Innovation Policy and the Lifecycle of Inventors

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PRELIMINARY

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A Former Swiss Patent Examiner

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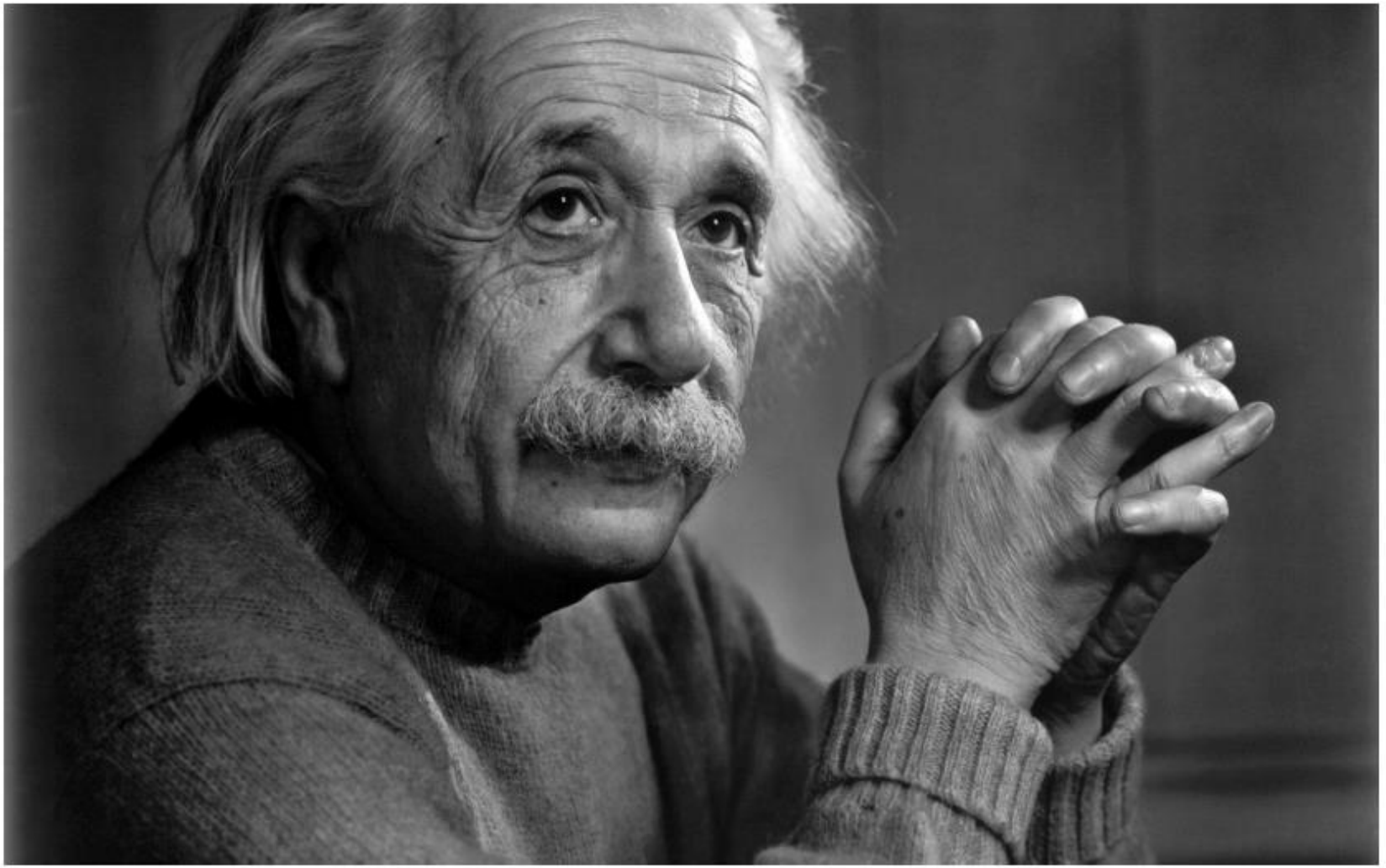


- Father an engineer & salesman & owned a company that manufactured electrical equipment
- High quality education in Germany, Italy & Switzerland; attended ETH Zurich
- If Einstein was born poor could he have ended up a factory worker?
- How much poorer would the world be?

Motivation

- Innovation is at the center of modern theories of economic growth
  (Aghion & Howitt, 1994) because spillovers crucial (Bloom, Schankerman, Van Reenen, 2013)

- Surprisingly little is systematically known about characteristics and life trajectories of **inventors** from population databases

  - Empirical literature has focused mainly on **firm-level** incentives rather than on **individual incentives**

  - Data on parental background, income, age, gender is scarce

  - Limited evidence on returns to innovation, career trajectories, etc.

Overview

- **Specific aim**: descriptive portrait of the lifecycle of inventors (compared to non-inventors) using "Big Data" on over 1 billion obs

- **Broader goal**: understand which types of policies are most likely to spark innovation
  - "Demand-side" policies (more studied)
    - R&D subsidies; (tax rates for those on high incomes)
  - "Supply-side" policies to draw more people into innovation sector (less studied)
    - Investments in human capital
  - Supply side policies likely to be more effective in the long-run (Romer, 2000; Goolsbee, 1998)

Overview

- Focus on patents as a measure of innovation
  - Widely used in literature (Griliches 1998) with well known pros and cons
  - Many studies have linked patent data to firms (Hall et al, 2005; Akcigit & Kerr, 2013) to study company innovation
  - We link U.S. patent data to **individual** tax records for all inventors
- Using linked patent-tax data, we characterize the lives of inventors
  - Birth and family background
  - Childhood and education

Overview

- We do not identify causal determinants of innovation, but our results point to three general lessons for policy:

1. Misallocation of talent may lead to substantial losses in innovation
   - Children with low-income parents are significantly less likely to patent despite having similar measured early ability
   - Subsequent schooling essentially accounts for this difference
   - Place where kids grow up also important

2. Potential gains from tax incentives may be more modest
   - Significant income/wage returns for highly cited patents
   - Very skewed returns (implies top taxes not so important)

3. Rigorous evaluation evidence on innovation policy important
   - we have much more rigorous knowledge of what happens in

Some Prior Literature(s)

- **Individual Inventors:** Scotchmer (2004) theory; Schmookler (1957) 87 US; Jung & Ejermo (2014) Survey & Sweden; Toivanen & Vaananen (2012,2015) Finland; Depalo & Addario (2014) Italy; Dorner (2014) Germany; Giuri et al (2007) PatVal-EU 9,107 EPO inventors

- **Inter-generational Inequality:** Chetty, Hendren, Kline & Saez (2014); Plowman, DeFries, Knopik & Neiderhiser (2013); Dearden, Machin & Reed (1997); Solon (1992)

- **Place effects:** Chetty, Hendren & Katz (2015); Chetty & Hendren (2014) Jaffe, Trajtenberg & Henderson (1993); Griffith, Lee & Van Reenen (2011)

- **Education & growth:** Nelson & Phelps (1996); Aghion & Howitt (1992); Barro & Xali-i-Martin (2004); Sianesi & Van Reenen (2003); Aghion et al (2009)

- **Misallocation of Talent:** Hsieh & Klenow (2009); Celik (2015); Hsieh, Hurst, Jones, and Klenow (2013); Acemoglu, Akcigit, Bloom, and Kerr (2013)

Part 1
Data matching inventors to tax records

Patent Data

- We obtain data on all patents granted between 1996 and 2012 from US Patent and Trademark Office
- ~1.5m patents in database (approx. 100k-200k granted per year)
- Key variables: inventors' names, application date, sector, subsequent citations

Tax Data

- Link to tax data by inventor name, city, and state at time of patent application
  - Income from wages, self-employment, capital, royalties, etc.
  - ~90% of individual inventors in raw patent file are linked to tax data
  - Matched and unmatched patents balanced on observables such as location, citations, technology classes
- 786,656 inventors in linked patent-tax data (2.5m income observations)
  - Median individual has 2 patents

