

The Bright Side of Patents

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The research was conducted while Hegde was Edison Scholar at the United States Patent and Trademark Office (USPTO). However, the views and comments expressed herein are solely the opinion of the authors, do not reflect the performance of duties in the authors' official capacities, and are not endorsed by, nor should be construed as, any viewpoint official or unofficial of the USPTO.

- Patents award their holders the right to exclude

- But patents may not help their holders much if....
 - Too costly to enforce → Holders spend > \$20 billion on enforcing patents (Bessen et al 2015)
 - Awarded for trivial inventions → <http://www.patentlysilly.com/>
 - Take too long to process → Average patent takes > 3 years to issue

How much do patents help startups?

RESEARCH QUESTIONS

1. Do patents have a *causal* effect on startup growth and innovation?
 - Startups play a key role in innovation and economic growth
 - Expected benefits of patents are crucial for the innovation-related decisions of financially constrained startups
2. Do patent *grant delays* affect startup growth and success?
 - Delays may increase imitation risk for firms without other assets to protect their inventions (generally startups)
3. What are the *mechanisms* through which patents benefit startups?
 - Focus on patents' role in facilitating startups' access to capital

Previous research suggests patents benefit inventors

RELATED LITERATURE

Patents may encourage follow-on innovation. Nordhaus (1969), Murray & Stern (2007), Sakakibara & Branstetter (2001), Moser (2012, 2013), Williams (2013), Galasso & Schankerman (2015, 2016), Williams & Sampat (2016)

Patents increase imitation costs. Mansfield, Schwartz, & Wagner (1981), Levin et al (1987), Cohen, Nelson & Walsh (2000), Cohen, Goto, Nagata, Nelson & Walsh (2002), Hall & Ziedonis (2001)

Patents facilitate the market for ideas. Arora (1995), Gans, Hsu & Stern (2002, 2008), Arora, Fosfuri & Gambardella (2004), Hegde (2014), Long (2002), Hegde & Luo (2016)

Patents facilitate access to capital. Hsu & Ziedonis (2013), Conti, Thursby & Thursby (2013), Graham, Merges, Samuelson & Sichelman (2009), Graham & Sichelman (2008), Mann (2015), Gaulle (2015), Hall, Jaffe & Trajtenberg (2005)

Patents are privately valuable. Schankerman & Pakes (1986), Schankerman (1998), Kieff (2001), Balasubramanian & Sivadasan (2011), Bhaskarabhatla & Hegde (2015), Hall, Helmers, Rogers & Sena (2014)

But recent studies question the value of patents

RELATED LITERATURE

- Survey evidence suggests patents are not the primary mechanism used by firms to protect their inventions ([Cohen et al. 2000](#))
- Too much patenting has created overlapping rights and diminished the private value of patents ([Heller & Eisenberg 2013](#))
 - The patent office gives away patents with little scrutiny ([Becker & Posner 2013](#); [Quillen & Webster 2009](#))
 - About 25% of litigated patents are found invalid ([Hegde 2012](#))
- “Patents are like lottery tickets. There is tremendous uncertainty about the scope and validity of patents. A patent does not confer upon its owner the right to exclude but rather a right to try to exclude by asserting the patent in court... If the patent is found invalid, the property right will have evaporated.” ([Lemley & Shapiro 2005](#))

How much do patents help startups?

CAVEATS

- We do not undertake a welfare analysis of the patent system
 - We cannot conclude that the current system is optimal or even welfare enhancing
- Our study does not inform selection into patenting
 - We measure the effect of awarding a patent for those who chose to file a patent application
- We estimate causal effects of a startup's *first* patent application
 - Estimates are Local Average Treatment Effects (LATE)
 - We cannot generalize estimates to subsequent patents

Outline

1. Do patents have a *causal* effect on startup growth and success?

- ❑ Empirical challenges and identification strategy
- ❑ The sample
- ❑ Findings

2. Do patent *grant delays* causally affect startup growth and success?

- ❑ Data
- ❑ Identification strategy
- ❑ Findings

3. What are the *mechanisms* through which patents benefit startups?

- ❑ Data
- ❑ Cross sectional analysis
- ❑ Findings

Measuring the effect of patents on startups is challenging

Consider estimating $Firm\ outcomes_i = \beta Patents_i + \gamma X_i + \varepsilon_i$

where i indexes firms and $Patents$ measures patent stock

EMPIRICAL CHALLENGES

1. Historically, only data on *granted* patents were available
 - β measures effect of patent rights and the patented invention
2. Data on firm outcomes for privately-held startups are not easily available
3. Patent approvals are likely correlated with *unobserved* firm and innovation quality
 - β provides a biased estimate of the effect of patent rights

We use unique USPTO data to estimate the effect of patents on startups

We estimate $Firm\ outcomes_i = \beta Patent\ approved_i + \gamma X_i + \varepsilon_i$

