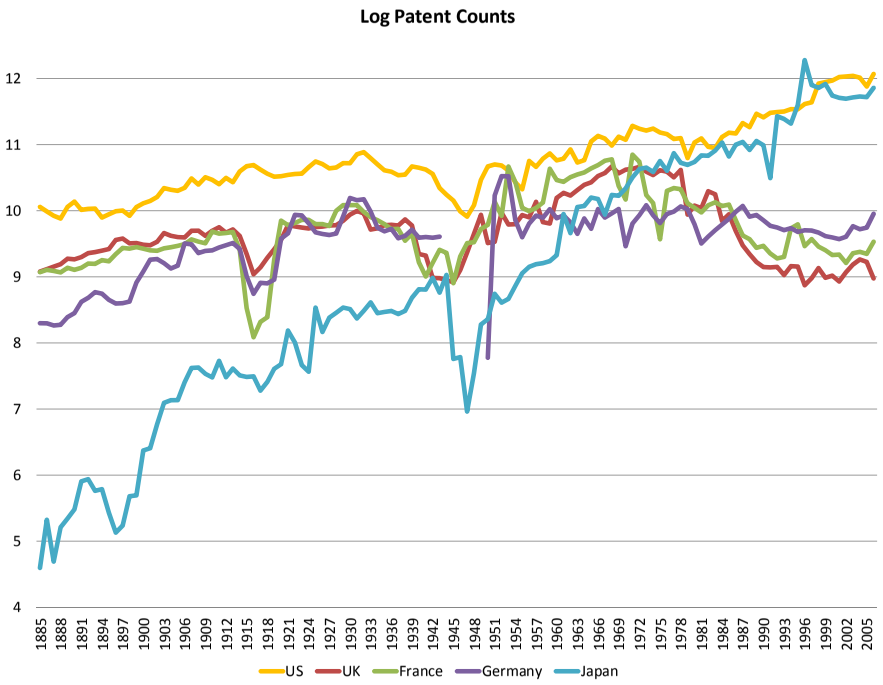


Introduction



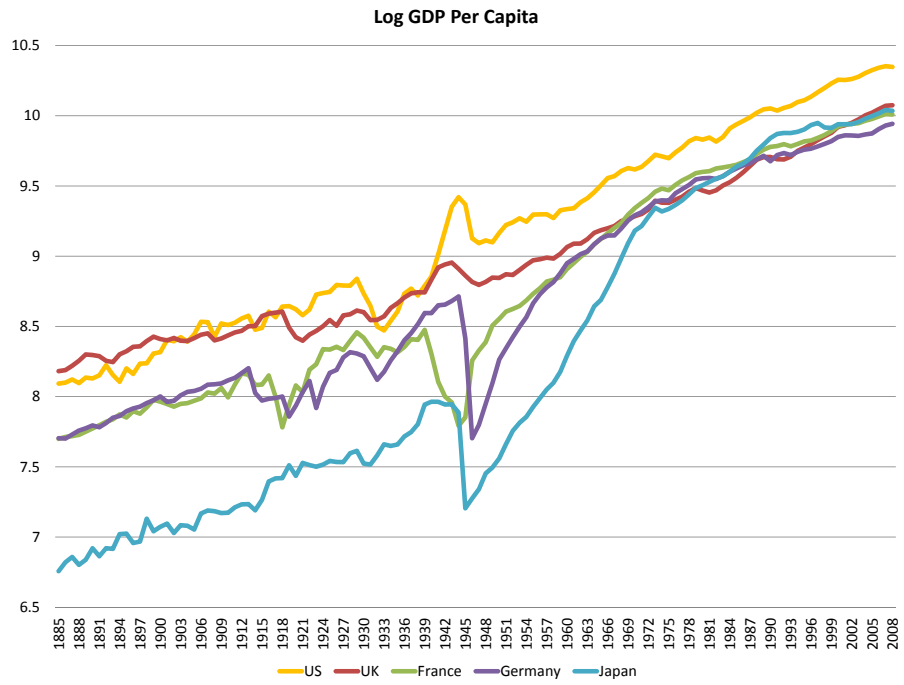
Patenting vs Growth

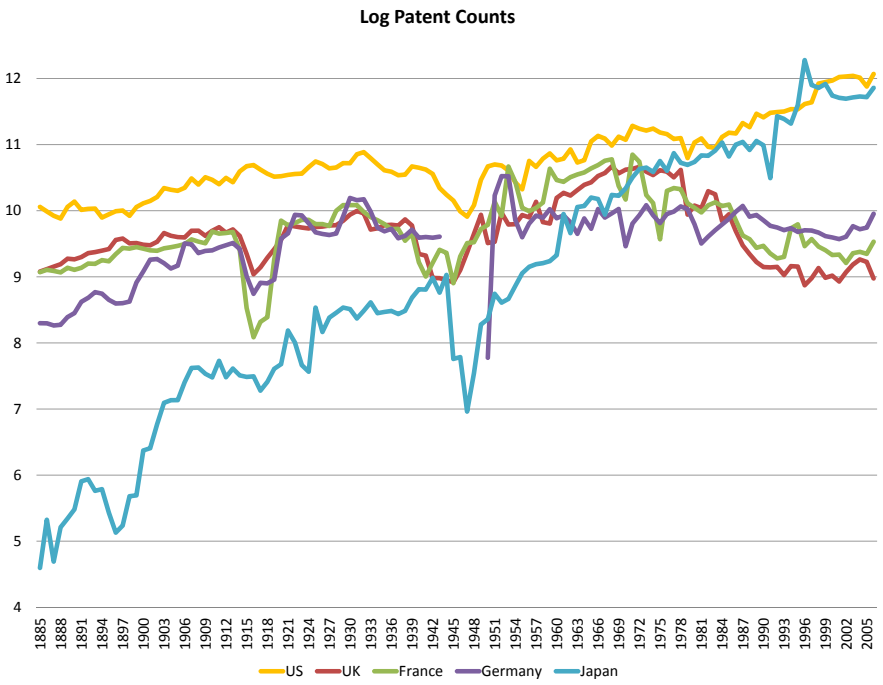




Two observations:

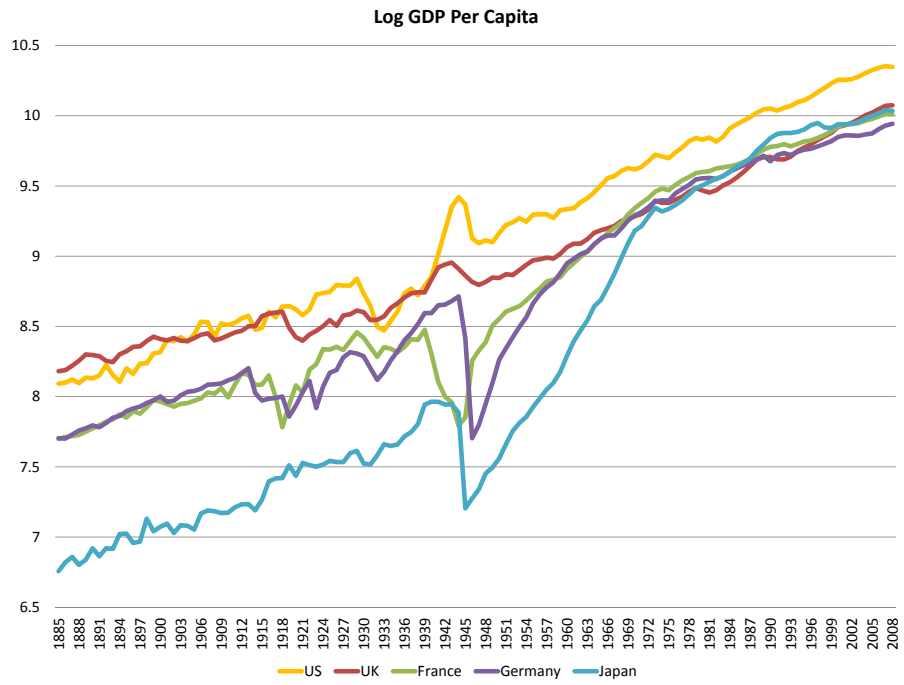
Patenting vs Growth

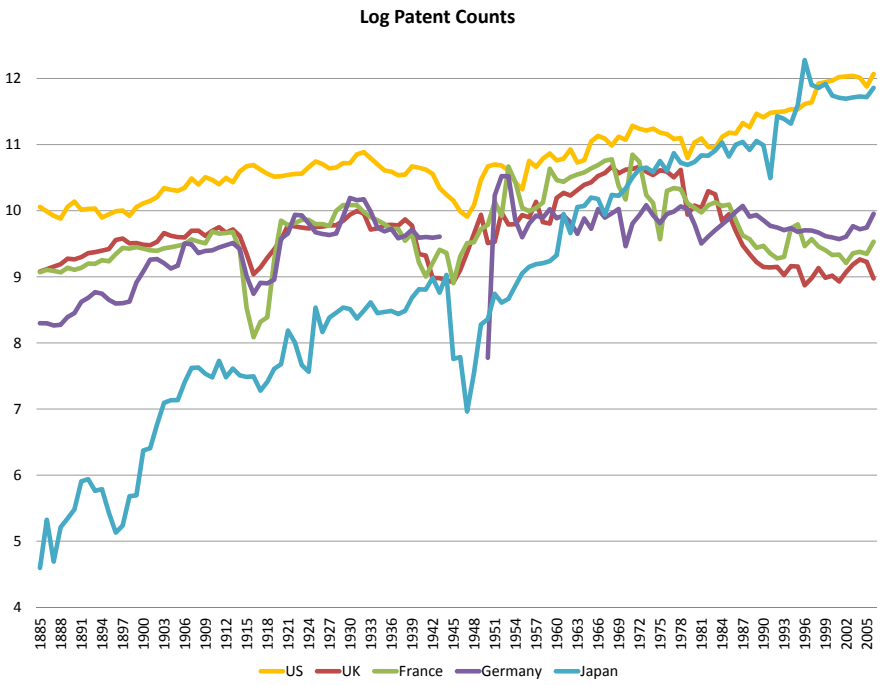




1) United States vs United Kingdom:
The US keeps inventing whereas the UK falls behind in innovation.
The result is that the US leapfrogs the UK over 150-year period.

Patenting vs Growth

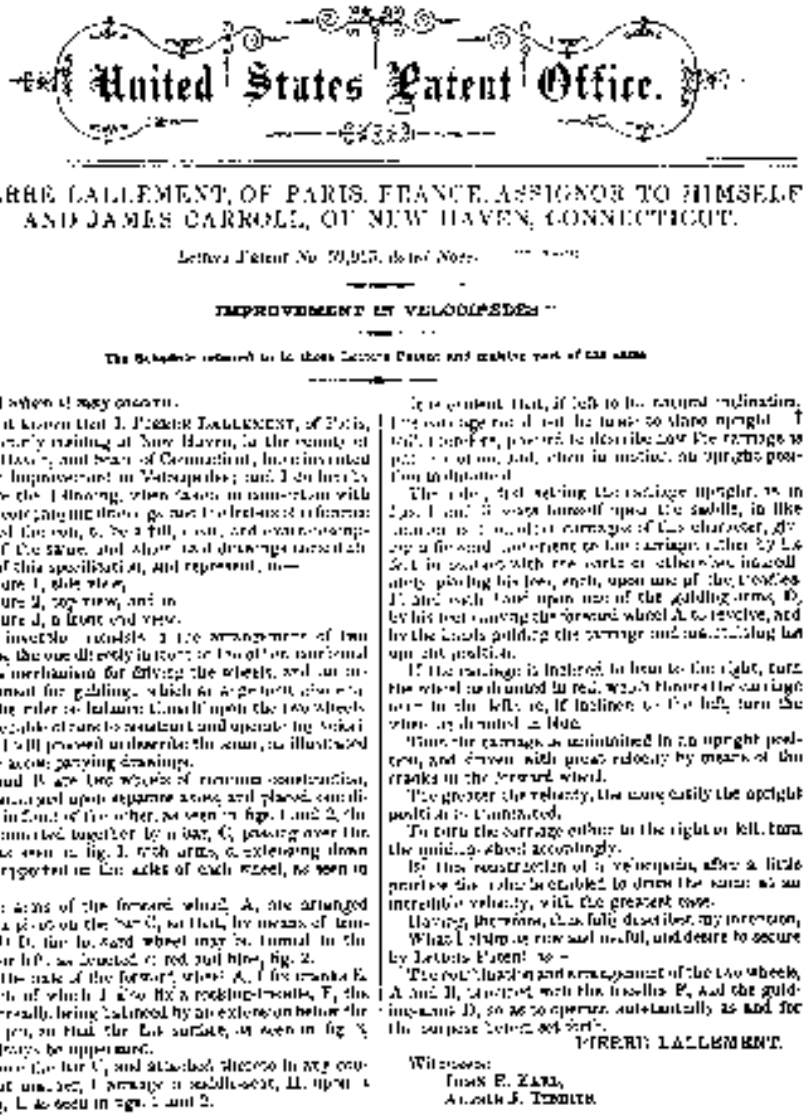




2) Japan vs the rest of the countries:
Japan has a remarkable increase in innovation. The result is that Japan closes the big income gap over 150-year period.