Table 1: Summary Statistics for Inventors

	Mean	Median	Standard Deviation
Patents	3.93	2.00	9.21
Citations	36.19	6.00	168.96
Age at Patent	46.55	45	19.95
Wage Income ($)	139,427	100,082	558,855
Total Income ($)	214,424	122,346	1,564,315
Female (%)	11.6		

Number of Inventors: 786,656

Figure 1: Age Distribution of Patent Applicants in 2000

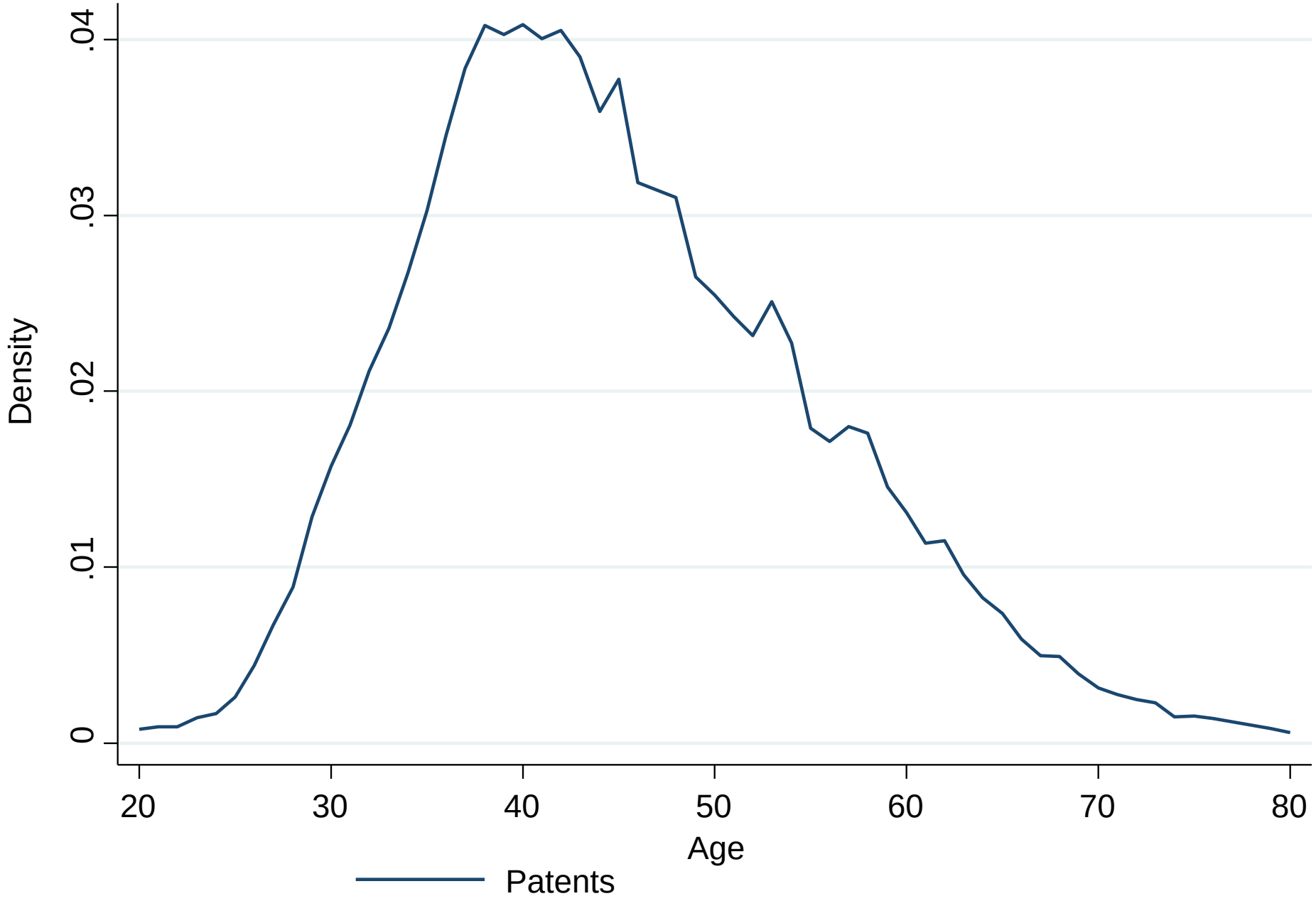
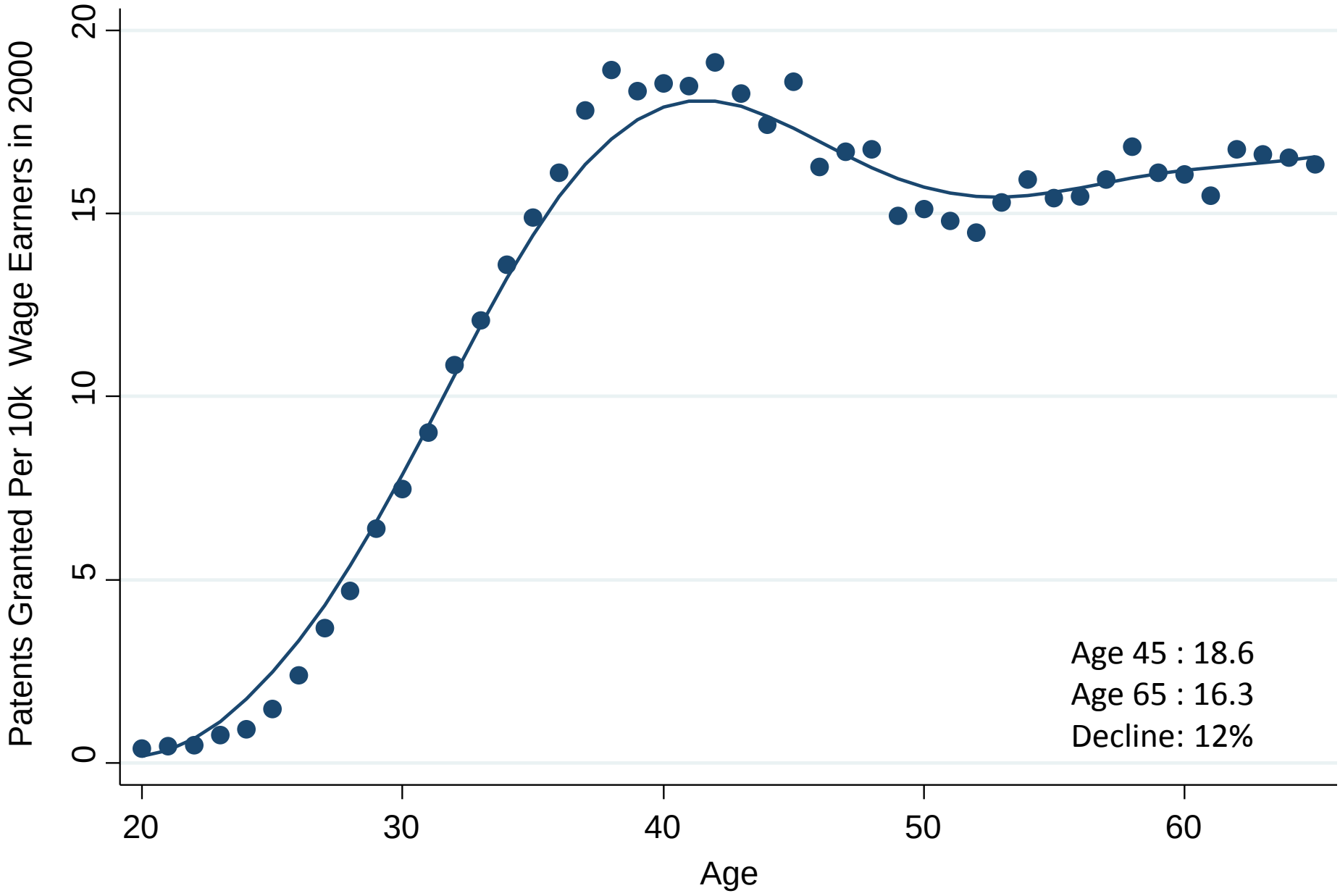