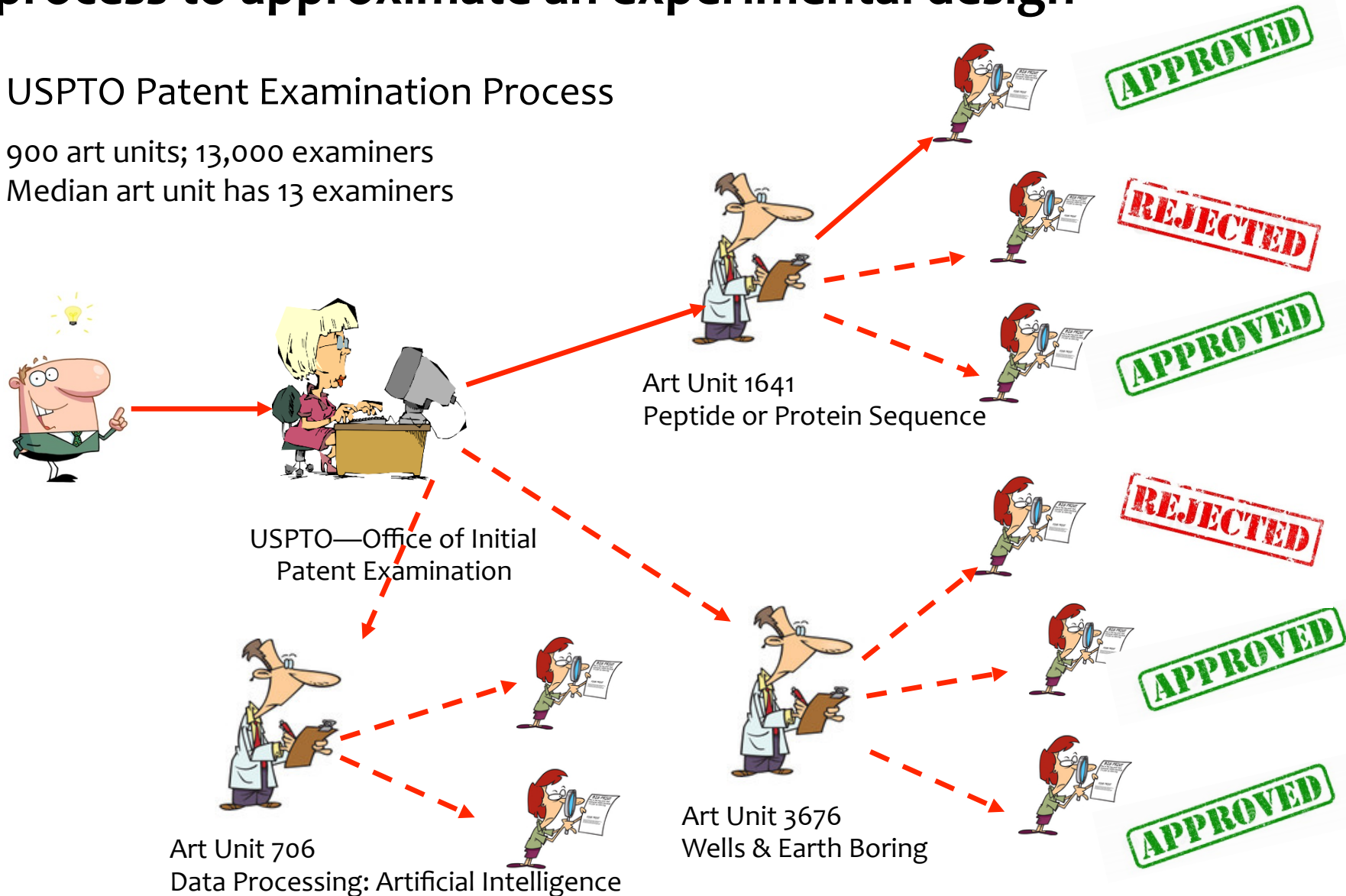
where i indexes startups and *Patent approved* measures outcome of first patent application

- USPTO data on 45,817 US startups that filed for their first patent application after 2001 and received a final decision by 2014
 - Population of first-time US-based applicants that claimed small-entity status
 - 66% approved, 34% rejected (consistent with [Carley, Hegde & Marco 2015](#))
- NETS (Dun & Bradstreet) data on sales, employment, financial indicators and demographics for public and private US firms
 - Coverage at least as good as Census' LBD ([Neumark et al. 2007](#))
 - 65% match rate
 - USPTO data on subsequent patent applications and grants

We use institutional features of the patent examination process to approximate an experimental design

USPTO Patent Examination Process

900 art units; 13,000 examiners
Median art unit has 13 examiners



'First-in first-out' system ensures quasi-random assignment of applications to examiners