Examples of Famous Patents

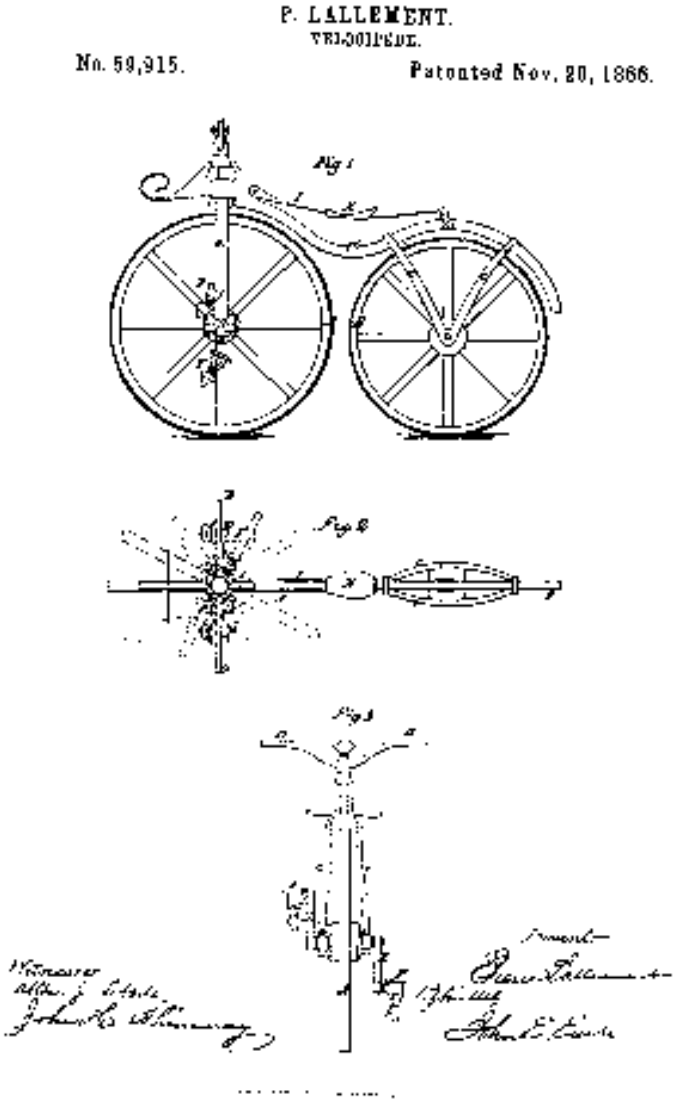
Example #1



United States Patent Office.

PIERRE LALLEMENT, OF PARIS, FRANCE, ASSIGNOR TO HIMSELF AND JAMES CARROLL, OF NEW HAVEN, CONNECTICUT.

IMPROVEMENT IN VELOCIPEDES.



P. LALLEMENT.
VELOCIPEDE.
No. 59,915. Patented Nov. 20, 1866.

Example #2

US005255452A

United States Patent [19]

Jackson et al.

[11] **Patent Number: 5,255,452**

[45] **Date of Patent: Oct. 26, 1993**

[54] **METHOD AND MEANS FOR CREATING ANTI-GRAVITY ILLUSION**

[75] Inventors: **Michael J. Jackson**, Los Angeles; **Michael L. Bush; Dennis Tompkins**, both of Hollywood, Calif.

[73] Assignee: **Triumph International, Inc.**, Los Angeles, Calif.

[21] Appl. No.: **905,479**

[22] Filed: **Jun. 29, 1992**

[51] **Int. Cl.**[5] **A43B 5/00**; A43B 3/00

[52] **U.S. Cl.** **36/113**; 36/1; 36/136; 36/80; 36/132

[58] **Field of Search** 36/1, 80, 103, 113, 36/114, 131, 132, 136; 482/70, 71, 105

[56] **References Cited**

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2,114,790	4/1938	Venables	36/132
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4,882,858	11/1989	Signori	36/131
5,042,173	8/1991	Blizzard et al.	36/113

Primary Examiner—Steven N. Meyers
Assistant Examiner—M. Denise Patterson
Attorney, Agent, or Firm—Drucker & Sommers

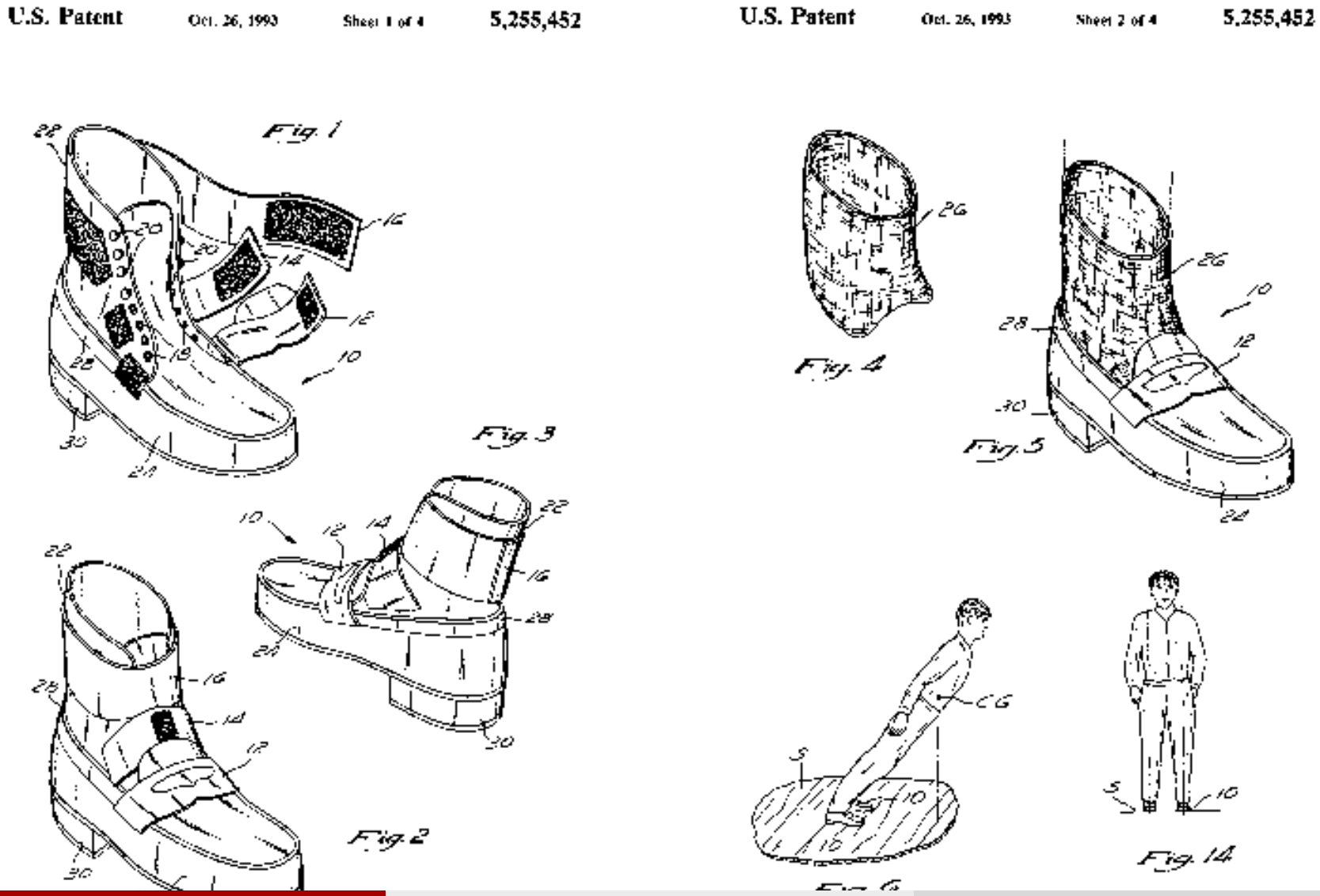
[57] **ABSTRACT**

A system for allowing a shoe wearer to lean forwardly beyond his center of gravity by virtue of wearing a specially designed pair of shoes which will engage with a hitch member movably projectable through a stage surface. The shoes have a specially designed heel slot which can be detachably engaged with the hitch member by simply sliding the shoe wearer's foot forward, thereby engaging with the hitch member.

13 Claims, 4 Drawing Sheets

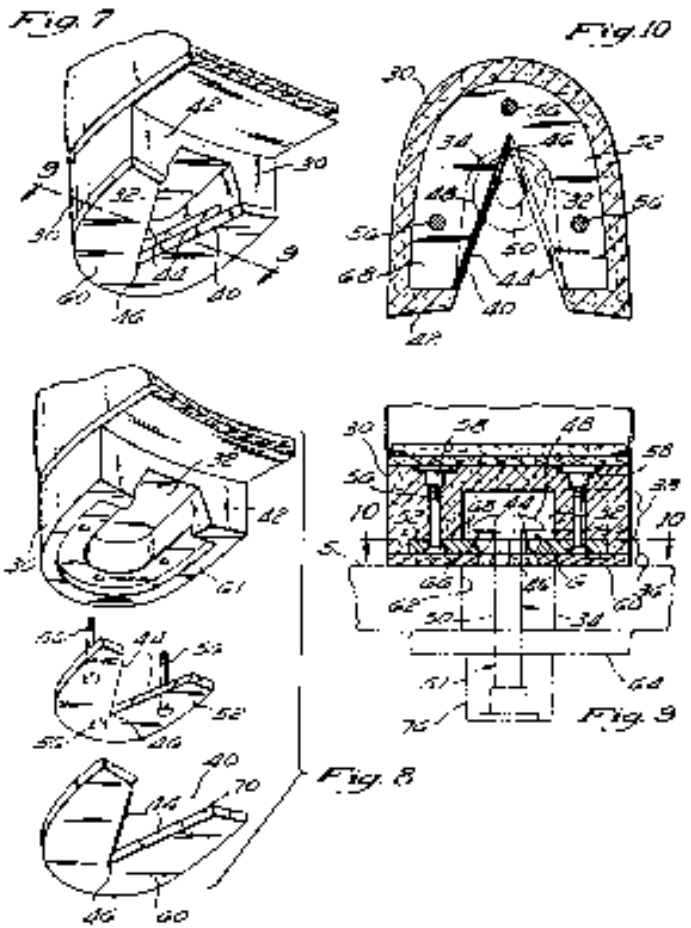
Example #2

Example #2

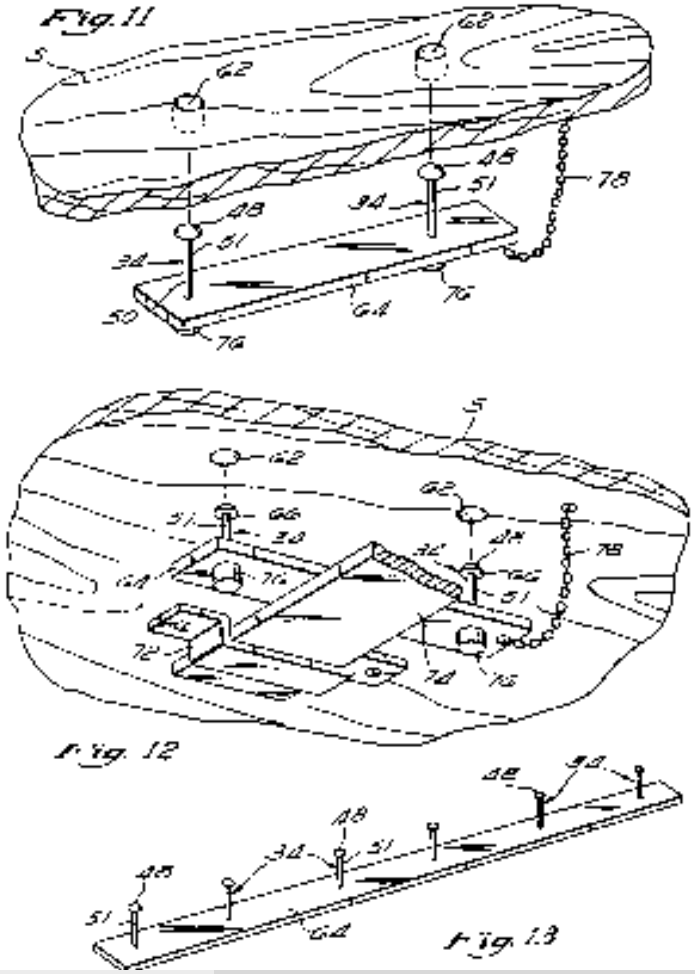

U.S. Patent Oct. 26, 1993 Sheet 1 of 4 5,255,452
U.S. Patent Oct. 26, 1993 Sheet 2 of 4 5,255,452
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 14

Example #2

U.S. Patent Oct. 26, 1993 Sheet 3 of 4 5,255,452



U.S. Patent Oct. 26, 1993 Sheet 4 of 4 5,255,452



Example #3

(12) **United States Patent**
Ording

(10) **Patent No.: US 8,209,606 B2**
(45) **Date of Patent: *Jun. 26, 2012**

(54) **DEVICE, METHOD, AND GRAPHICAL USER INTERFACE FOR LIST SCROLLING ON A TOUCH-SCREEN DISPLAY**

(75) Inventor: **Bas Ording**, San Francisco, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 763 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: 12/270,807

(22) Filed: **Nov. 13, 2008**

(65) **Prior Publication Data**

US 2009/0073194 A1 Mar. 19, 2009

Related U.S. Application Data

(63) Continuation of application No. 11/956,969, filed on Dec. 14, 2007, now Pat. No. 7,464,381.