Figure 2: Patents Per Wage Earner by Age in 2000



Part 2
The Lifecycle of Inventors

The Lifecycle of Inventors

- Organize analysis around the chronology of an inventor's life

Parent Characteristics

- Link parents to children based on dependent claiming (Chetty, Hendren, Kline, Saez & Turner, 2014)
- We can reliably identify parents only for children born in or after 1980
  - Forces us to study young inventors: patents before age 32 (in 2012)
- Still a substantial sample: 20,000 inventors in our sample born after 1980
  - 8.35% of inventors on patents in 2000 were below age 32

Parent Income

- Measure parent income as mean household income from 1996-2000
- Calculate fraction of children in 1980-90 birth cohorts who are granted patents before age 32 in each parental percentile bin

Table 5: Patent Rates vs. Parent Income

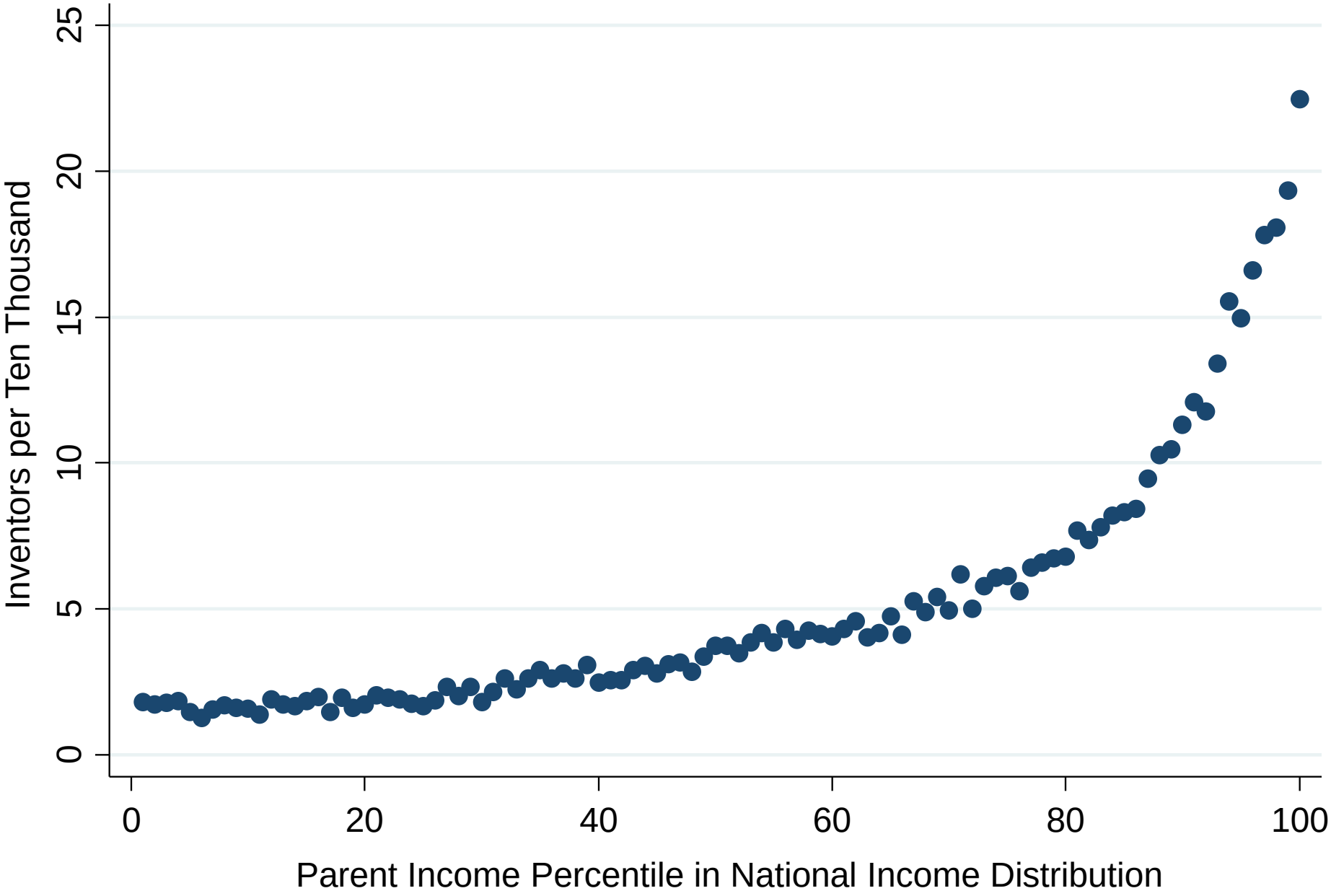
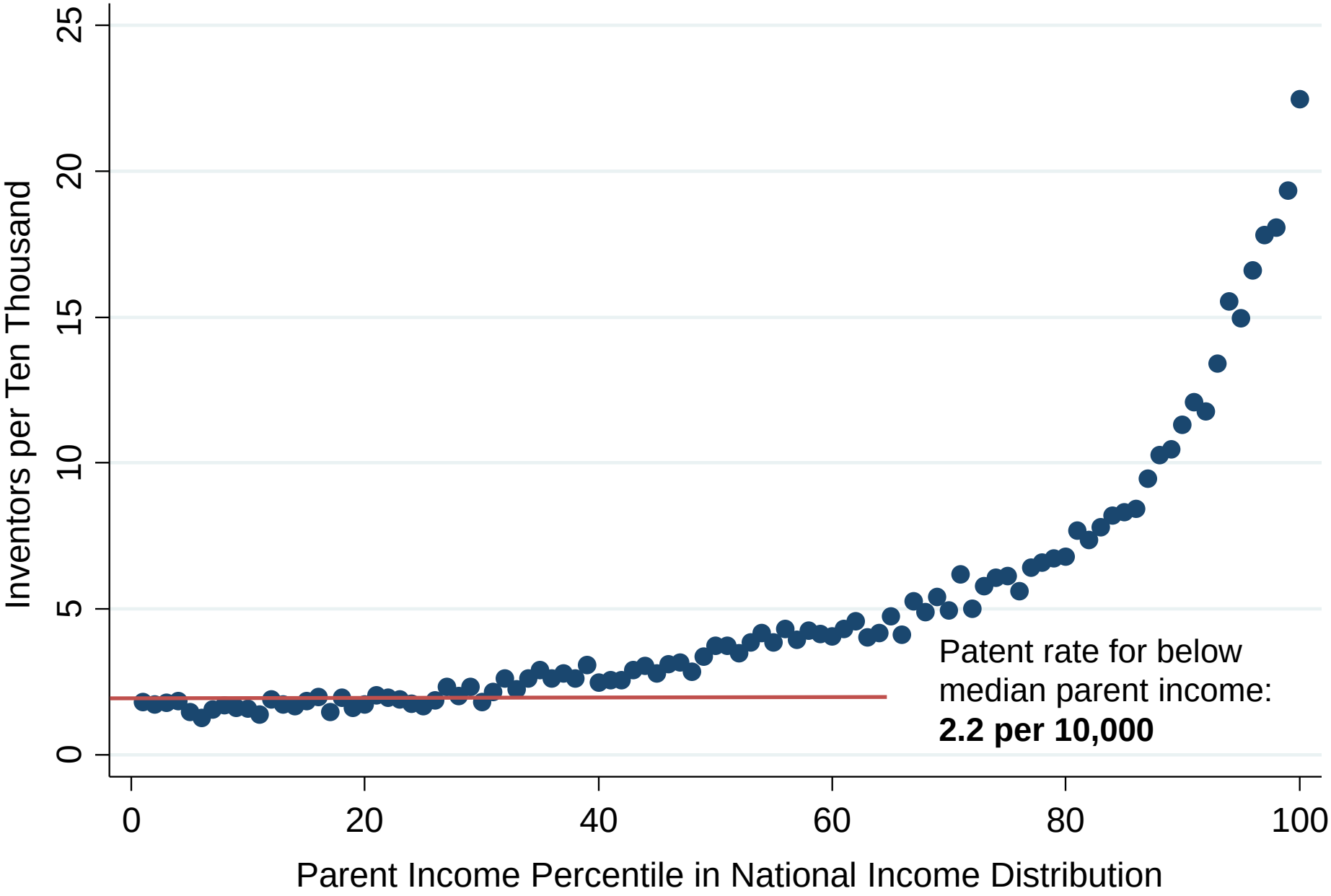