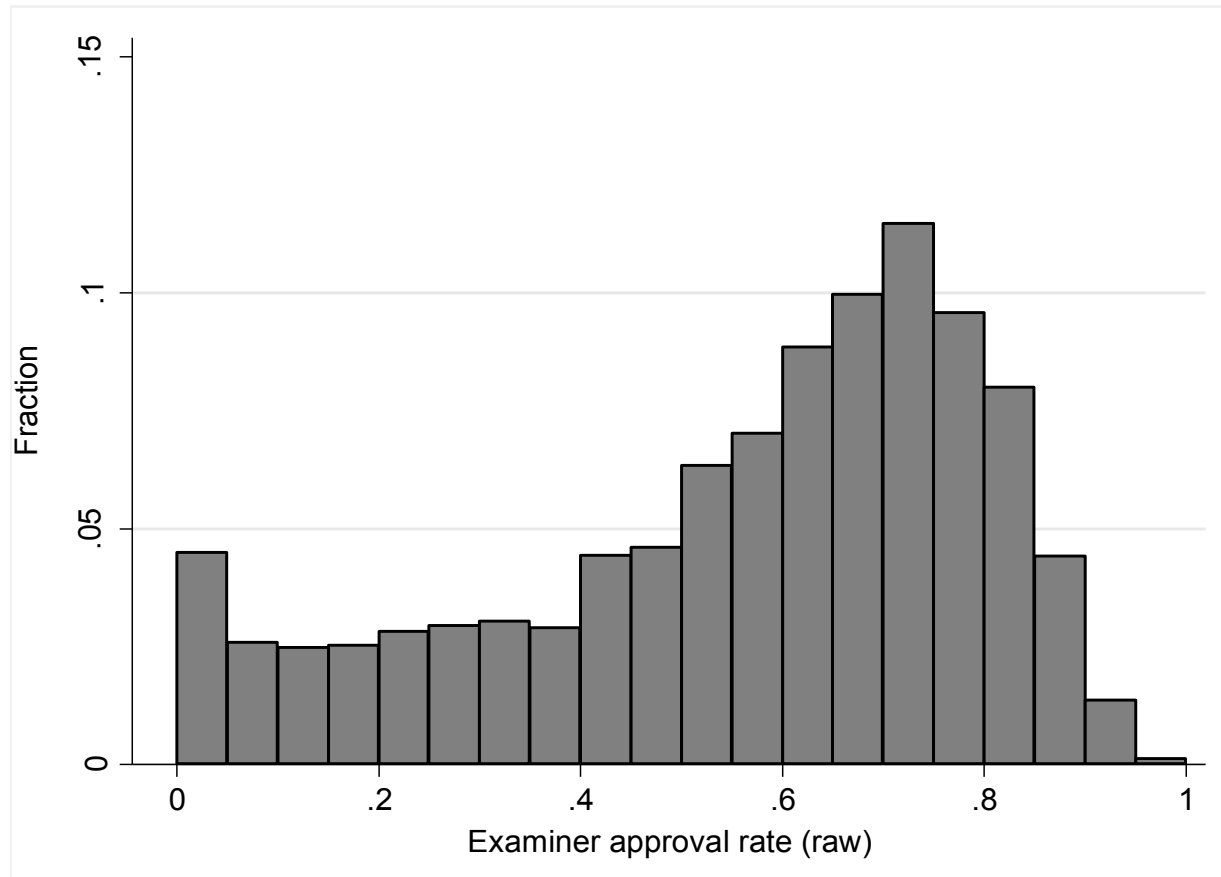
- Assignment of applications to examiners within art units is random with respect to application quality
 - Earliest application is assigned to the first examiner available for examination
 - Applicants cannot influence examiner assignment
- Within each art unit, some examiners are more likely to approve applications than others
 - Determination of patentability involves human judgement
 - Process similar to journal refereeing, grant review, soccer umpires, and court judges
- We use IV-2SLS that exploits within art-unit variation in the propensity of examiners to approve patents (as in [Sampat & Williams 2015](#))

$$\text{IV} \equiv \text{Examiner approval rate}_{ijt} = \frac{n_{\text{granted}_{jt}}}{n_{\text{reviewed}_{jt}}}$$

where n_{granted} and n_{reviewed} are the no. of patents granted and reviewed by examiner j assigned to examine application i at t

Instrument relevance: Variation in approval rates

IV should display meaningful variation and be strongly correlated with endogenous variable (probability of patent approval)

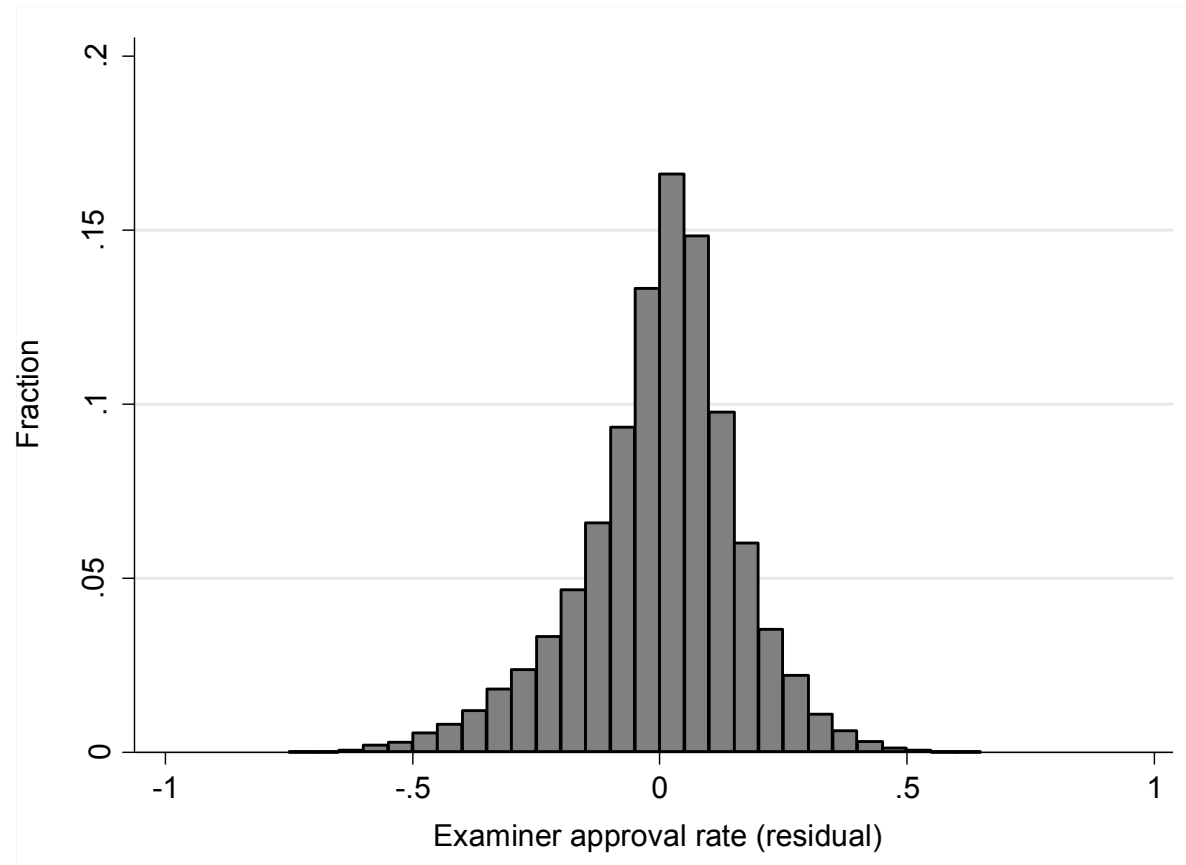


Interquartile range (IQR) is 33%; mean is 56%

Median examiner in sample has examined 418 applications

Instrument relevance: Variation in approval rates

IV should display meaningful variation and be strongly correlated with endogenous variable (probability of patent approval)