(60) Provisional application No. 60/937,993, filed on Jun. 29, 2007, provisional application No. 60/946,971, filed on Jun. 28, 2007, provisional application No. 60/945,858, filed on Jun. 22, 2007, provisional application No. 60/879,469, filed on Jan. 8, 2007, provisional application No. 60/883,801, filed on Jan. 7, 2007, provisional application No. 60/879,253, filed on Jan. 7, 2007.

(51) **Int. Cl.**
G06F 3/00 (2006.01)
G06F 3/01 (2006.01)

(52) **U.S. Cl.** 715/700; 715/786; 715/763; 715/784; 345/173; 345/156

(58) **Field of Classification Search** 345/173, 345/180, 156; 715/784, 763, 786, 700
See application file for complete search history.

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(Continued)

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(Continued)

OTHER PUBLICATIONS

Examiner's Amendment dated Oct. 29, 2008, in related U.S. Appl. No. 11/956,969.

(Continued)

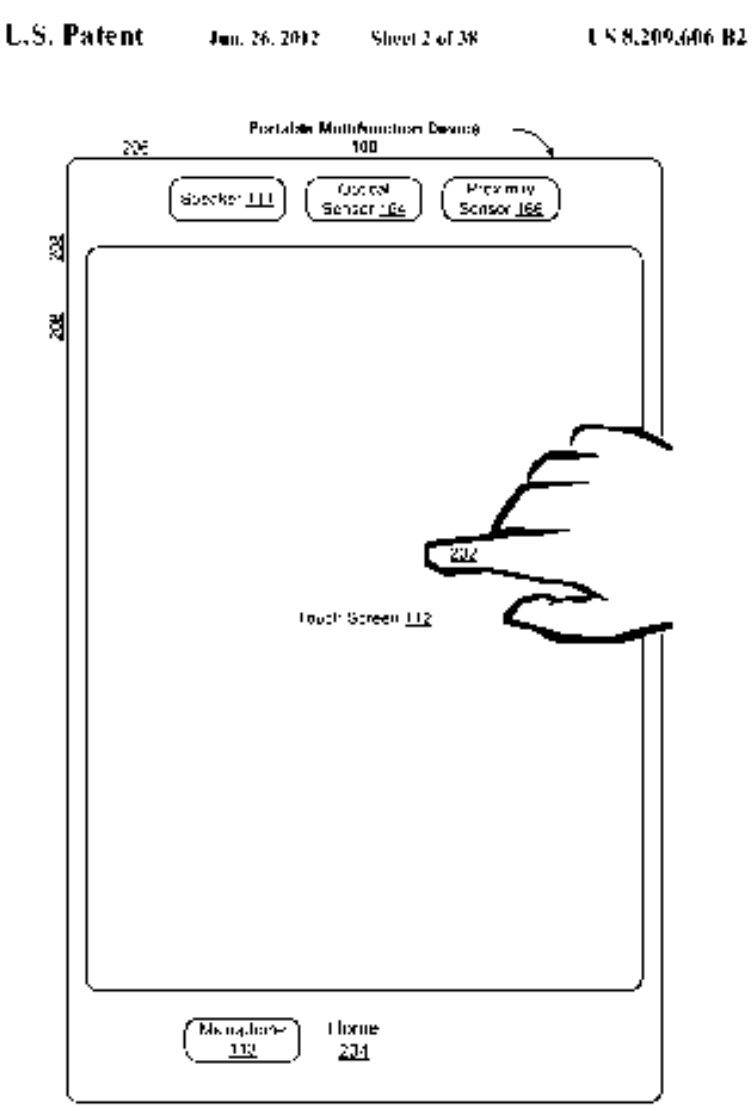
Primary Examiner Mark Rinehart
Assistant Examiner Tuan Vu
(74) *Attorney, Agent, or Firm* Morgan, Lewis & Bockius LLP

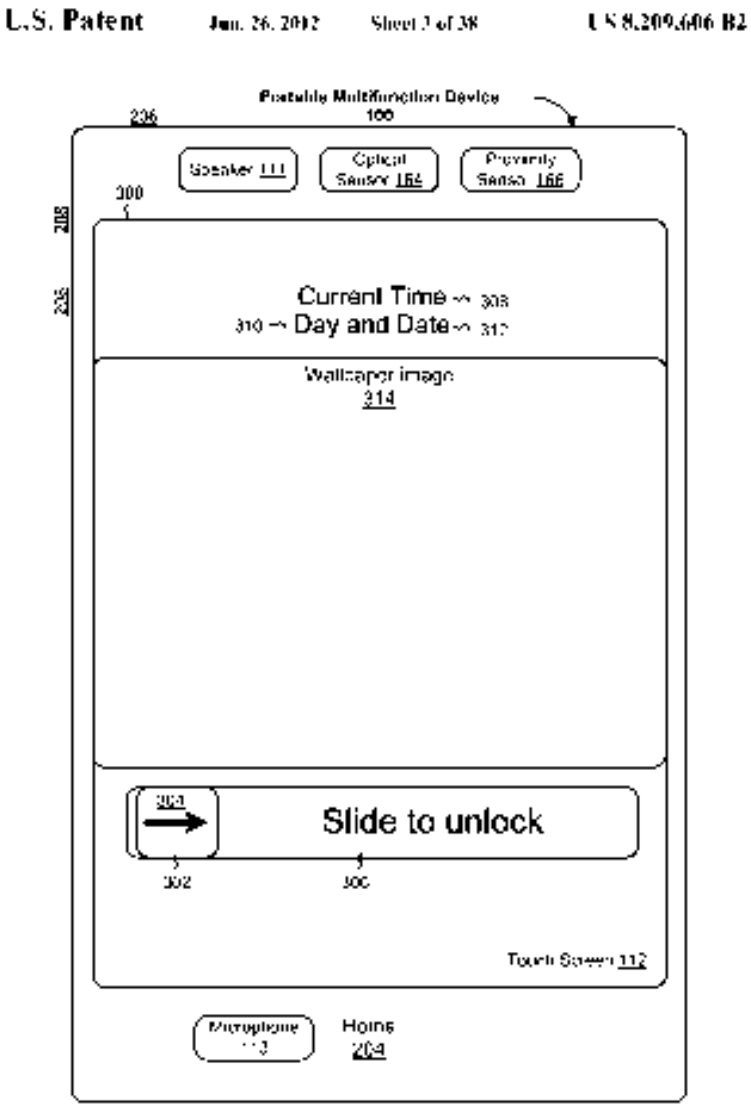
(57) **ABSTRACT**

In accordance with some embodiments, a computer-implemented method for use in conjunction with a device with a touch screen display is disclosed. In the method, a movement of an object on or near the touch screen display is detected. In response to detecting the movement, a list of items displayed on the touch screen display is scrolled in a first direction. If a terminus of the list is reached while scrolling the list in the first direction while the object is still detected on or near the touch screen display, an area beyond the terminus of the list is displayed. In response to detecting that the object is no longer on or near the touch screen display, the list is scrolled in a second direction until the area beyond the terminus of the list is no longer displayed.

21 Claims, 38 Drawing Sheets

Example #3


L.S. Patent
Jun. 26, 2012
Sheet 2 of 38
US 8,209,606 B2
Portable Multifunction Device
100
Touch Screen 112
Home
204
Figure 2


L.S. Patent
Jun. 26, 2012
Sheet 3 of 38
US 8,209,606 B2
Portable Multifunction Device
100
Speaker 111
Current Time
Day and Date
Wallpaper image
314
Slide to unlock
Touch Screen 112
Home
204
Figure 3

Example #4

A.D. 1769 . . . . . N° 913.

Steam Engines, &c.

WATT'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, JAMES WATT, of Glasgow, in Scotland, Merchant, send greeting.

WHEREAS His most Excellent Majesty King George the Third, by His Letters Patent under the Great Seal of Great Britain, bearing date the Fifth day of January, in the ninth year of His said Majesty's reign, did give and grant unto me, the said James Watt, His special licence, full power, sole privilege and authority, that I, the said James Watt, my Heirs, Executors, and Assigns, should and lawfully might, during the term of years therein expressed, use, exercise, and vend, throughout that part of His Majesty's Kingdom of Great Britain called England, the Dominion of Wales, and Town of Berwick upon Tweed, and also in His Majesty's Colonies and Plantations abroad, my "NEW INVENTED METHOD OF LESSENING THE CONSUMPTION OF STEAM AND FUEL IN FIRE ENGINES;" in which said recited Letters Patent is contained a proviso obliging me, the said James Watt, by writing under my hand and seal, to cause a particular description of the nature of the said Invention to be inrolled in His Majesties High Court of Chancery within four calendar months after the date of the said recited Letters Patent, as in and by the said Letters Patent, and the Statute in that behalf made, relation being thereunto respectively had, may more at large appear.

NOW KNOW YE, that in compliance with the said proviso, and in pur-

weights are pressed, but not in the contrary. As the steam vessel moves round it is supplied with steam from the boiler, and that which has performed its office may either be discharged by means of condensers, or into the open air.

Sixthly, I intend in some cases to apply a degree of cold not capable of reducing the steam to water, but of contracting it considerably, so that the engines shall be worked by the alternate expansion and contraction of the steam.

Lastly, instead of using water to render the piston or other parts of the engines air and steam tight, I employ oils, wax, tenacious bodies, fat of animals, quicksilver and other metalls, in their Solid state.

In witness whereof, I have hereunto set my hand and seal, this Twenty-fifth day of April, in the year of our Lord One thousand seven hundred and sixty-nine.

JAMES WATT. (L.S.)

Sealed and delivered in the presence of
COLL. WILKIE.
GEO. JARDINE.
JOHN ROBISON.

Be it remembered, that the said James Watt doth not intend that any thing in the fourth article shall be understood to extend to any engine where the water to be raised enters the steam vessell itself, or any vessell having an open communication with it.

JAMES WATT.

Witnesses,
COLL. WILKIE.
GEO. JARDINE.

AND BE IT REMEMBERED, that on the Twenty-fifth day of April, in the year of our Lord 1769, the aforesaid James Watt came before our said Lord the King in His Chancery, and acknowledged the Specification aforesaid, and all and every thing therein contained and specified, in form above written. And also the Specification aforesaid was stampt according to the tenor of the Statute made in the sixth year of the reign of the late King and Queen William and Mary of England, and so forth.

Inrolled the Twenty-ninth day of April, in the year of our Lord One thousand seven hundred and sixty-nine.

LONDON:

So far we took the existence of the patent system as given.

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Let's step back for a second and ask the following question:

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Let's step back for a second and ask the following question:

How does the patent system affect innovation, growth and welfare?

Supporters:

- Patents promote innovation through the grant of limited monopolies, as a reward to inventors for the time, effort and ingenuity invested in creating new products and processes.
- The potential for financial returns adds an incentive to the traditional rewards of scientific innovation, such as academic recognition and promotion within research institutions.
- Without the incentive provided by patents, private investors may be reluctant to invest, resulting in greater calls on government funding or a failure to develop and exploit new technology.

Opponents:

- Boldrin and Levine (2005) argues that innovations can perfectly take place in absence of what they call "intellectual monopoly".
- Their idea behind this possibility is that the first mover advantage in the market of an innovator preserves a certain amount of profits even when entry of imitators is free, and this Stackelberg advantage can be sufficient to promote innovation.
- Hence, no need for additional static distortions.
- In addition patent are used for strategic purposes:
  - Blocking patents: A patent relating to a particular area of technology which prevents another patent from being used because the other patent relies on technology covered by the first.

Boldrin and Levine (2005)

Boldrin and Levine (2005)

Boldrin and Levine (2004, p. 348-350) argue that *by choosing to patent that invention in 1769, Watt ultimately "set back the industrial revolution by a decade or two"*.