Table 5: Patent Rates vs. Parent Income



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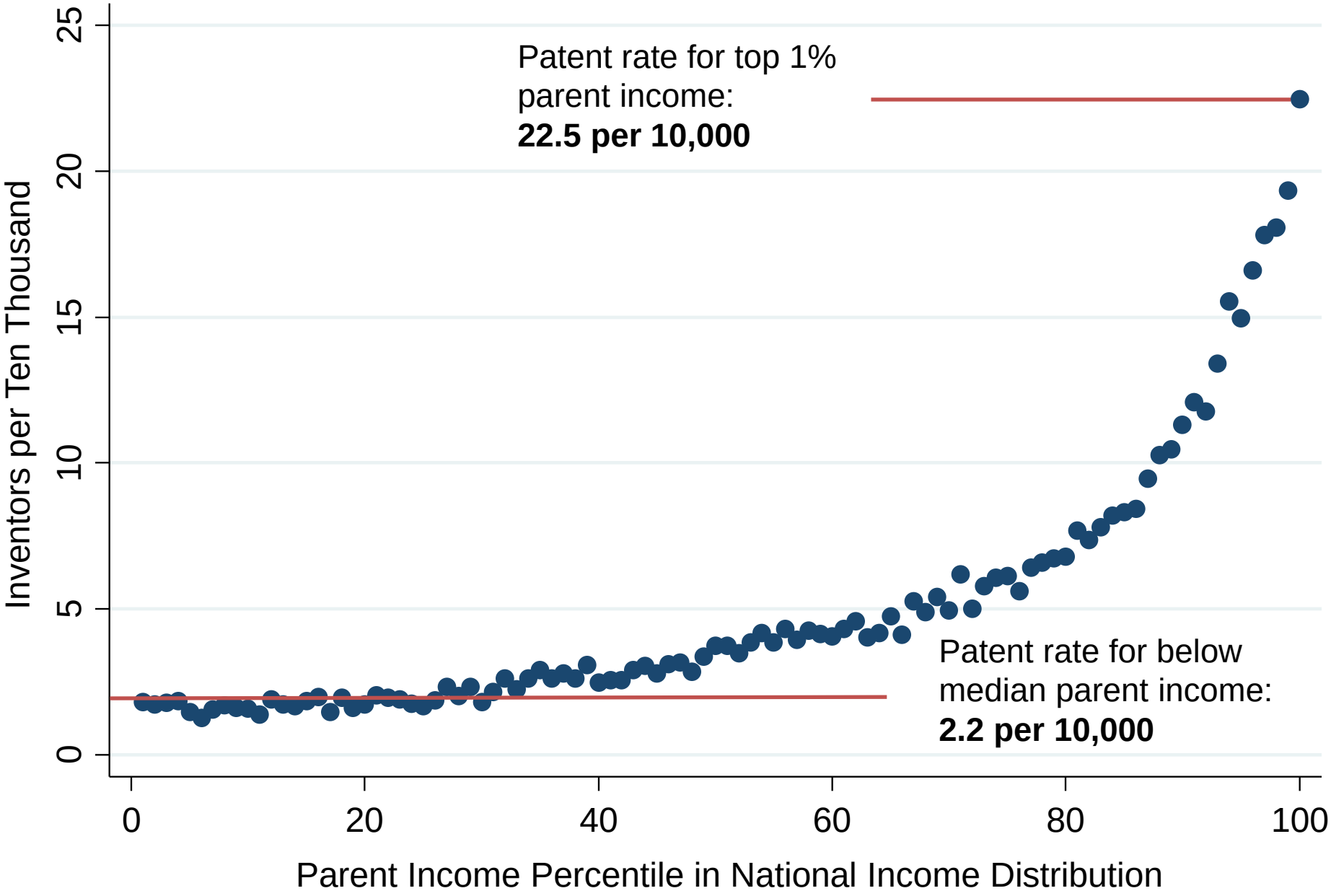


Why Do Patent Rates Vary with Parent

- Correlation between parent income and children growing up to be inventors could be driven by various mechanisms

  1. Children from high-income families have higher ability

  2. Misallocation of talent: lower income children face other barriers despite having comparable talent

  3. Preferences: lower income children prefer other occupations (e.g., because of risk aversion)

Why Do Patent Rates Vary with Parent

- Correlation between parent income and patent rates could be driven by various mechanisms

  1. Children from high-income families have higher **ability**

  2. **Misallocation of talent**: lower income children face other barriers despite having comparable talent

  3. **Preferences**: lower income children prefer other occupations (e.g., because of risk aversion)