Residual approval rate after regressing IV on full set of art unit-by-year FE
Interquartile range (IQR) after purging out art-unit X year effects: 17.7%

Instrument relevance: Correlation w/ endog. variable

IV should display meaningful variation and be strongly correlated with endogenous variable (probability of patent approval)

	First stage
<i>Dep. var.:</i>	Patent approved?
	<i>OLS</i>
	(1)
IV: patent examiner approval rate	0.660*** 0.017
<i>F</i> test: IV = 0	854.0***
Diagnostics	
R^2	27.8%
No. of observations (firms)	19,504
Unconditional mean of dep. variable	65.7%
Interquartile range of residual IV	17.7%

Each percentage-point (p.p.) increase in past approval rate → 0.66 p.p. increase in Prob(patent approved)

All analyses include art unit-by-year FE and HQ state FE;
S.E. clustered at art unit level

Instrument exclusion restriction

IV should only affect firm growth through the effect it has on the endogenous variable (the likelihood that the patent application is approved)

<i>Dep. var.:</i>	IV: Patent examiner approval rate				
	(1)	(2)	(3)	(4)	(5)
Employment growth during year prior to patent filing	-0.001 <i>0.002</i>				
Sales growth during year prior to patent filing		-0.001 <i>0.002</i>			
Log (employees at filing date)			0.000 <i>0.001</i>		
Log (sales at filing date)				0.000 <i>0.001</i>	
Art unit × year fixed effects	Yes	Yes	Yes	Yes	Yes
HQ state fixed effects	Yes	Yes	Yes	Yes	Yes
Diagnostics					
R^2	60.4%	60.4%	60.4%	60.4%	60.4%
No. of observations (firms)	19,173	19,173	19,173	19,173	19,173

Test confirms that high-growth firms are not drawing more (or less) lenient examiners

Instrument exclusion restriction

IV should only affect firm growth through the effect it has on the endogenous variable (the likelihood that the patent application is approved)

	<i>Dep. var.:</i> IV: Patent examiner approval rate		
	(6)	(7)	(8)
Employment growth during year prior to patent filing			
Sales growth during year prior to patent filing			
Log (employees at filing date)			
Log (sales at filing date)			
Log (no. of initial claims in application)	0.001 0.002		
Log (no. of initial words in application)		0.001 0.002	
Art unit × year fixed effects	Yes	Yes	Yes
HQ state fixed effects	Yes	Yes	Yes
Diagnostics			
R^2	56.46%	56.46%	56.46%
No. of observations (firms)	39,150	39,150	39,150

Test confirms that high-growth firms are not drawing more (or less) lenient examiners

Sample statistics – At first patent application

		Firms whose first patent application is ...	
		approved	rejected
No. firms		30,120	15,697
% of firms		65.7%	34.3%
Age at first patent filing (years)	median	2	2
Employees at filing date	mean	28.7	27.7
	median	8.0	8.0
	st.dev.	47.8	47.0
Sales at filing date (\$ million)	mean	4.4	4.3
	median	1.0	0.8
	st.dev.	8.0	8.1
Pre-patent-filing employment growth	mean	17.1%	15.8%
	st.dev.	74.4%	70.1%
Pre-patent-filing sales growth	mean	18.7%	16.7%
	st.dev.	77.6%	73.5%

Sample statistics – Post-decision growth rates

		Firms whose first patent application is ...	
		approved	rejected
Employment growth after first-action decision on the firm's first patent application, measured over the following ...			
... 1 year	mean	5.4%	-1.4%
	st.dev.	52.5%	48.3%
... 3 years	mean	15.4%	-0.8%
	st.dev.	120.9%	112.2%
... 5 years	mean	20.1%	-4.1%
	st.dev.	157.3%	132.6%
Sales growth after first-action decision on the firm's first patent application, measured over the following ...			
... 1 year	mean	7.6%	-0.2%
	st.dev.	62.5%	56.8%
... 3 years	mean	22.8%	5.3%
	st.dev.	144.1%	135.7%
... 5 years	mean	36.7%	7.8%
	st.dev.	208.6%	176.4%

Sample statistics – Post-decision innovation

		Firms whose first patent application is ...	
		approved	rejected
No. subsequent patent applications	mean	3.3	1.2
	st.dev.	16.8	5.9
No. subsequent approved patents	mean	1.8	0.5
	st.dev.	9.6	2.8
Approval rate of subsequent patent applications		57.1%	36.4%
Total citations to all subsequent patent applications	mean	7.5	1.9
	st.dev.	72.4	23.9
Average citations-per-patent to subsequent approved patents	mean	1.9	1.5
	st.dev.	3.8	3.0