- Conclusion: Lack of empirical evidence makes it hard to judge!
- What I will argue next is that we can use patent citations to understand the benefits and bottlenecks of the innovation process better.

Patent Value and Citations: Creative Destruction or Defensive Disruption?

Introduction

- Understanding the (private and social) value of innovation is a crucial input for growth policy.
- Patent is by far the best proxy for innovation.
- How to quantify patent value?
- The most common measure: Citations

Research Questions

- What is the empirical link between patent value and citations?
  - The answer requires good data.
- What is the economic meaning of citations?
  - The answer requires a good theoretical framework.

Existing Studies on Patent Valuation & Citations

- Patent value proxies vs patent citations:
  - Trajtenberg (1990)
    - Individual patent specific social value for Computed Tomography Scanners.
  - Hall, Jaffe and Trajtenberg (2005)
    - Stock market value
  - Harhoff, Scherer and Vopel (1999, 2003), Gambardella, Harhoff and Verspagen (2005)
    - Survey of inventors.
  - Bessen (2008)
    - Patent renewals (decision to pay the annual renewal fee).

Contribution #1: New Data

- First Data Available with:

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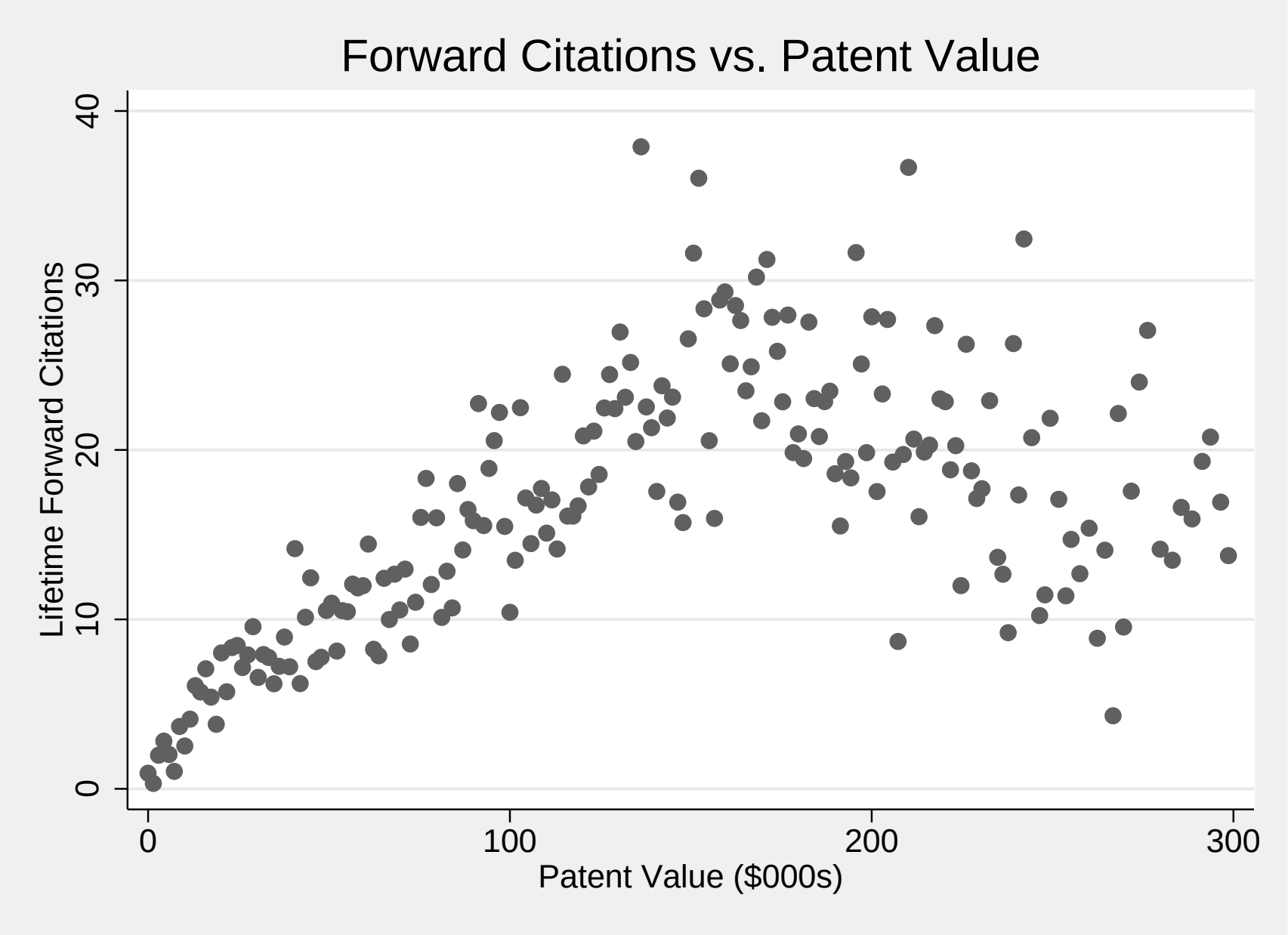
  - Large N: tens of thousands of patents from NPEs
  - Many Technology Classes (248 USPTO class codes)... and
  - Actual Patent-Specific Revenues


Forward Citations vs. Patent Value
Lifetime Forward Citations
0
10
20
30
40
0
100
200
300
Patent Value ($000s)

Contribution #2: New Theory

- What underlying economic behavior can explain this finding?
- We propose a new theoretical framework.
- 2 standard roles of patents:
  - productive patents: generate spillovers
  - defensive patents: defend incumbent's territory, extract non-productive rents.
- These two types of patents combine to generate the inverted-U.

Theoretical Model

Model

- Continuous time, quality ladder model.
- A unique final good C_t is produced using a continuum of intermediates

$$C_t = \exp \int_0^1 \ln c_{jt} dj, \tag{1}$$

- This production function generates a unit elastic demand for each variety:

$$c_{jt} = \frac{C_t}{p_{jt}} \tag{2}$$

Model

- Intermediate good (c_{jt}) production function

$$c_{jt} = q_{jt} l_{jt}$$

- q_{jt} : productivity in product line j at time t,
  l_{jt} : labor.

- Hence the marginal cost of production is

$$M_{jt} = \frac{w_t}{q_{jt}}$$

- Productivity q_{jt} improves through innovations.

- With each innovation comes a patent that makes the owner a monopolist over that technology.

Model

- Firms with different technologies in j compete à la Bertrand.
  - Unit elastic demand + Bertrand $\Longrightarrow$ limit pricing!
- The price to be charged by the most recent monopolist n is simply:

$$p_{j,n} = \frac{w_t}{q_{j,n-1}}.$$

- Hence the profit is

$$\begin{aligned} \pi_t\left(q_{j,n}\right) &= \left[p_{j,n} - M_{j,n}\right] c_{j,n} \\ &= \left[p_{j,n} - \frac{w_t}{q_{j,n}}\right] \frac{C_t}{p_{j,n}} \\ &= \left[1 - \frac{q_{j,n-1}}{q_{j,n}}\right] C_t \end{aligned}$$

Model

- Define the technology gap between the latest monopolist n and the previous incumbent $n-1$ by

$$1+\eta_{j,n} \equiv \frac{q_{j,n}}{q_{j,n-1}}$$

- Normalized profits depend mainly on the technology gap:

$$\pi\left(\eta_{j,n}\right) = \frac{\eta_{j,n}}{\eta_{j,n}+1}$$

Productive Innovations

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Productive Innovations

- Entrants invest in productive innovations that come in two types:
  1. *radical innovations* at the rate z_0,
  2. *follow-on innovations* at the rate z_n
- Resulting innovation sizes:

$$\eta_n = \begin{cases} \eta \text{ if radical innovation} \\ \eta\alpha^n \text{ if follow-on innovation} \end{cases}.$$

where $\alpha \in (0,1)$.

Productive Innovations

- The normalized value of the nth innovation is:

$$v_{nt} = \frac{\eta_n}{1+\eta_n}\Delta t + (1 - r\Delta t)\left[\begin{array}{c} (z_0\Delta t + z_{n+1}\Delta t) \times 0 \\ \\ + (1 - z_0\Delta t - z_{n+1}\Delta t)\, v_{nt+\Delta t} \end{array}\right].$$

Productive Innovations

- The normalized value of the nth innovation is:

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Lemma

The normalized value of the nth follow-on innovation at time t is equal to

$$v_n \equiv \frac{V_{nt}}{C_t} = \frac{\pi_n}{\rho + \bar{z}_{n+1} + \bar{z}_0} \tag{3}$$

where $\pi_n \equiv \frac{\eta_n}{1+\eta_n}$.

- New entrants invest in
  - productive radical innovations

$$\max_{z_0} \{z_0 v_0 - C(z_0)\}$$

  - or productive follow-on innovations

$$\max_{z_{n+1}} \{z_{n+1} v_{n+1} - C(z_{n+1})\}$$

$C(z_.)$: cost of innovation.

Productive Innovations

$$\underbrace{\frac{\eta}{P_1}\,\frac{\eta\alpha}{P_2}\,\frac{\eta\alpha^2}{P_3}\,\frac{\eta\alpha^3}{P_4}}_{\text{Tech Cluster 1}} \;\Big|\; \underbrace{\frac{\eta}{P_5}\,\frac{\eta\alpha}{P_6}}_{\text{Tech Cluster 2}} \;\Big|\; \underbrace{\frac{\eta}{P_7}\,\frac{\eta\alpha}{P_8}\,\frac{\eta\alpha^2}{P_9}}_{\text{Tech Cluster 3}} \;\Big|\; \underbrace{\frac{\eta}{P_{10}}\cdots}_{\text{Tech Cluster 4}}$$

AN EXAMPLE OF A SEQUENCE OF INNOVATIONS IN A PRODUCT LINE

Cited	**Citing**	**Cited**	**Citing**
P_1 :	P_2, P_3, P_4	P_6 :	*none*
P_2 :	P_3, P_4	P_7 :	P_8, P_9
P_3 :	P_4	P_8 :	P_9
P_4 :	*none*	P_9 :	*none*
P_5 :	P_6	P_{10} :	...

Productive Innovations

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Proposition

The average number of forward citations received by an η_n patent during any time interval $[t_1, t_2]$ decreases in n.

Productive Innovations

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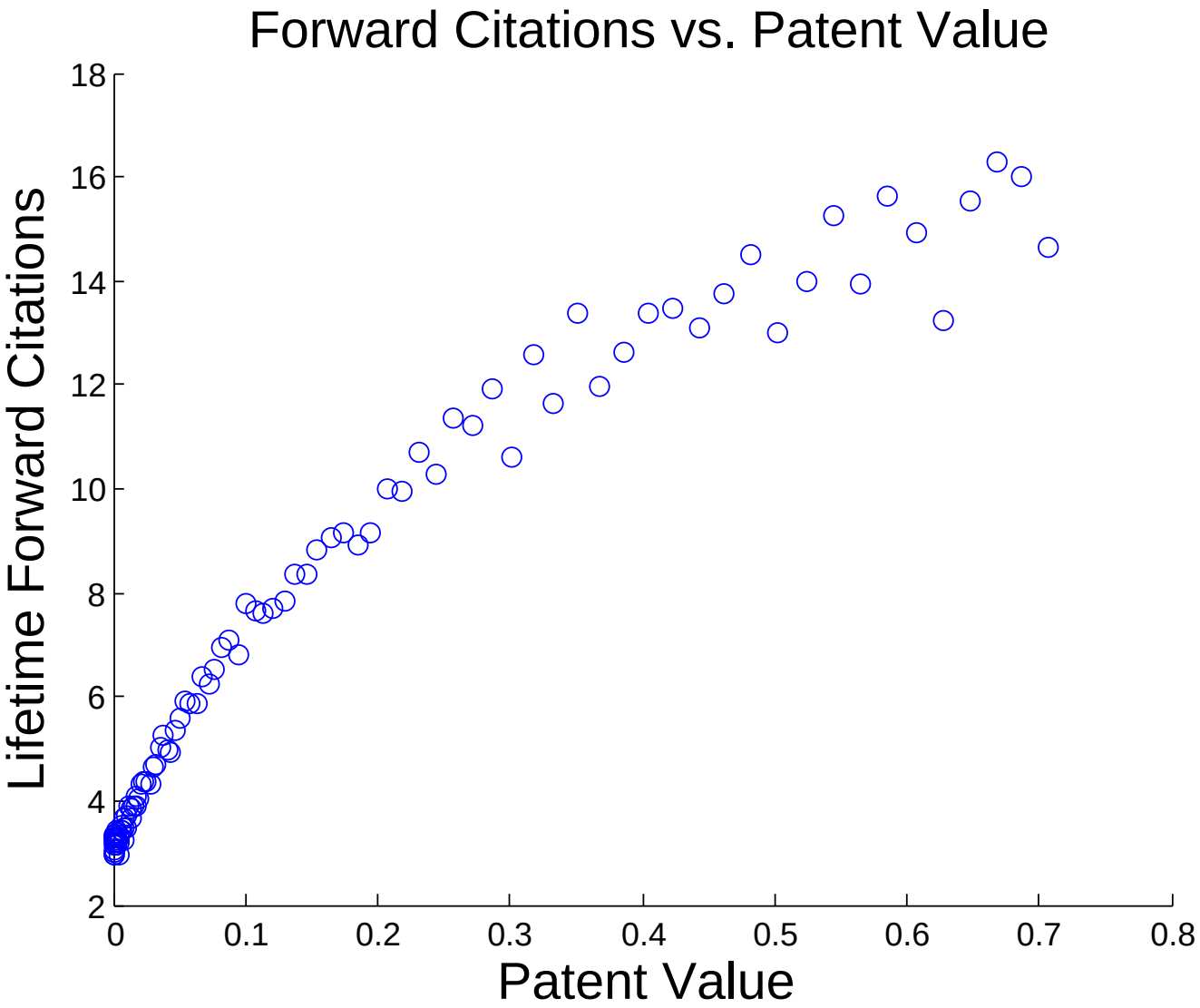
Corollary

Hence, in the case of productive patents, patent value and forward citations are ***positively correlated****.*

Productive Innovations



Defensive Innovations

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Defensive Innovations

- Firms do defensive patenting to make the life harder for subsequent inventors
- Incumbents can pay a fixed cost $\psi > 0$ and produce a defensive patent to protect an earlier productive patent
  - Fixed cost implies that you want to protect only the high value productive patents.
- A defensive patent increases the cost of innovation for subsequent innovators by a random factor $m > 1$:

$$\max_{z_n} \{z_n v_n - mC(z_n)\}.$$

Defensive Innovations

Defensive Innovations

Proposition

The value of defended patents increases in m.