- (Partially) distinguish between these explanations using measures of ability

  - Use data on test scores for children in New York City public schools

Figure 6: Patent Rates vs. 3rd Grade Test Scores

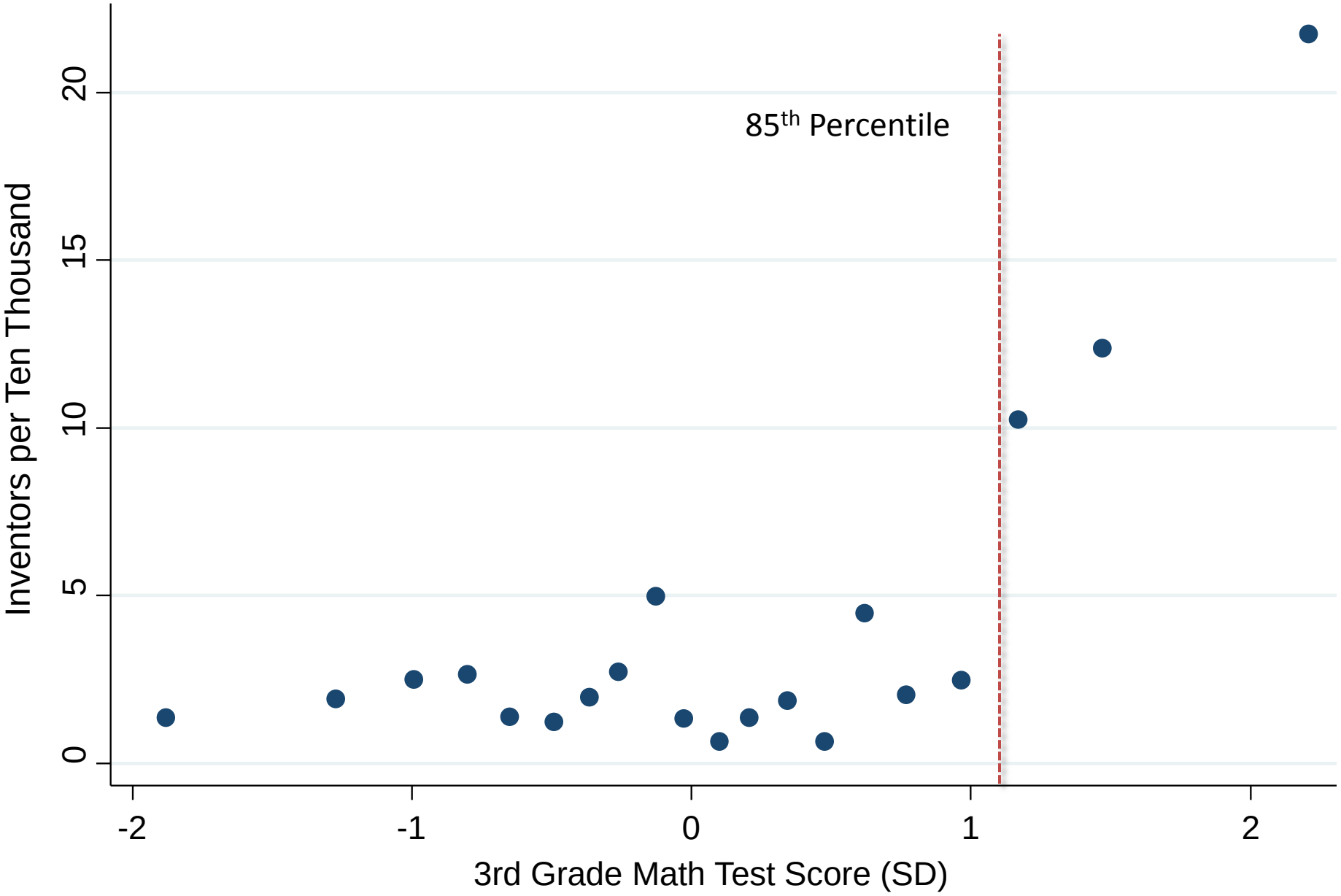


Figure 7: Distribution of Math Test Scores in 3rd Grade for Children with Low vs. High Income Parents

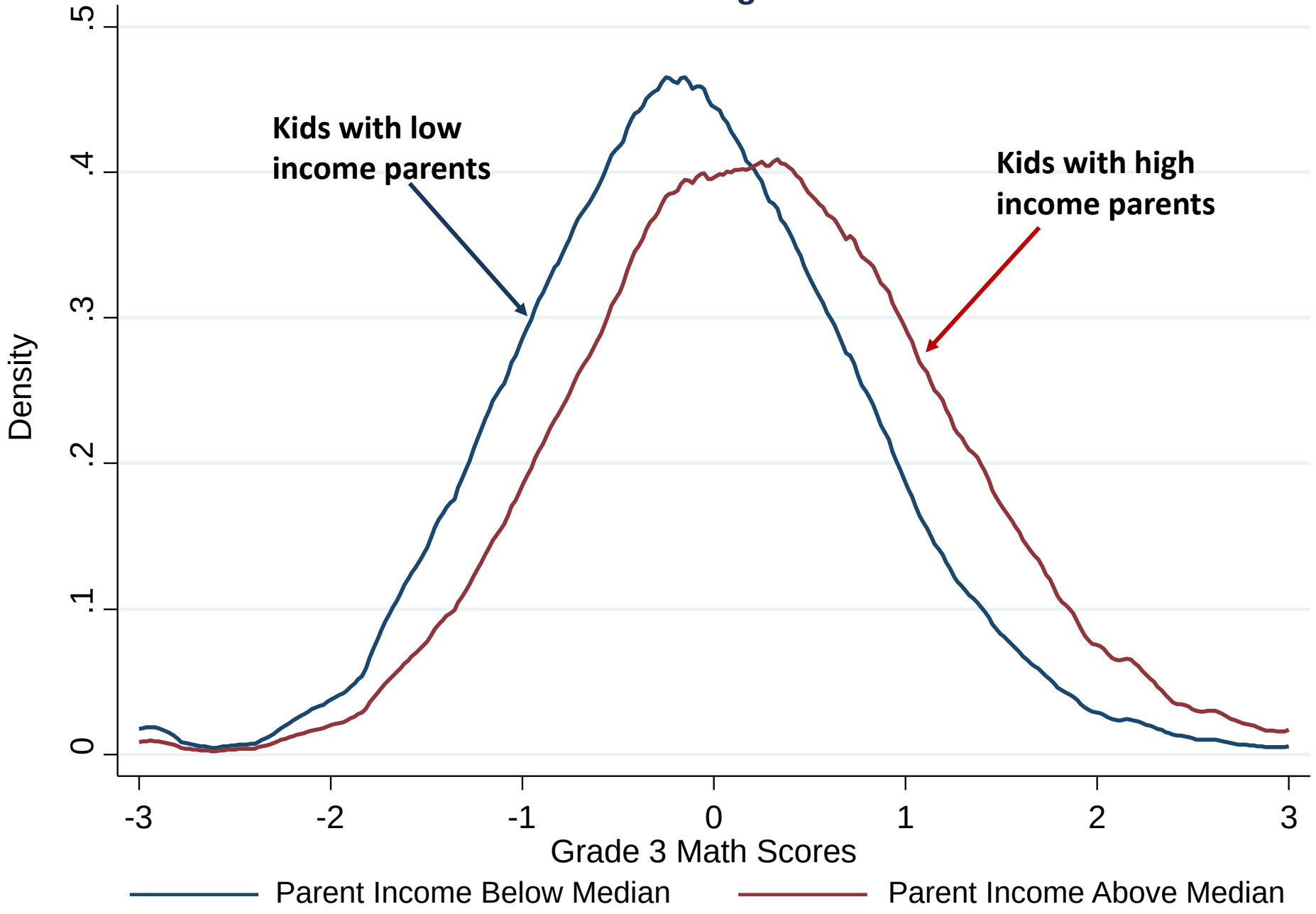


Table 2: What Fraction of the Gap in Patenting by Parent Income is Explained by Differences in Test Scores?

	Patent Rate (per 10k Individuals)	Gap Relative to Above-Med. Income
Above Median Income	5.82	
Below Median Income	2.15	3.67
Below Median Income (Reweighting Scores)	2.76	3.06 (= 5.82 - 2.76)
% of gap accounted for by 3rd grade scores		16.7%

Note: Calculated through a DiNardo, Fortin & Lemieux (1996) style decomposition reweighting below median income vingtiles with density of 3rd grade test scores of the above median income kids

Figure 8: Patent Rates vs. 3rd Grade Test Scores for Children with Low vs. High Income Parents