Approval of first patent application does not affect firm survival

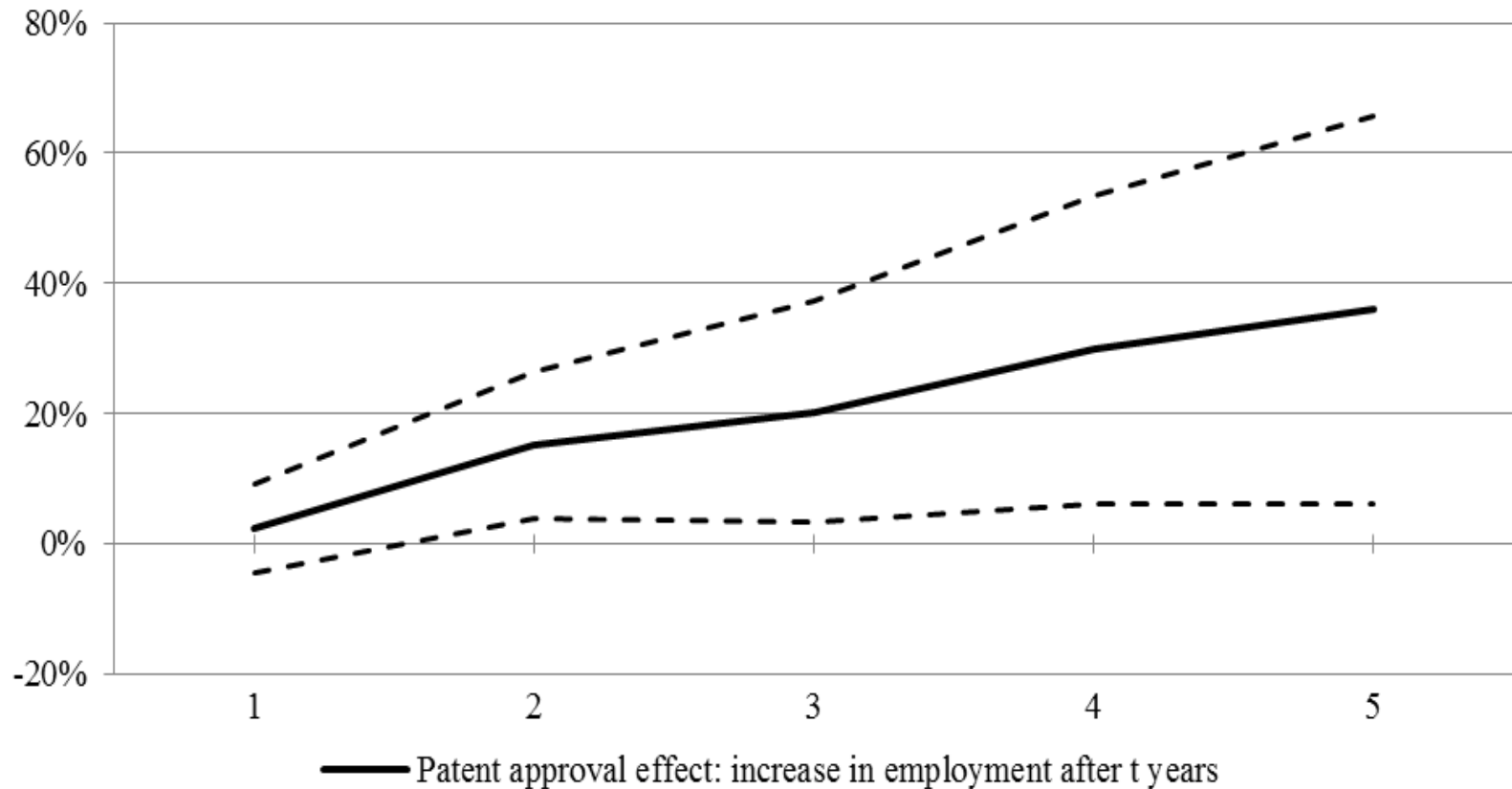
LPM Estimates	<i>Dep. var.:</i>		Is the firm alive after ...			
	1 year?		3 years?		5 years?	
	<i>OLS</i>	<i>2SLS</i>	<i>OLS</i>	<i>2SLS</i>	<i>OLS</i>	<i>2SLS</i>
	(1)	(2)	(3)	(4)	(5)	(6)
First application approved	0.028*** <i>0.004</i>	-0.013 <i>0.016</i>	0.055*** <i>0.007</i>	-0.003 <i>0.026</i>	0.074*** <i>0.009</i>	-0.009 <i>0.042</i>
Log (employees at first-action)	0.006*** <i>0.001</i>	0.006*** <i>0.001</i>	0.015*** <i>0.002</i>	0.016*** <i>0.002</i>	0.017*** <i>0.003</i>	0.017*** <i>0.003</i>
Diagnostics						
R^2	12.3%	n.a.	14.5%	n.a.	15.3%	n.a.
Unconditional mean of dep. variable	94.6%	94.6%	84.6%	84.6%	77.6%	77.6%
F test: IV (examiner approval rate) = 0		928.9***		794.9***		469.3***
No. of observations (firms)	21,869	21,869	19,009	19,009	12,798	12,798

95%, 85% and 78% of firms are alive 1, 3 and 5 years respectively after first patent decision

Approval of first patent application leads to employment growth

IV Estimates	<i>Dep. var.:</i>	Employment growth after first-action decision on the firm's first patent application, measured over the following ...				
		1 year (1)	2 years (2)	3 years (3)	4 years (4)	5 years (5)
First patent application is approved		0.024 <i>0.035</i>	0.153*** <i>0.057</i>	0.203** <i>0.086</i>	0.303** <i>0.120</i>	0.372** <i>0.153</i>
Log (employees at first-action)		-0.021*** <i>0.002</i>	-0.051*** <i>0.004</i>	-0.068*** <i>0.006</i>	-0.086*** <i>0.007</i>	-0.098*** <i>0.009</i>
Diagnostics						
No. of observations (firms)		22,050	22,050	19,168	15,737	12,882
Unconditional mean of dep. variable		3.0%	7.7%	10.0%	12.8%	13.5%
<i>F</i> test from first stage: IV (examiner approval rate) = 0		935.0***	935.0***	798.9***	559.4***	455.4***