Defensive Innovations

Proposition

The value of defended patents increases in m.

Proposition

The entry rate (forward citations) decreases in m.

Defensive Innovations

Proposition

The value of defended patents increases in m.

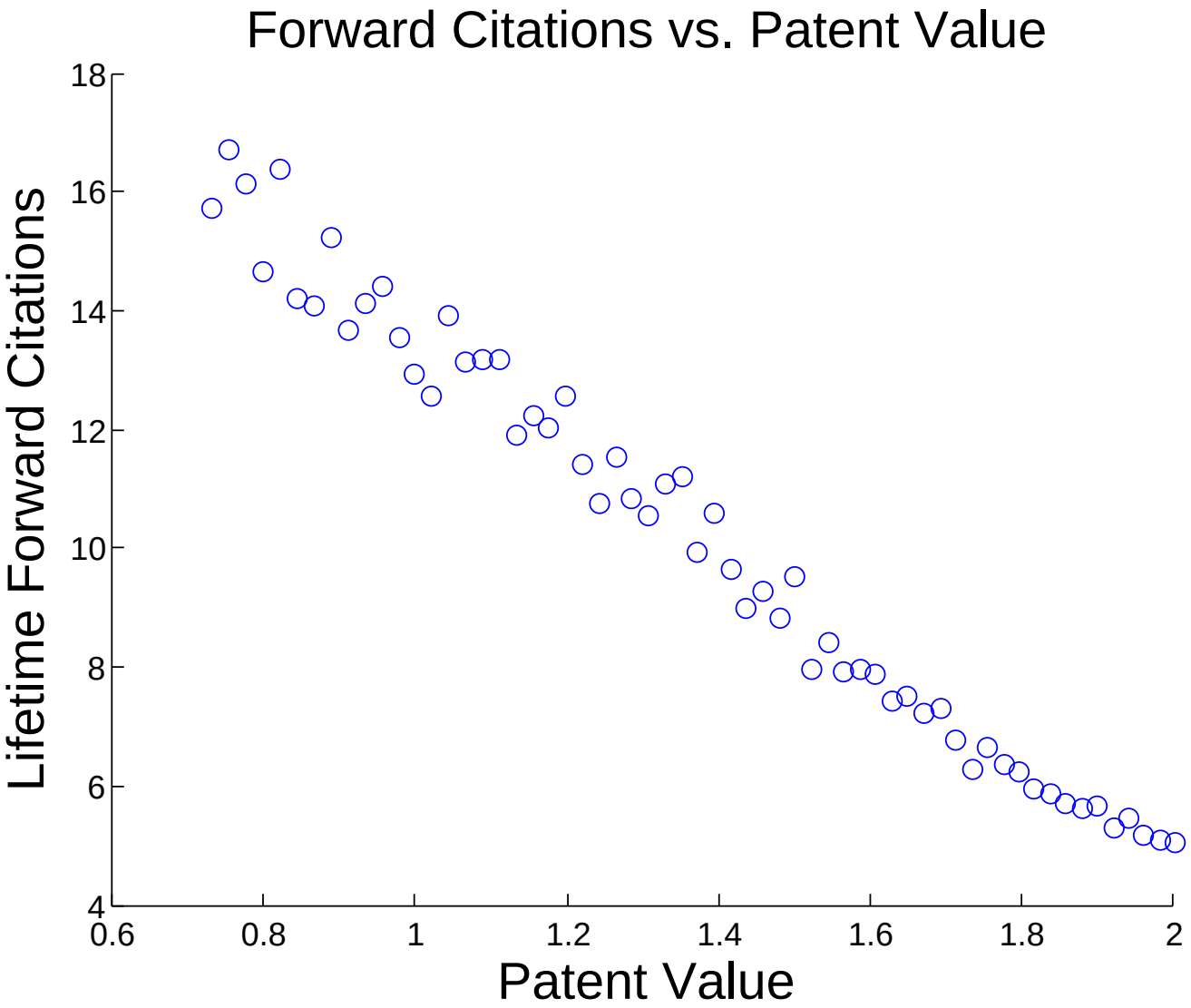
Proposition

The entry rate (forward citations) decreases in m.

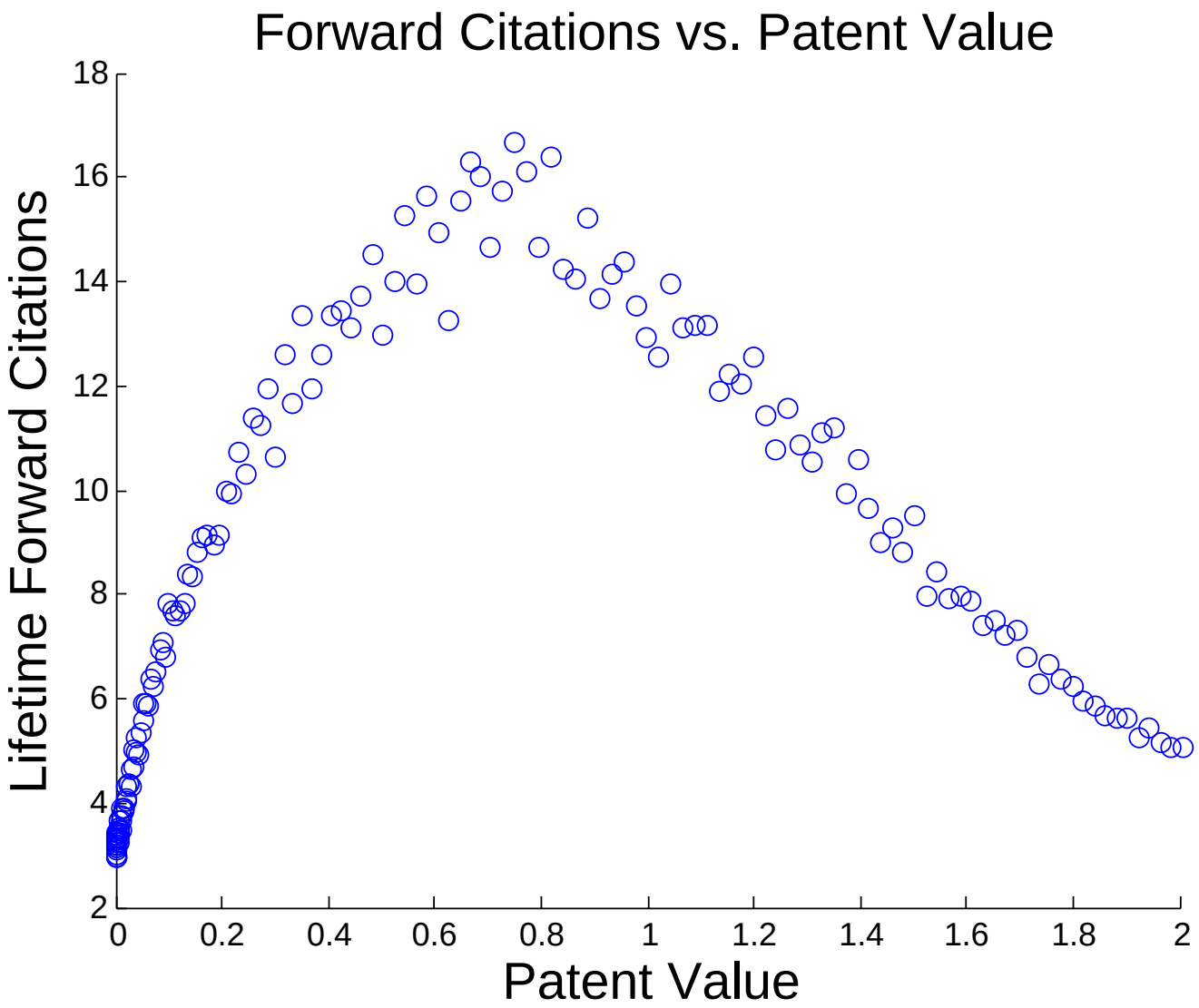
Corollary

Hence, in the case of defensive innovations, patent value and forward citations are ***negatively correlated****.*

Defensive Innovations



Productive+Defensive Innovations = Inverted-U



Model Summary

- Radical productive patents generate high market value and attract subsequent entry through spillovers.
  - Initial positive link between value and citations
- Above a certain value threshold, incumbents find it worthwhile to pay the fixed cost and produce defensive patents to prevent entry.
  - High value implies less subsequent entry and fewer citations, i.e., a negative relationship.
- Overall, an inverted-U relationship between patent value and citations.

Empirical Results

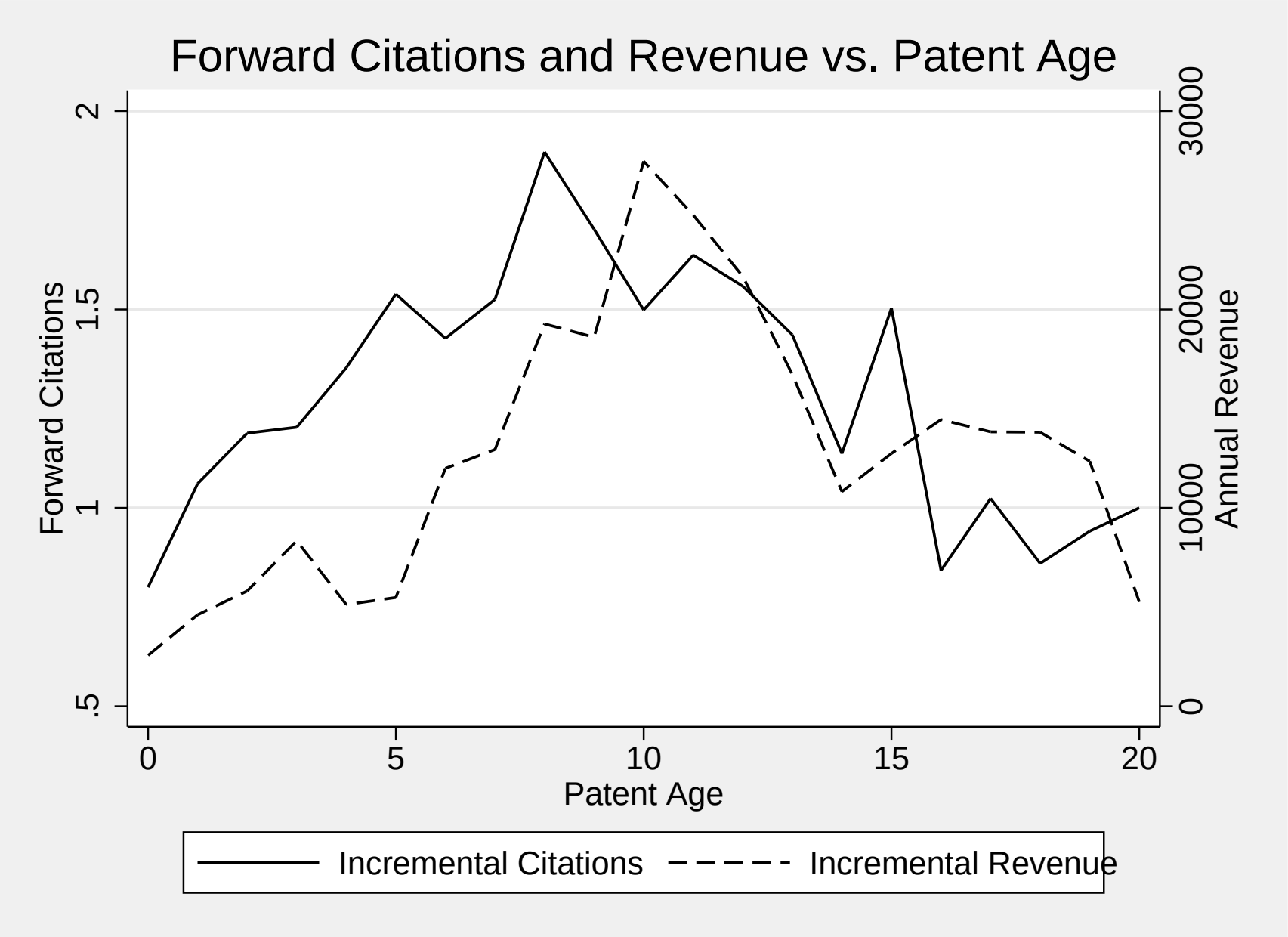
Data Details

- Confidentiality agreements put some limits on what we can disclose.
- We cannot identify the data sources, nor the exact level of revenues.
- But we can report a lot of information about the data set:
  - Tens of thousands of patents
  - Revenues are derived almost exclusively from licensing deals
  - Patent-year-licensee level annual revenues between 2007-2012 which we aggregate to the patent-year level