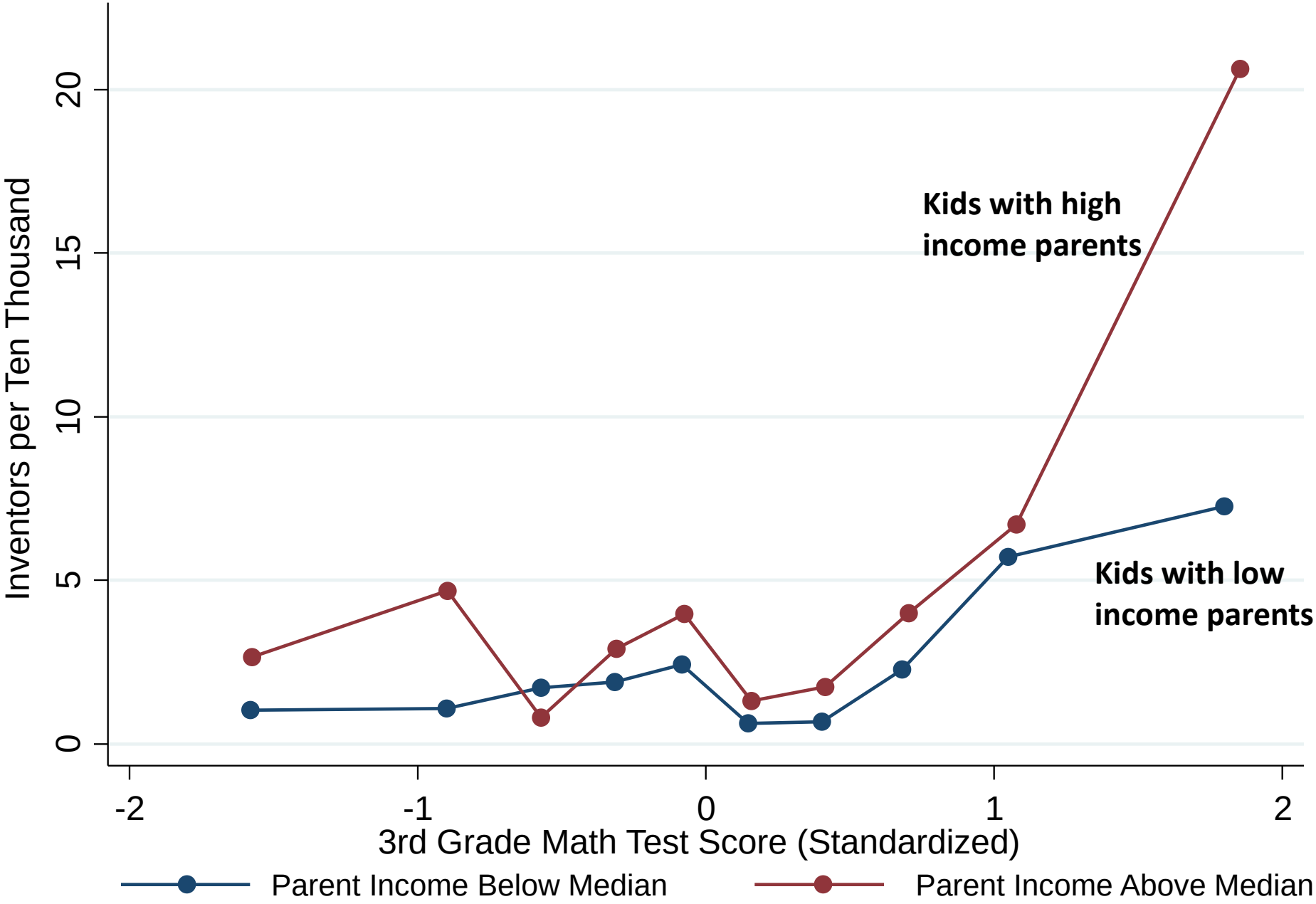


Figure 9: Percent of Gap in Patent Rates Between Low vs High-Income Students Explained by Test Scores in Grades 3-8

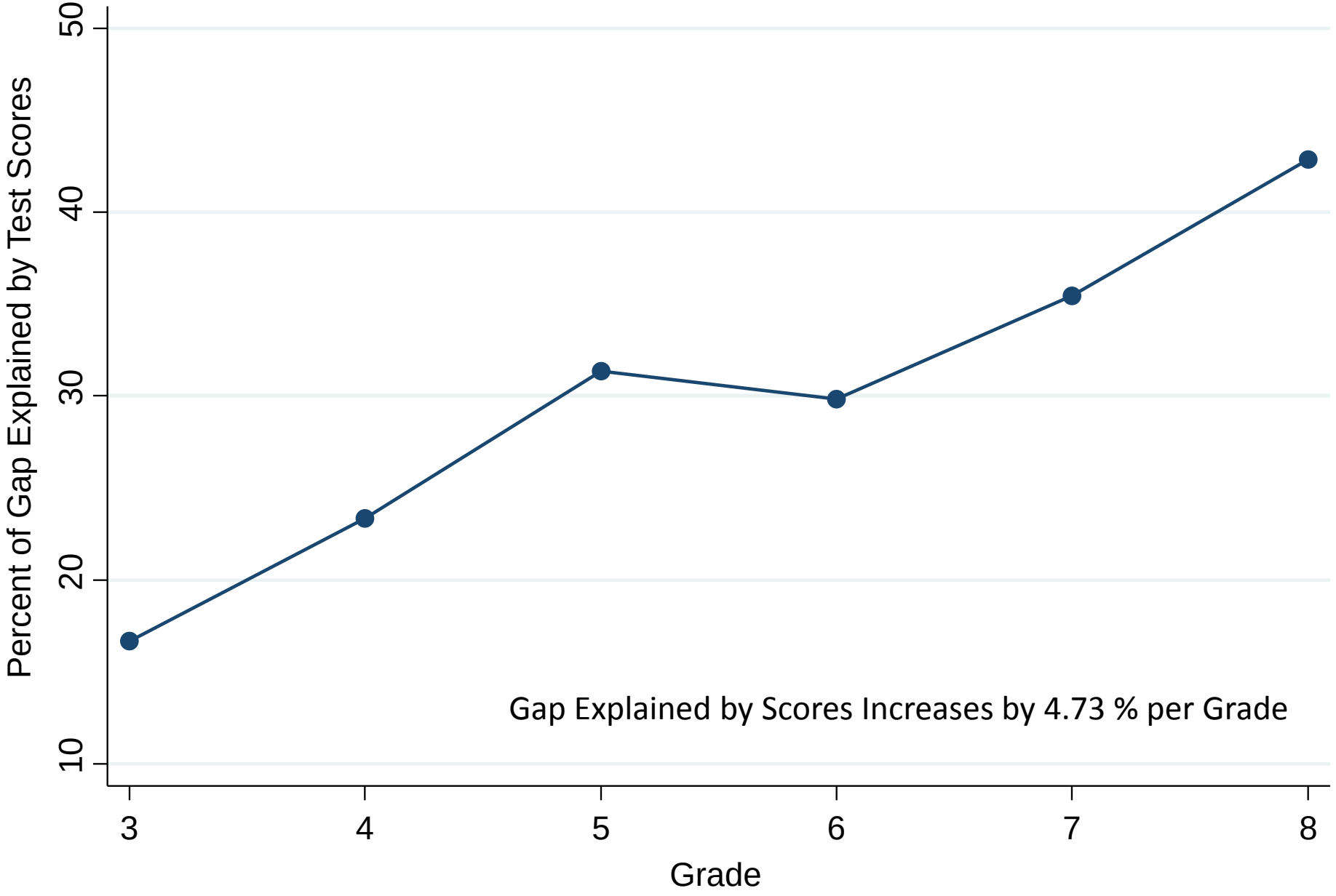
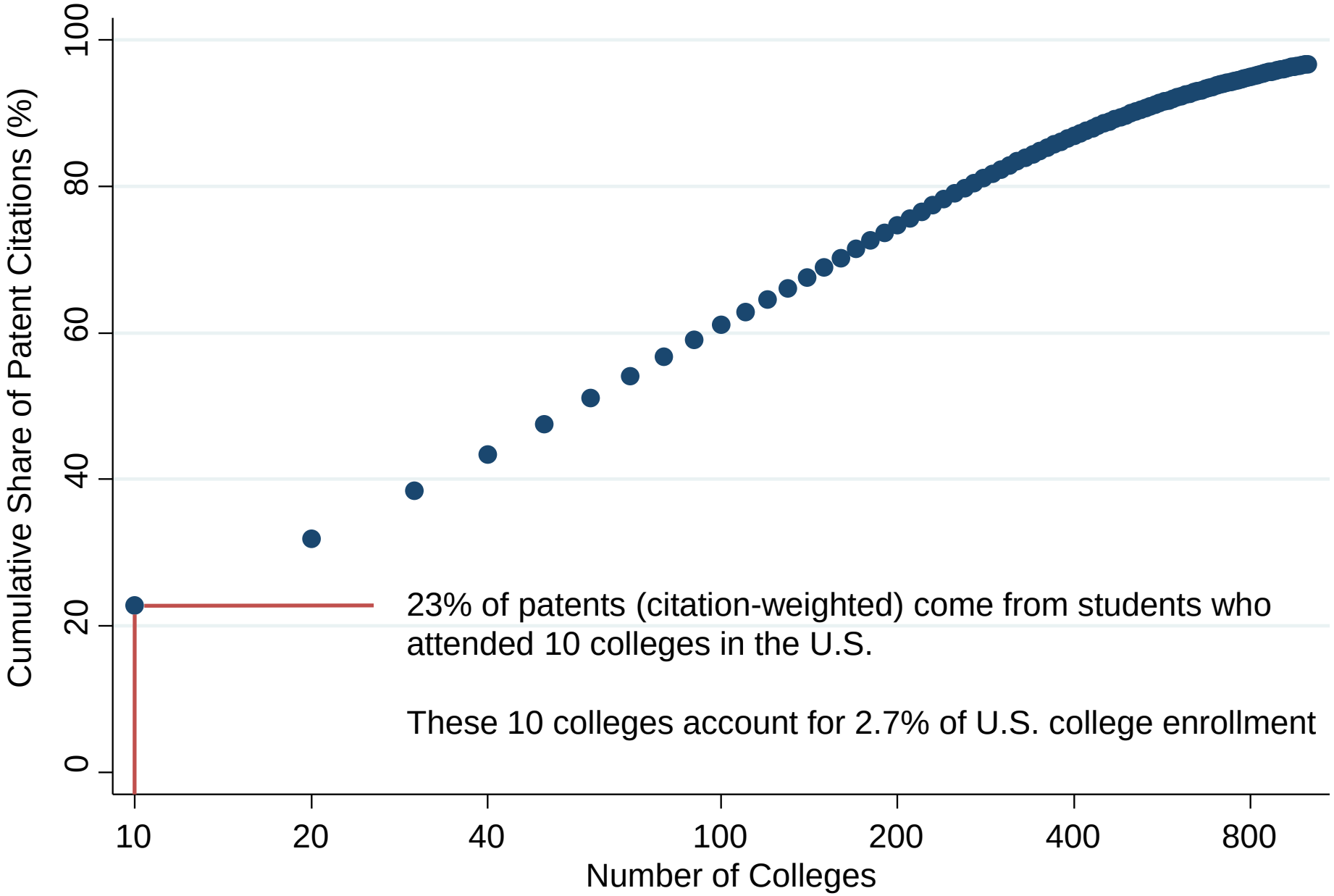