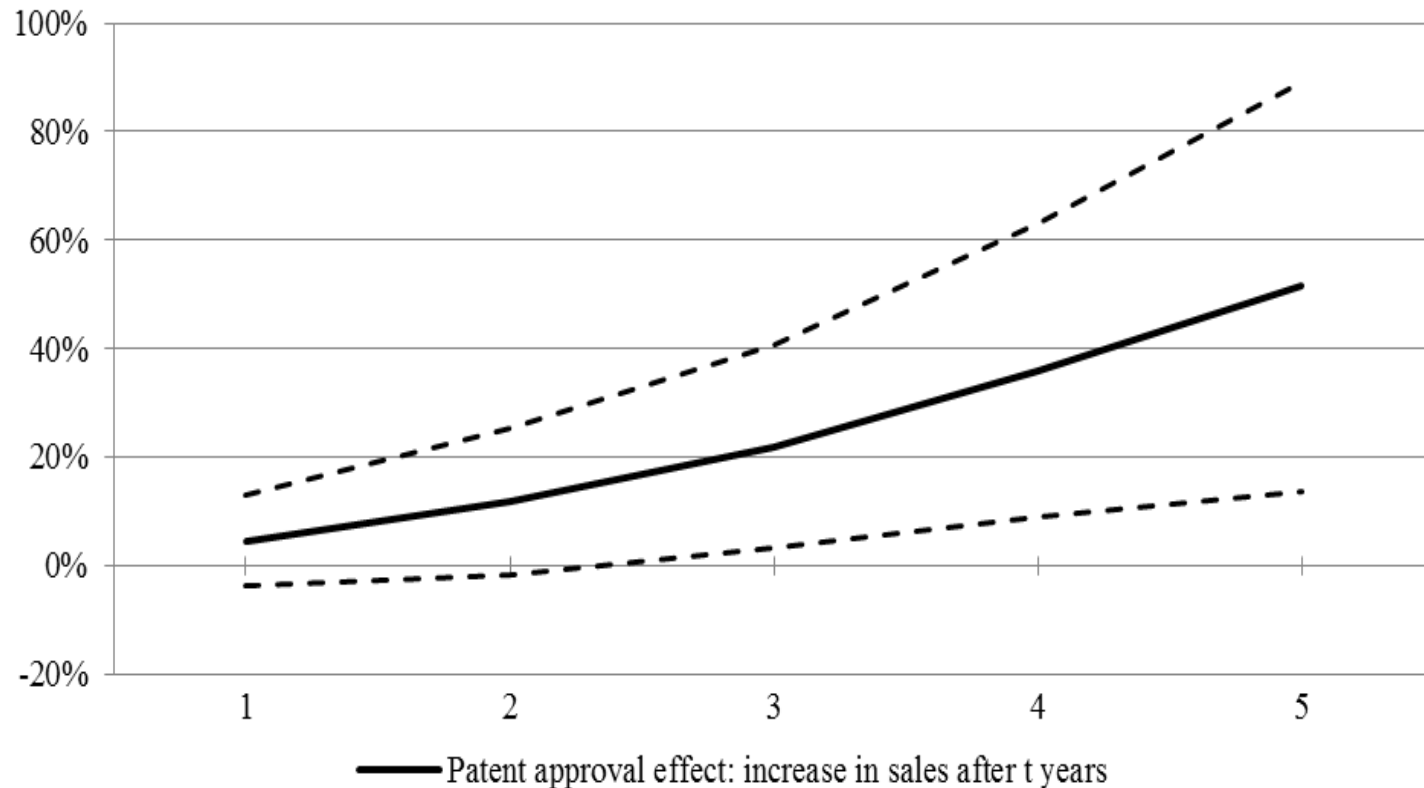
Approval of first patent application leads to employment growth



IV Estimates

Median firm has 8 employees at first-action → Approval of its first patent application leads to, on average, 3 more employees 5 years later

Approval of first patent application leads to persistent sales growth



IV Estimates

Median firm has \$4.35M in revenues at first-action → Approval of its first patent application leads to, on average, \$2.26M higher sales 5 years later.

(Average estimated cost of patent application = \$20,000 according to [Lemley 2001](#))

Approval of first patent application leads to higher rate and quality of subsequent innovation

IV Estimates	Dep. var.:	Log (1 + subsequent patent applications)	Log (1 + subsequent approved patents)	Approval rate of subsequent patent appl.	Log (1 + total citations to all subsequent patent appl.)	Log (1 + avg. citations-per-patent to subsequent approved patents)
		(1)	(2)	(3)	(4)	(5)
First patent application is approved		0.509*** 0.036	0.395*** 0.029	0.176*** 0.035	0.522*** 0.045	0.238*** 0.073
Diagnostics						
No. of observations (firms)		46,362	46,362	18,720	46,361	13,832
Unconditional mean of non-logged dep. variable		2.71	1.47	54.2%	6.04	1.93
F test from first stage: IV (examiner approval rate) = 0		1,623.8***	1,623.8***	742.8***	1,623.9***	371.7***

Approval of first patent application leads to:

- 66.4% increase in no. of subsequent applications, 48.4% in no. of approved patents
- 17.6 p.p. higher approval rate of patent applications
- 68.5% increase in no. of total citations, 26.9% increase in no. of citations per patent

Outline

1. Do patents have a *causal effect* on startup growth and success?

- Empirical challenge and identification strategy
- The sample
- Findings

2. Do patent *grant delays* affect startup growth and success?

- Identification strategy
- Data
- Findings

3. What are the *mechanisms* through which patents benefit startups?

- Data
- Cross sectional analysis
- Findings

Do patent grant delays affect startups?