Summary Statistics

	Mean	Standard Deviation	Median
Patent Value ($000s)	204.2	1904.7	52.19
Lifetime Forward Citations	13.4	38.4	0.0
Backward Citations	23.1	60.3	8.0
Fraction of Backward Cites in Past 3 Years	0.20	0.30	0.00
Fraction of Backward Cites in Past 5 Years	0.28	0.37	0.00
Original Indicator	0.84	0.36	1.00
Application Year	1999	4.7	2000
Individual Inventor Indicator	0.14	0.35	1.00

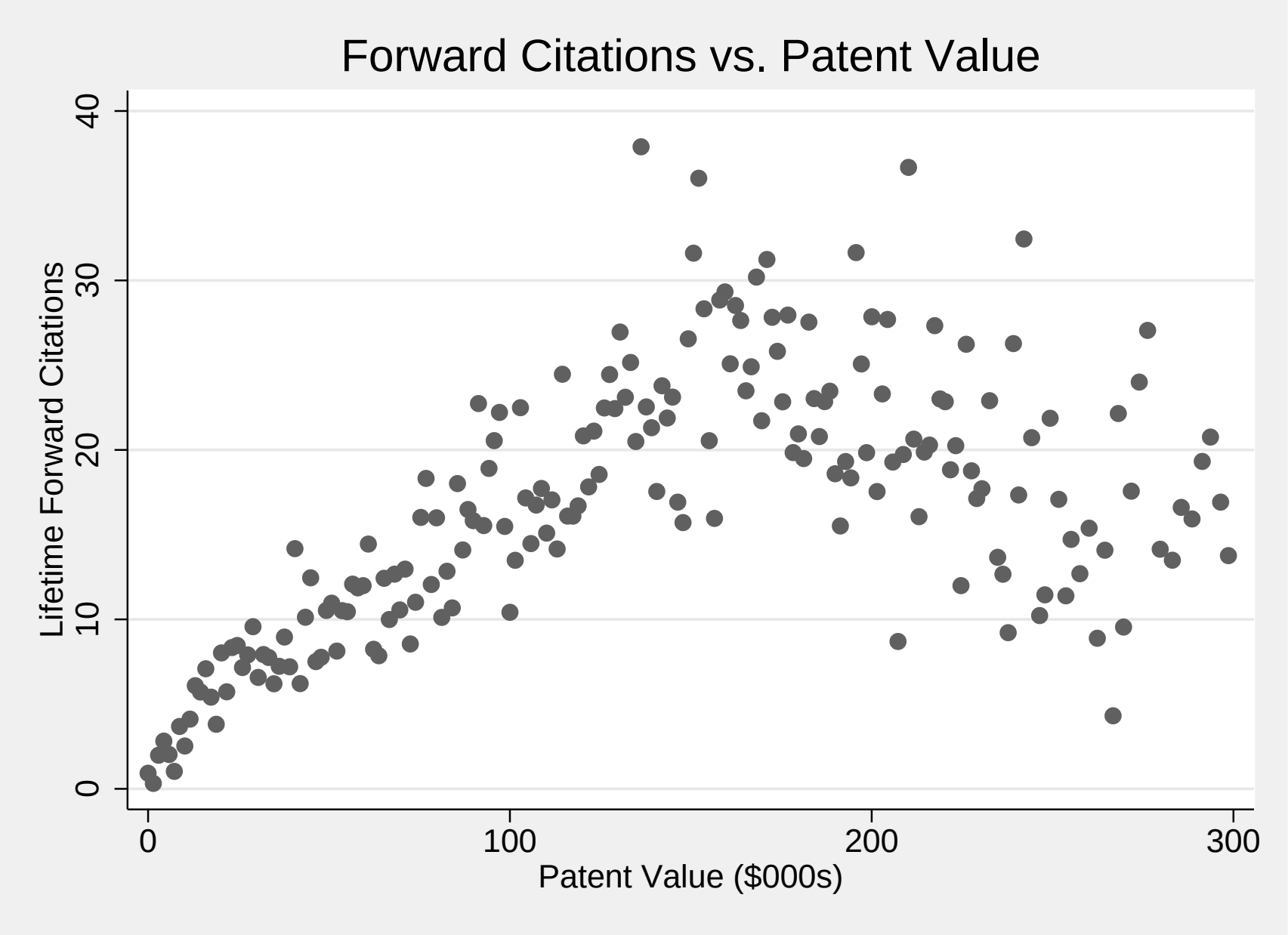
Note: Data is normalized so that the mean annual revenue is $10,000 (2010$). Original patent applications are those which are not divisionals or continuations.


Forward Citations and Revenue vs. Patent Age
Forward Citations
.5
1
1.5
2
Annual Revenue
0
10000
20000
30000
0
5
10
15
20
Patent Age
Incremental Citations
Incremental Revenue

Value and Forward Citations by Technology

Technology	Patent Value	Lifetime Forward Citations
Circuits	$367,130	7.1
Computer Architecture	$283,773	6.0
Internet & Software	$273,093	12.6
Wireless Communications	$174,605	35.4
Network Communications	$146,974	9.4
Semiconductor Devices	$115,824	7.8
Peripheral Devices	$99,801	8.1
Electro-Mechanical	$62,018	7.4
MEMS & Nano	$58,860	11.1
Optical Networking	$56,425	16.5

Note: Data is normalized so that the mean annual revenue is $10,000 (2010$).


Forward Citations vs. Patent Value
Lifetime Forward Citations
0
10
20
30
40
0
100
200
300
Patent Value ($000s)

Forward Citations and Patent Value

	Share of most valuable patents excluded					
	10%		5%		1%	
Patent Value ($100,000s)	9.047**	22.497**	7.104**	14.402**	6.961**	8.016**
	(0.256)	(0.654)	(0.232)	(0.566)	(0.246)	(0.432)
Patent Value Squared		-6.036**		-2.193**		-0.139*
		(0.288)		(0.195)		(0.070)
R^2	0.04	0.05	0.04	0.05	0.09	0.09

** Significant at the 1% level; * Significant at the 5% level
Note: Separate regressions reported in each column, with standard errors in parentheses. Dependent variable is lifetime forward citations. Data is normalized so that the mean annual revenue is $10,000 (2010$). Regression excludes indicated top percent of patents by value.

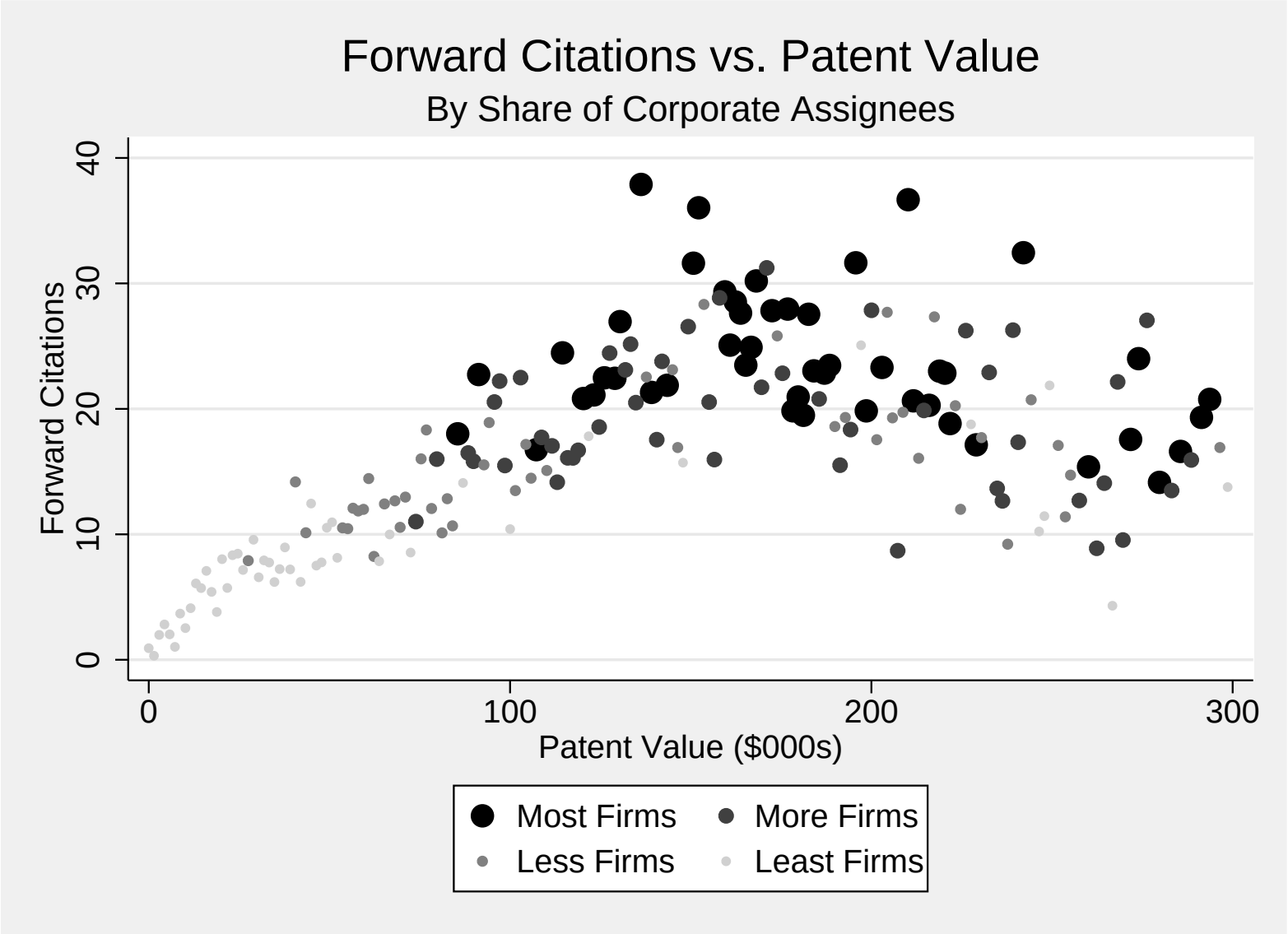
Forward Citations and Patent Value

- The inverted-U supports the theory of productive and defensive patenting.
- But further evidence is needed. We test 5 predictions of the theory.