Figure 16: Concentration of Innovation Among Graduates of Selected Colleges



Sample: 200,000 inventors enrolled in college between 1999-2012

Human Capital & Innovation

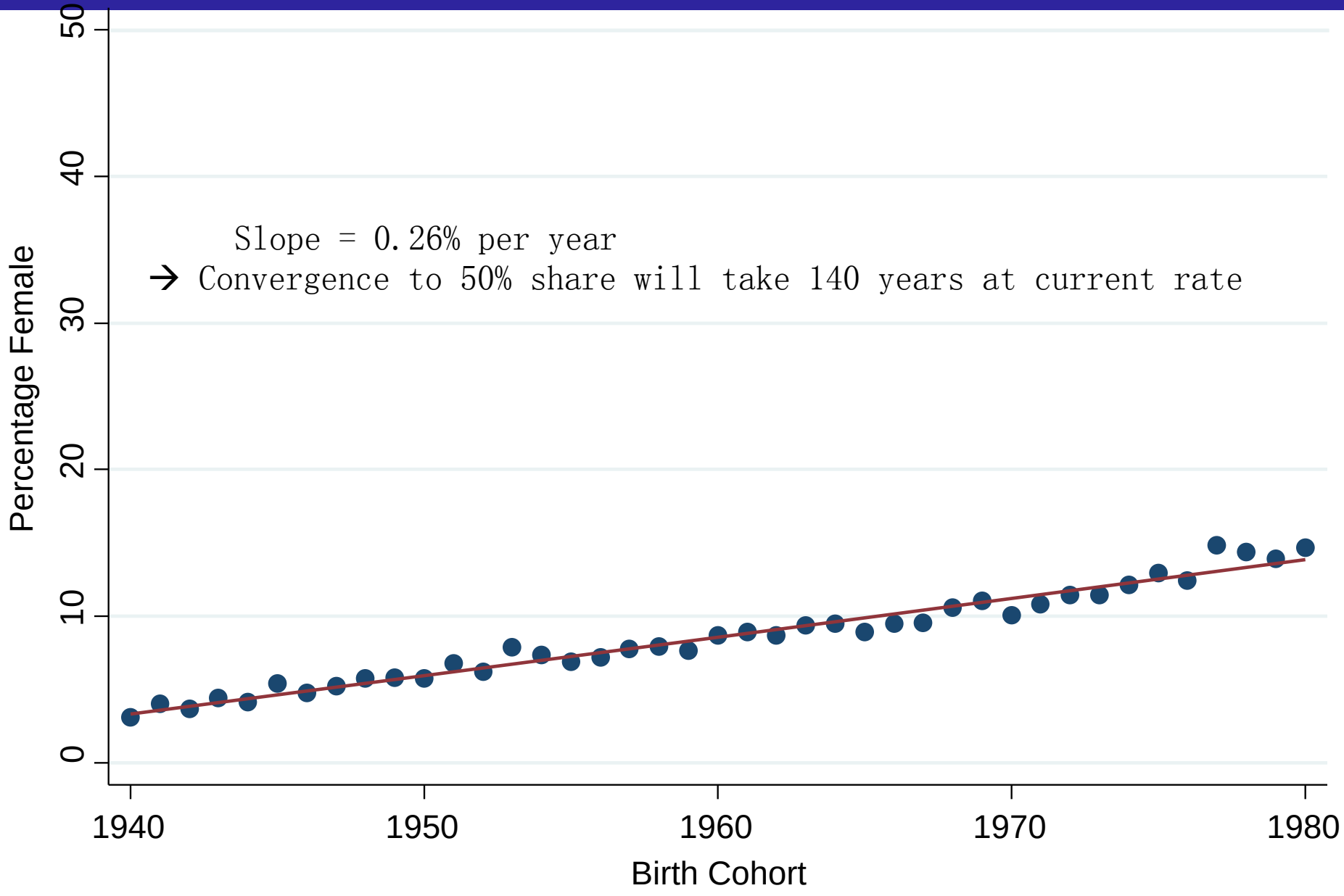
- Using whether individual attended a (high quality) college accounts for ~90% of the income-innovation relationship

- Issues with educational explanation of the income-innovation link
  - Measurement errors with test scores
  - Genes affect childhood development, not just initial level (Plomin et al 2013, *Behavioral Genetics* on Colorado Adoption studies)