- For firms that receive patents, estimate:

$$Firm\ outcomes_i = \beta First\ patent\ application\ review\ lag_i + \gamma X_i + \varepsilon_i$$

- But patent application review lag is endogenously determined with application quality
 - Low (or high) quality inventions may take longer for patent approval
- We break down review lag into two parts:

Review lag = time until patent assigned to examiner in art unit

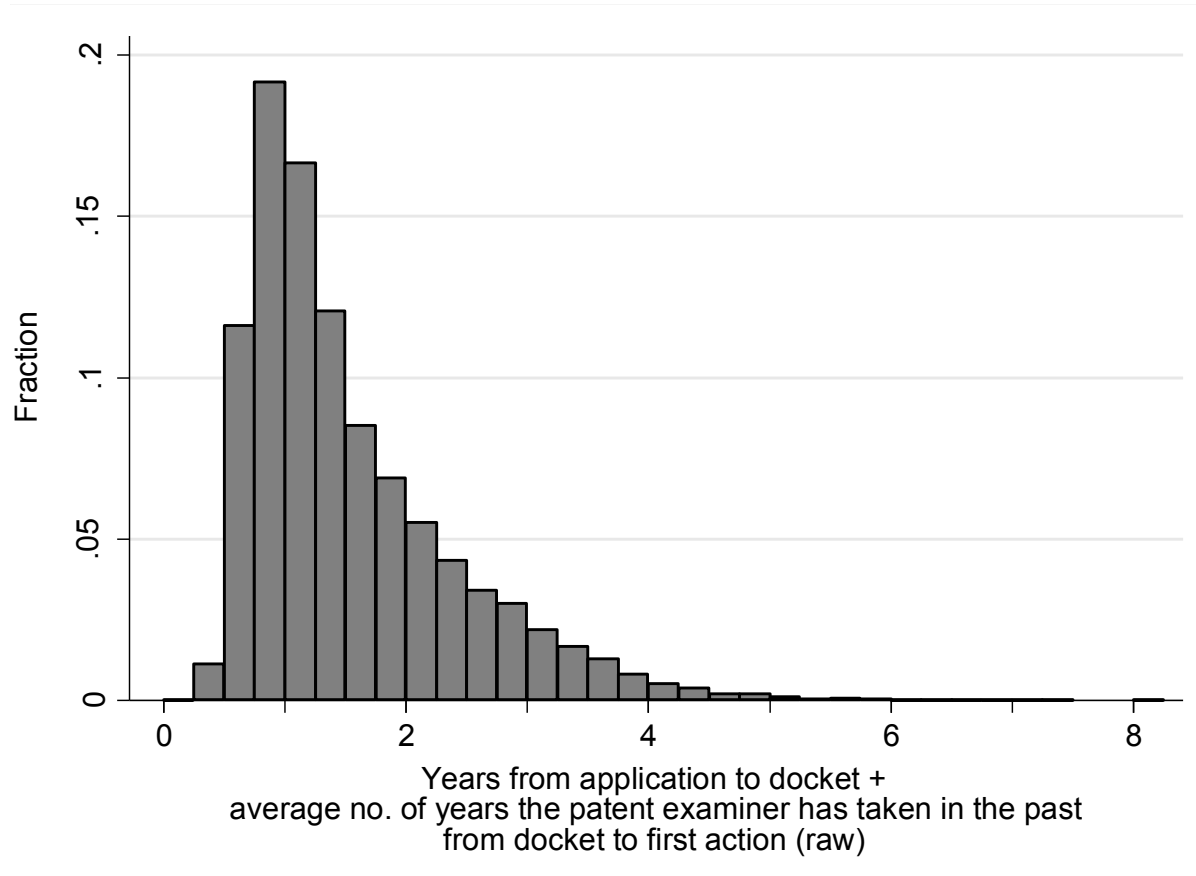
exogenous
(process automated, caused by administrative delays)

+ time examiner takes to take first action

potentially endogenous
(IV: average time examiner has taken to take first action in the past)
Identifying assumption: assignment of applications to examiners is random