Prediction 1

- **Theory:** The cost to attempt a defensive innovation is more easily borne by larger entities
- **Prediction 1:** Large-entities are more likely to employ defensive patenting than individuals and small-entities

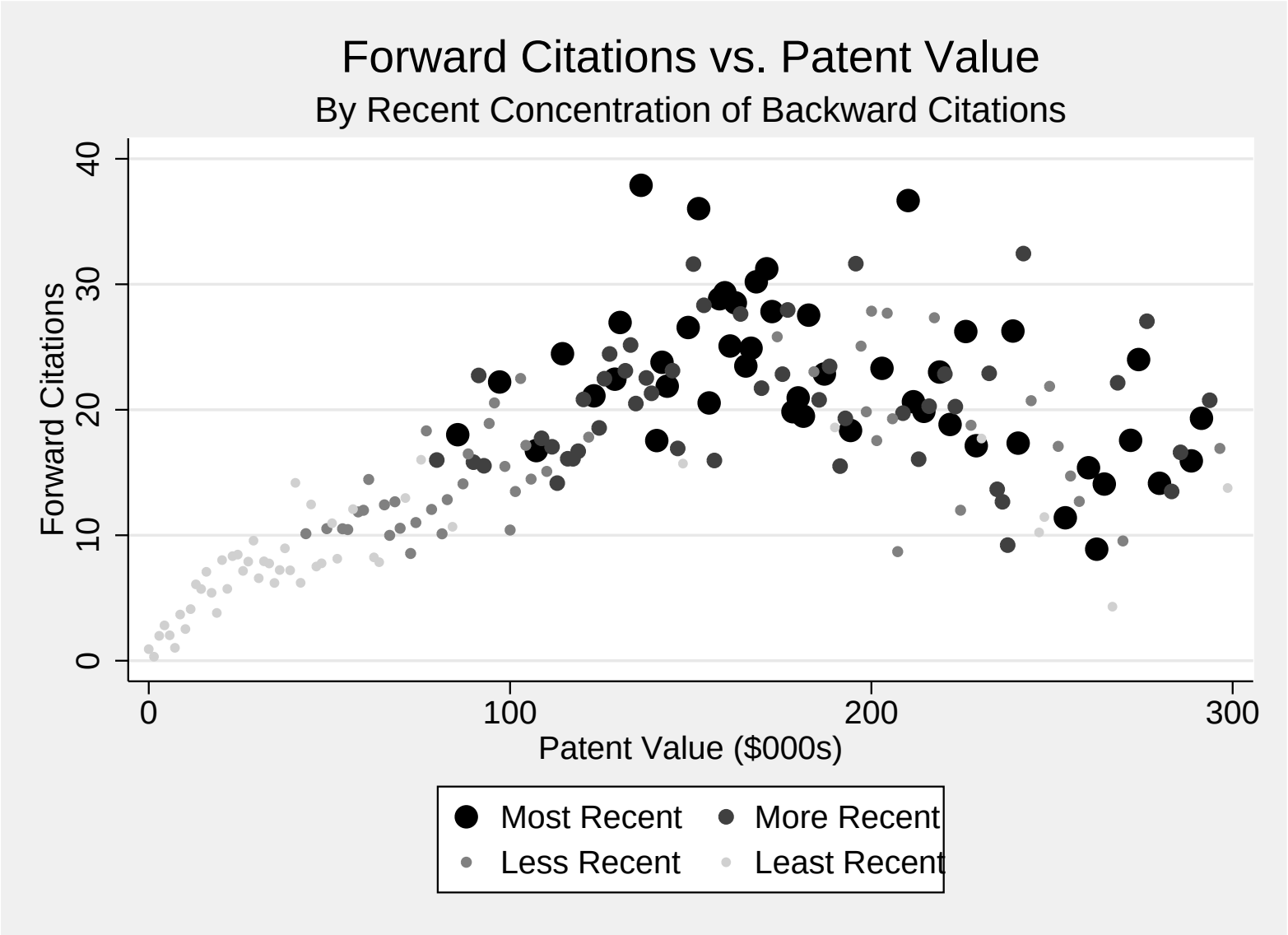
Testing Prediction 1



Prediction 2

- **Theory:** Greater profits are available in fields of rapid growth.
- **Prediction 2:** Defensive patenting will be more common when backward citations are concentrated in recent years.

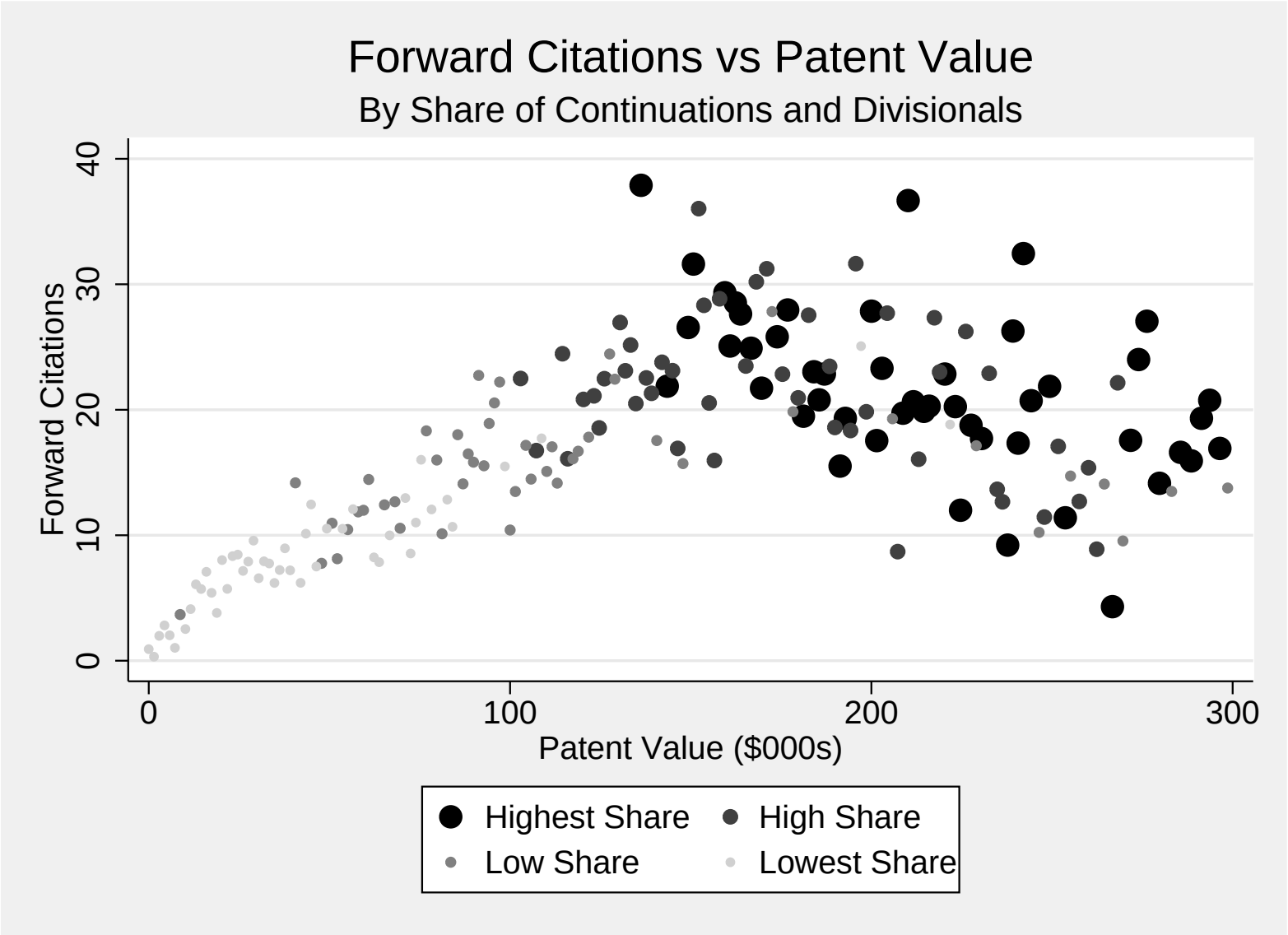
Testing Prediction 2



Prediction 3

- **Theory:** More sophisticated and costly patenting strategies should be more prevalent for defensive innovations.
- **Prediction 3:** Divisional and Continuation patents will be more commonly used for defensive purposes.

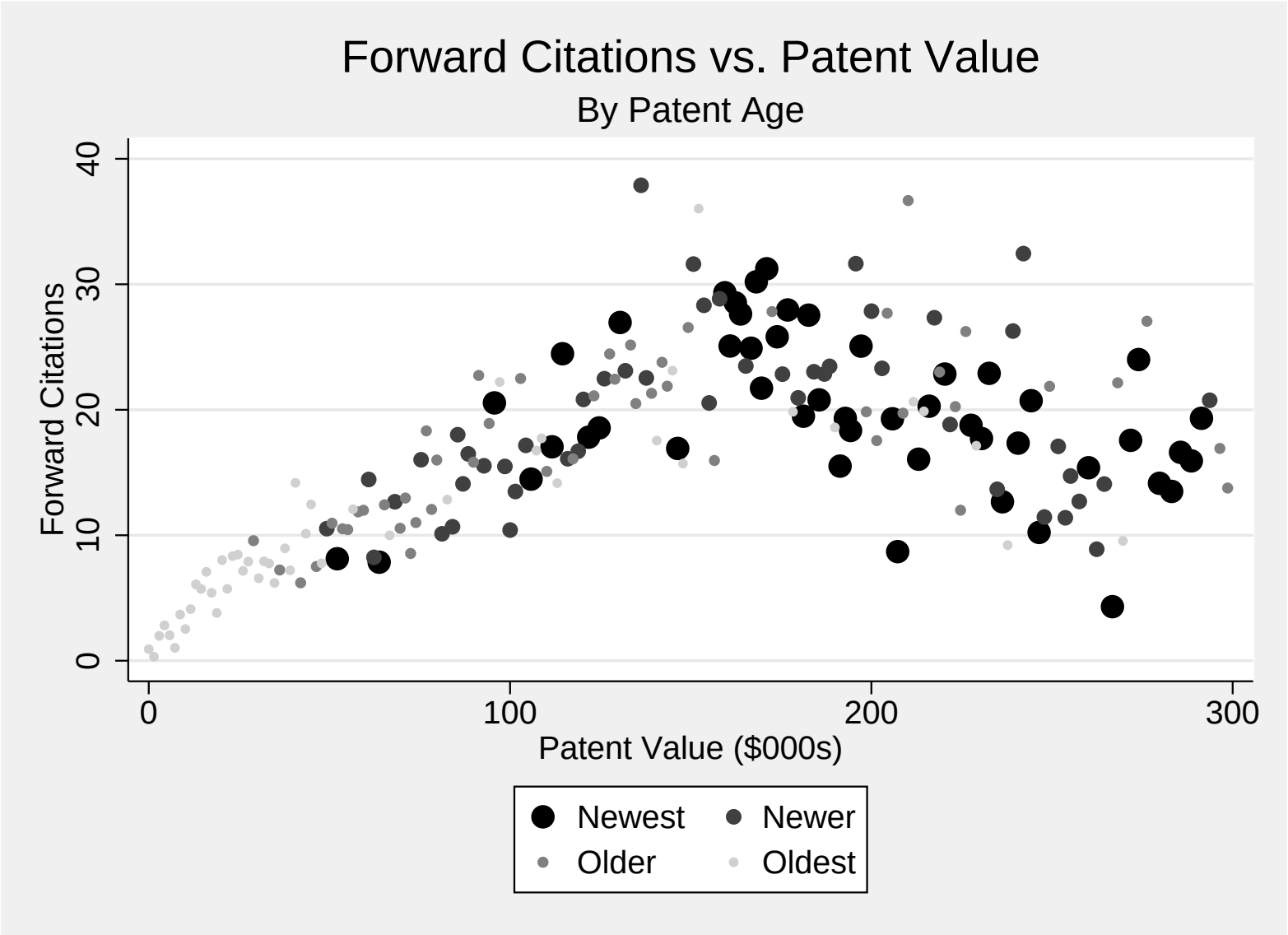
Testing Prediction 3



Prediction 4

- **Theory:** Defensive innovation is increasing in the level of returns.
- **Prediction 4:** Newer patents will comprise a larger share of defensive patents due to the increase in value over time.