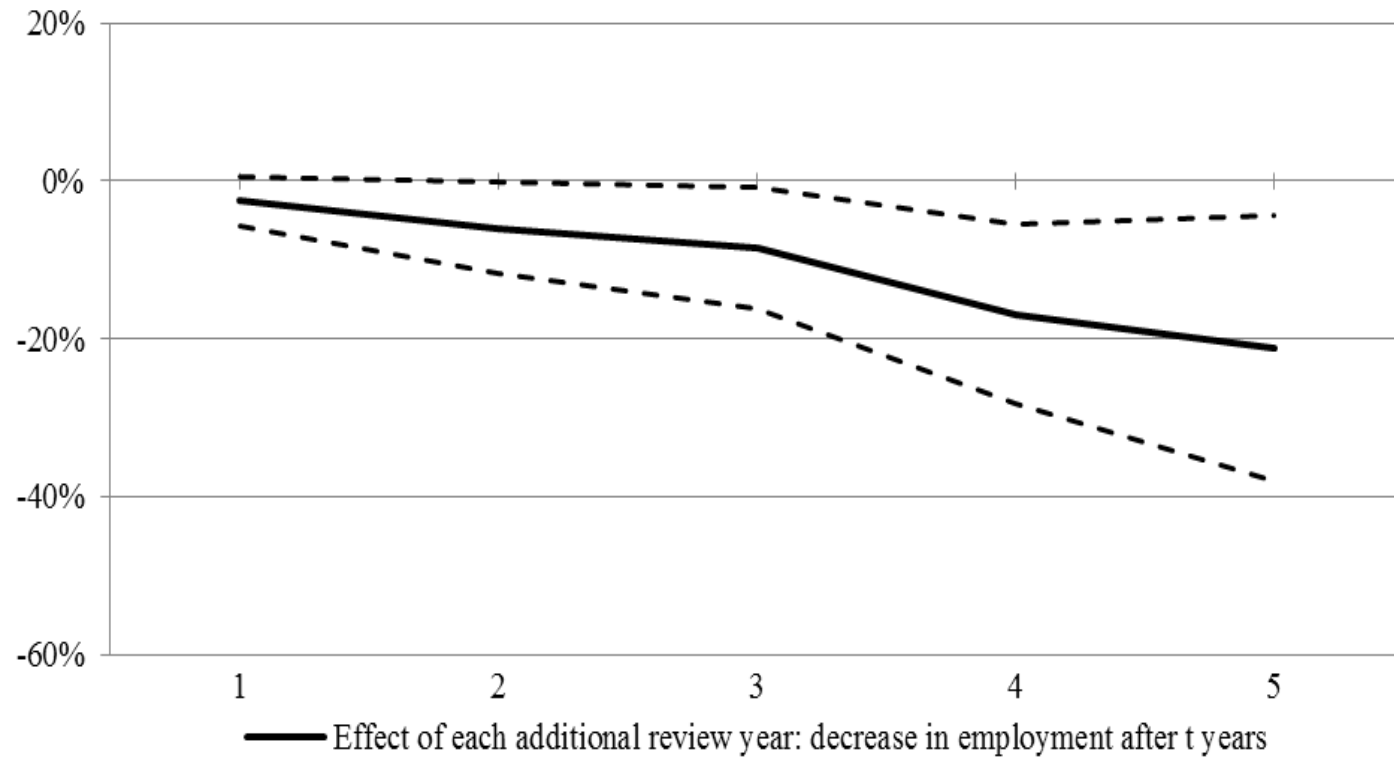
Relevance of IV for review lags

Review lag IV = time until patent assigned to examiner in art unit + avg. time examiner has taken to take first action in the past



Mean review lag: 1.6 yrs; Residual IQR review lag: 0.7 yrs

Delays in patent approval have a persistent negative effect on employment growth



IV Estimates

Delays in patent approval have a persistent negative effect on other measures of startup growth

- Delays in patent approval reduce sales growth
 - Sales growth decreases by 3.6%, 12.8%, 28.4% over 1 year, 3 year and 5 years for each year of delay
- Delays reduce the quantity and quality of subsequent innovation
 - 14% decrease in no. of subsequent applications and patents
 - 4 p.p. lower approval rate of applications
 - 8% decrease in no. of citations per patent

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2. Do patent *grant delays* affect startup growth and success?

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- Identification strategy
- Findings

3. What are the *mechanisms* through which patents benefit startups?

- Discussion
- Cross sectional analysis
- Findings

What are the mechanisms through which patents affect firm growth?

- Early approval of first patent sets startups on growth path
- To understand mechanisms, need to investigate what happens between receiving patent approval and growth
- One of the biggest challenges for startups to grow is access to capital ([Evans & Jovanovic 1989](#); [Krishnan et al. 2015](#); [Schmalz et al. 2015](#))
 - risk, asymmetric information and expropriation problems impose frictions for financial contracting
 - theory suggests property rights should alleviate some information frictions

Do patent grants help firms survive and grow by facilitating access to capital?

- Outcome variable: D&B PAYDEX Score which indicates startups' risk of late payment (compiled from the total number of payment experiences in D&B file)
- Analysis subject to same measurement problems as analysis of the effect of patents on firm growth and innovations
- We instrument patent approval and review lags as before

Approval of first patent improves startups' immediate credit-worthiness

Change in D&B PayDex Score (1-100) after first-action decision on the startup's first patent application, measured over the following ...						
IV Estimates	<i>Dep. var.:</i>					
	1 year		2 years		3 years	
	<i>Raw change</i>	<i>% Change</i>	<i>Raw change</i>	<i>% Change</i>	<i>Raw change</i>	<i>% Change</i>
	(1)	(2)	(3)	(4)	(5)	(6)
First patent application approved	1.486*** <i>0.559</i>	0.025*** <i>0.009</i>	1.269 <i>0.957</i>	0.026* <i>0.016</i>	-1.165 <i>1.339</i>	-0.014 <i>0.022</i>
Diagnostics						
Unconditional mean of dep. variable	-0.48	-0.4%	-0.55	-0.2%	-0.50	0.0%
<i>F</i> test: IV (examiner approval rate) = 0	470.4***	470.4***	310.4***	310.4***	230.2***	230.2***
No. of observations (firms)	11,623	11,623	9,213	9,213	7,192	7,192

Additional evidence on patents' causal role in facilitating access to capital (companion paper)

- Patent approvals causally increase probability of venture capital (VC) funding by 57%
- Patents' effect on VC funding is higher in settings characterized by information frictions
 - *early* funding rounds
 - *IT sector*, where expropriation concerns are higher
 - markets where *competition* among startups is *high*
 - founders *without* prior entrepreneurial experience
- Patents may facilitate financial contracting between startups and investors via two information-related channels
 - Securing property rights
 - Signaling ([Long 2002](#), [Hsu & Ziedonis 2013](#))

Patents convey substantial benefits to startups

- Patents have a long-lasting positive causal effect on startups' growth and success
 - Patents increase employment and sales growth by 30-50 percent
 - Patents set startups on a growth path by facilitating access to capital
- Patent grant delays adversely affect startup growth and success
 - Startups can benefit substantially by applying for fast track prosecution
 - Patent reform should prioritize timely examination
- Changes in patent approval rates, quality, and timeliness have real economic effects
 - Findings alter the balance of evidence regarding the patent system's effects

COMMENTARY

The Myth Of the Wicked Patent Troll

Before we overhaul America's peerless patent system, let's see some evidence that innovation is being hindered.

By **STEPHEN HABER** And **ROSS LEVINE**

June 29, 2014 7:43 p.m. ET

Thank you!

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