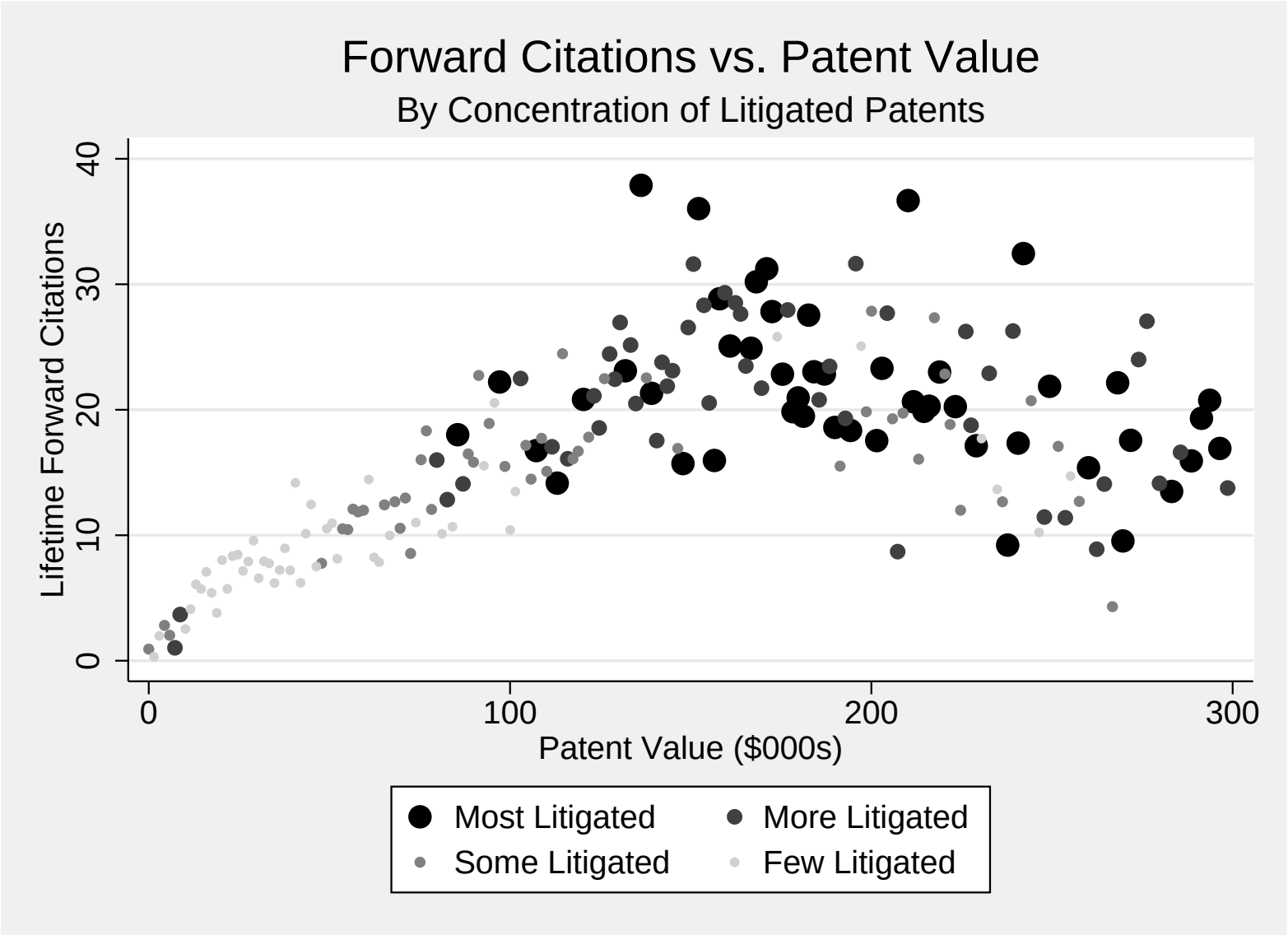
Testing Prediction 4



Prediction 5

- **Theory:** Defensive innovation is more likely to result in confrontation.
- **Prediction 5:** Litigated patents should comprise a larger share of defensive patents.

Testing Prediction 5



Inverted-U Robust Across Technologies

	Circuits	Computer Architecture	Electro-Mechanical	Internet & Software	MEMS & Nano
Patent Value ($100,000s)	6.233	14.497	10.917	23.542	17.051
	(6.89)**	(11.28)**	(6.60)**	(10.95)**	(4.75)**
Patent Value Squared	-0.777	-2.212	-2.341	-3.184	-4.325
	(3.18)**	(6.27)**	(3.93)**	(4.39)**	(3.80)**
R^2	0.05	0.09	0.04	0.05	0.06

	Networking Communication	Optical Networking	Peripheral Devices	Semiconductors	Wireless Communications
Patent Value ($100,000s)	19.107	13.496	9.847	9.329	18.007
	(8.64)**	(11.43)**	(14.64)**	(9.60)**	(12.04)**
Patent Value Squared	-2.328	-2.114	-2.355	-1.020	-3.292
	(2.90)**	(4.57)**	(11.09)**	(3.01)**	(5.91)**
R^2	0.08	0.07	0.02	0.06	0.07

** Significant at the 1% level; * Significant at the 5% level

Note: Separate regressions reported in each column, t-statistics in parentheses. Dependent variable is lifetime forward citations. Data is normalized so that the mean annual revenue is $10,000 (2010$).

Conclusion

- This new data on direct licensing revenues confirms the positive correlation between patent value and citations. However it also indicates that the relationship is more complex.
- The citation-value relationship has an inverted-U shape.
- The theoretical model and data provide strong evidence for the strategic use of patents, a topic of great recent interest.
- While these results may not generalize to all USPTO patents, the sample's extensive coverage of technology patents should help illuminate major policy discussions.

Young, Restless and Creative: Openness to Disruption and Creative Innovations

Daron Acemoglu[†] Ufuk Akcigit[‡] Murat Alp Celik[§]

Creative Innovations

- More than half a million patents per year granted by the USPTO but only a handful of those are truly transformative.
- E.g., in drugs and medical inventions, 223,452 patents between the years 1975 and 2001, but the median number of citations to these patents within the next five years was **four** (and with limited impact on the technology of the field).
- But the patent for "systems and methods for selective electrosurgical treatment of body structures" by the ArthroCare Corporation received many more citations and has been transformative for surgical procedures.
- Similarly, Amazon's patent for "method and system for placing a purchase order via a communications network" (263 citations within the next five years) was a game changer for online business.

Creative Innovations

- More interestingly, the average age of top managers
  - at ArthroCare Corporation was 41 at the time, and
  - only 33 at Amazon.
- The average manager age among all Compustat companies is 54.84.

This Paper

- Building on the Schumpeter (1934), we argue that a key determinant of creating innovations is a society's or an organization's openness to disruption—openness to new new ideas, innovations and practices and tolerance to disruptive or even rebellious behavior.
- Captured by Facebook's inscription on its headquarter walls:

  "move fast and break things."

- Such openness is a function of a company's "corporate culture," also influenced by society-wide institutions and policies and perhaps social norms ("national culture").

Cross-Country Motivation

- In cross-country data, we can look at various different measures to capture these ideas.
  1. Individualism:
     - Edmund Burke: individualism as the cause for the community to "crumble away, be disconnected into the dust and powder of individuality".
     - Alexis de Tocqueville: individualism in America resulting from the recognition of individual rights and freedoms and restrained government
     - Hofstede's index of individualism: "preference for a loosely-knit social framework in which individuals are expected to take care of themselves and their immediate family only".
  2. Hofstede's index of uncertainty avoidance.
  3. Our own measure of average age of top managers—as a proxy for an open corporate culture.
  4. Institutional variables, such as rule of law.

Figure 1. Innovation Quality vs Different Proxies for Openness to Disruption

Data Sources

- USPTO Utility Patents Grant Data (PDP)
- Compustat North American Fundamentals - Annual
- Executive Compensation Data (Execucomp)
- The Careers and Co-Authorship Networks of U.S. Patent-Holders
- National Culture Dimensions
- Worldwide Governance Indicators of the World Bank.
- Barro-Lee data set
- World Bank's World Development Indicators database.

Measures of Creative Innovation

- We focus on 4 different measures of "creative innovation" measures:
  1. **Innovation Quality:** average number of claims per patent
  2. **Fraction of superstars**: fraction very highly cited patents.
  3. **Tail innovations**: citations at the tail vs. median

     $$Tail\_innv = V_{ct}(p,q) \equiv \frac{s_{ct}(p)}{s_{ct}(q)}$$

     where $s_{ct}(p)$ is the fraction of patents that are above the pth percentile of the year t distribution that are from country c, and we take $p = 99$ and $q = 50$.
  4. **Diversity of innovation**: how much does innovation follow existing paths.

Creative Innovation Variables: Diversity of Innovations

- Diversity of Innovations:
  - Let $i = 1, 2, ...I$ denote a technology class and $s_{ij} \in (0, 1)$ denote the share of backward citations of patent j given to patents in technology class i ($\sum_{i=1}^{I} s_{ij} = 1$).
  - Then *distance* from the previous generation patents:

$$d_j = \frac{1}{\|\mathcal{J}_j\|} \sum_{j' \in \mathcal{J}_j} \frac{1}{I} \sum_{i=1}^{I} \left(s_{ij} - s_{ij'} \right)^2$$

    where $\mathcal{J}_j$ is the set of all patents cited by j.
  - **Our measure**: average distance of all patents from firm f or country c in year t:

$$Diversity\_innv = d_{ct} = \frac{1}{J_t} \sum_{j \in c}^{J_t} d_{jt}$$

    (where J_t = the total number of patents from firm f or country c in year t).

Table 3. Baseline Regressions: Cross Country

	Innov Quality	Superstar Frac	Tail Innov	Diversity of Innv
		Panel A: Individualism		
individualism	3.941	4.236	53.895	1.302
	(0.311)	(0.412)	(8.999)	(0.171)
R^2	0.90	0.96	0.94	0.76
		Panel B: Uncertainty Avoidance		
uncertainty avoidance	-4.608	-5.265	-60.749	-1.123
	(0.744)	(0.785)	(14.548)	(0.343)
R^2	0.87	0.96	0.93	0.38
		Panel C: Average Manager Age		
average manager age	-0.266	-0.282	-3.306	-0.078
	(0.032)	(0.055)	(0.960)	(0.018)
R^2	0.89	0.96	0.94	0.58
		Panel D: Rule of Law		
rule of law	8.839	8.059	89.084	2.025
	(2.819)	(4.037)	(49.689)	(1.045)
R^2	0.80	0.92	0.90	0.24

Notes: Weighted OLS regressions. Countries are weighted by their patent counts. Robust standard errors are reported in parantheses. Regressions in panels A and B have 50, in panel C 37, and in panel D 54 observations. Controls: log GDP per capita, average years of schooling, log patent counts.

Firm-Level Results

- Use average manager age (of top management) as a proxy for a corporate culture or approach more open to disruption.
  - In line with the model: firms targeting radical innovation is more likely to hire younger managers with more up-to-date knowledge base.
  - Only companies with relatively open corporate cultures will allow young managers to rise up the hierarchy.
- Using this variable, firm-level correlations very similar, but much stronger and more precisely estimated, than the cross-country patterns.

Table 5: Baseline Regressions: Firm Level

	Innov Quality	Superstar Frac	Tail Innov	Innov Diversity
average manager age	-0.105	-0.317	-6.432	-0.013
	(0.046)	(0.079)	(1.347)	(0.003)
log employment	-1.560	-1.412	-15.200	-0.115
	(0.448)	(0.758)	(11.095)	(0.041)
log sales	0.677	-0.865	-10.233	0.092
	(0.474)	(0.732)	(10.557)	(0.038)
log patent	0.612	1.878	27.134	0.031
	(0.179)	(0.294)	(4.846)	(0.017)
R^2	0.40	0.40	0.23	0.56
N	6,281	6,281	5,375	6,250

Notes: Controls include four-digit SIC sector dummies. Observations are weighted by the number of patent counts of the firm.

Interpreting Firm-Level Results

- Economically, as well as statistically significant:
- Moving from the 75th percentile of the average management age distribution to the 25th percentile increases:
  - innovation quality by 3.26%,
  - superstar fraction by 26.4%,
  - our measure of tail innovations by 44.7%,
  - our measure of diversity of innovations by 2.93%.

Table 6: Robustness (Alternative Measures)

	Innov Quality (Citations)	Tail Innov (95/50)	Innov Diversity (IPC1)	Superstar Frac (Best Patent)
average manager age	-0.214	-2.136	-0.091	-0.623
	(0.074)	(0.463)	(0.030)	(0.181)
R^2	0.36	0.35	0.51	0.64
N	4,993	5,407	6,250	6,281

Notes: Controls include log employment, log sales, log patent, and four-digit SIC sector dummies. Observations are weighted by the number of patent counts of the firm.

Stock of Knowledge, Opportunity Cost and Creativity of Innovations

- In line with the predictions of the model, greater impact of young managers on creative innovations when:
  - the firm has a larger stock of patents (**stock of knowledge effect**); and
  - the firm has slower sales (**opportunity cost effect**).

Table 8: Stock of Knowledge, Opportunity Cost and Creative Innovations

	Innov Quality	Superstar Frac	Tail Innov	Innov Diversity
average manager age	-0.024	-0.231	-4.266	-0.008
	(0.042)	(0.070)	(1.169)	(0.004)
log patent	0.382	1.544	20.413	0.013
	(0.122)	(0.267)	(4.332)	(0.018)
log sales	0.902	-0.536	-3.942	0.110
	(0.373)	(0.709)	(10.084)	(0.036)
average manager age × log patent counts	-0.116	-0.175	-3.295	-0.010
	(0.028)	(0.035)	(0.732)	(0.002)
average manager age × log sales	0.151	0.174	4.073	0.010
	(0.026)	(0.042)	(0.876)	(0.003)
R^2	0.41	0.41	0.25	0.57
N	6,281	6,281	5,375	6,250

Notes: Controls include four-digit SIC sector dummies. Observations are weighted by the number of patent counts of the firm.

Conclusion

- Extending the Schumpeterian approach to innovation by bringing in social incentives and openness to disruption in modeling creativity of innovations.
- First step in thinking about a broader set of incentives for innovation (and perhaps opening the black box of innovative organizations).
- Much to be done...