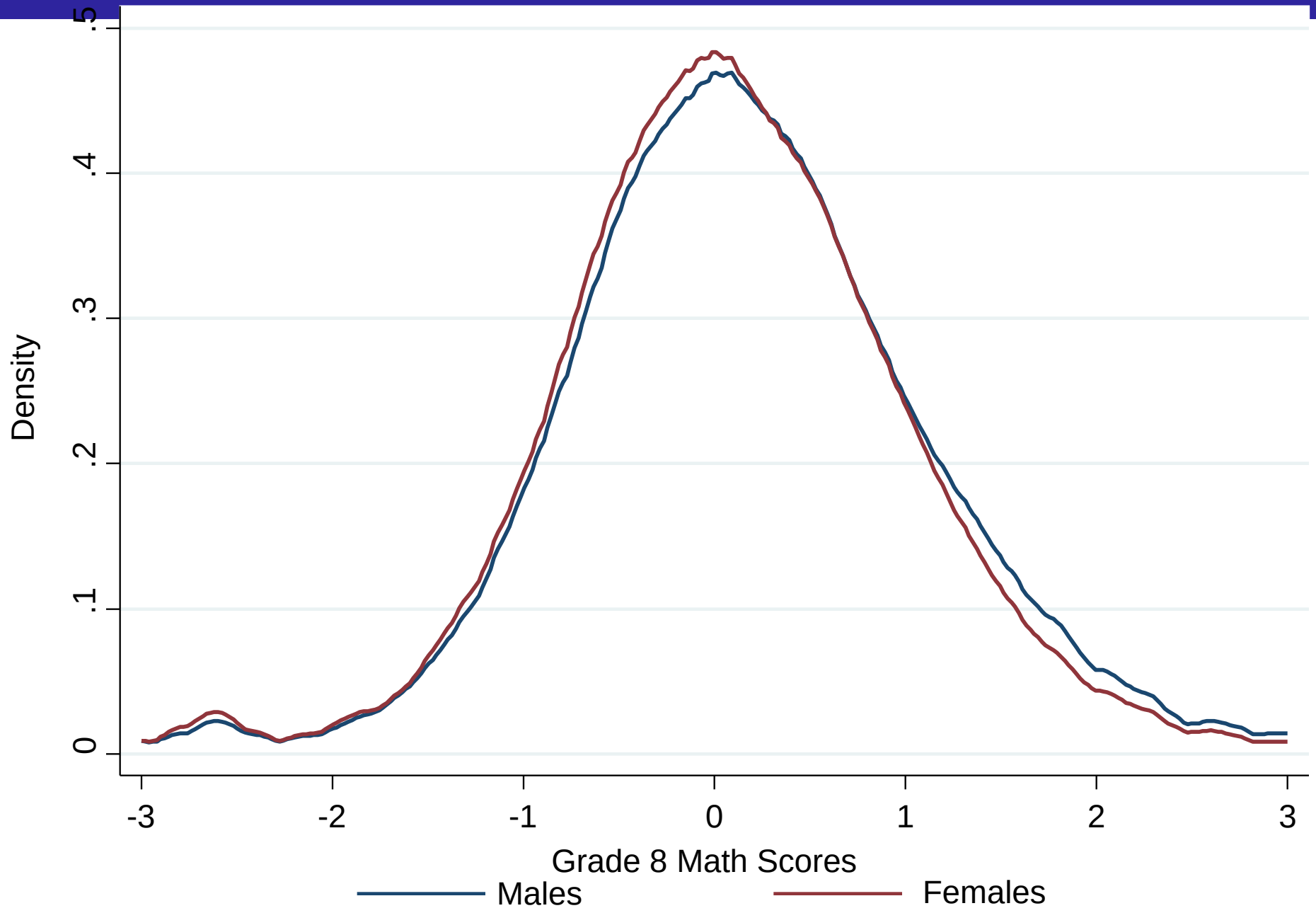
- Use birth certificates to distinguish between **biological** parents (named at time of birth) & adults who are currently bringing up child
  - Controlling for biological parents' income accounts does not explain all (~half) of the relationship between initial family income & innovation

- But many issues (e.g. income not sufficient for all biological influences) so also look at place-based designs

Percentage of Female Patent Holders by Birth Cohort



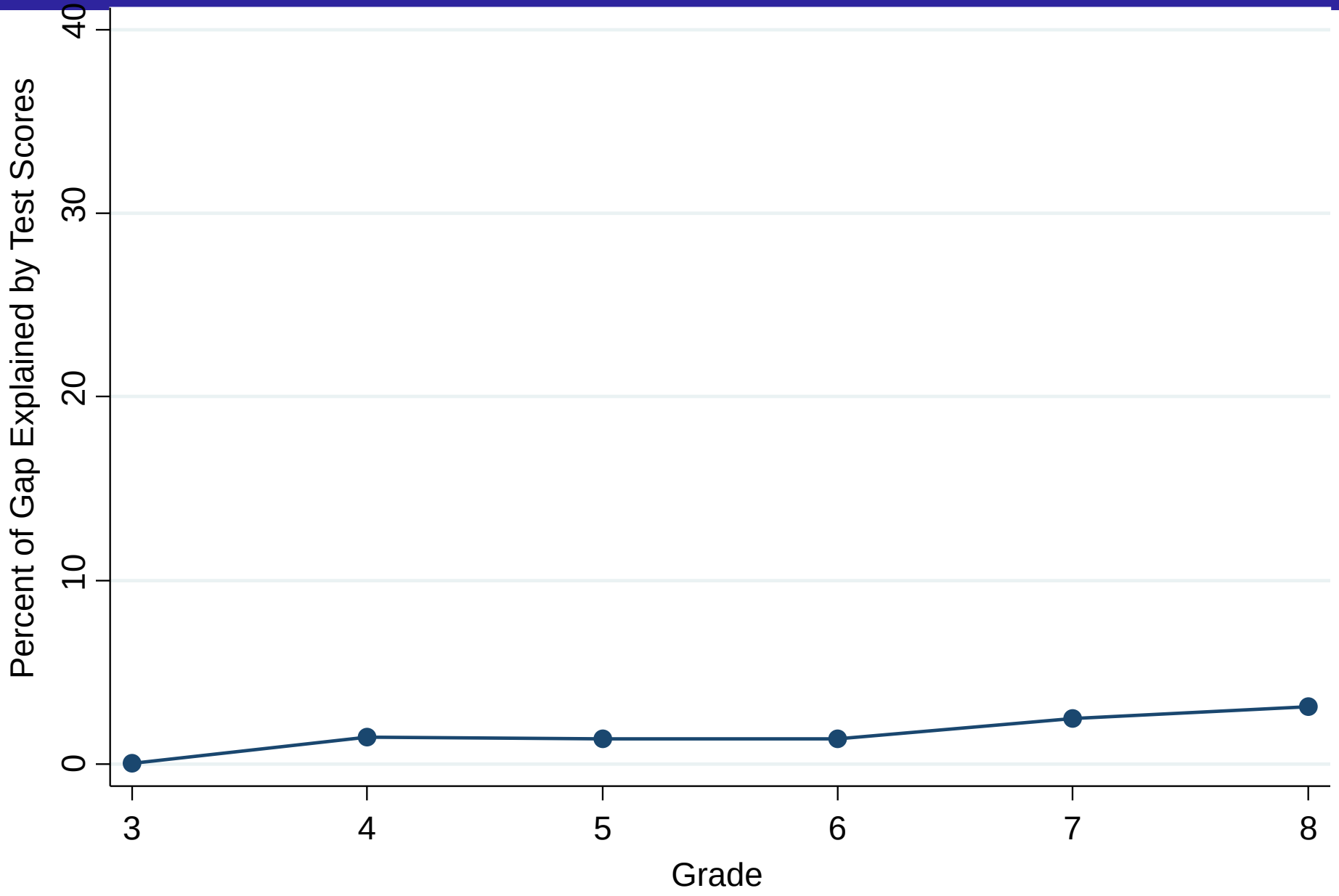
Distribution of Math Test Scores in 8th Grade for Males vs. Females



What Fraction of the Gender Gap in Patenting is Explained by Differences in Test Scores?

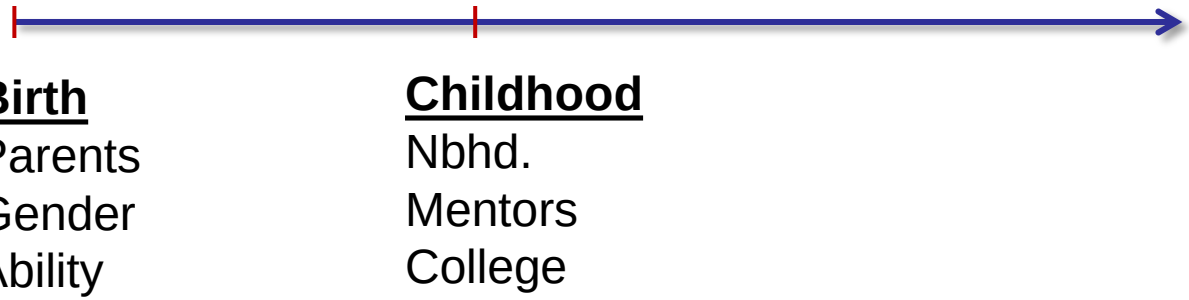
	Patent Rate (per 10k Individuals)	Gap Relative to Males
	(1)	(2)
Males	8.26	
Females	1.62	6.63
Females (Reweighting Scores)	1.83	6.42
%. of gap explained by 8th grade scores		3.1%

Percent of Gender Gap in Patent Rates Explained by Test Scores in Grades 3-8



The Lifecycle of Inventors

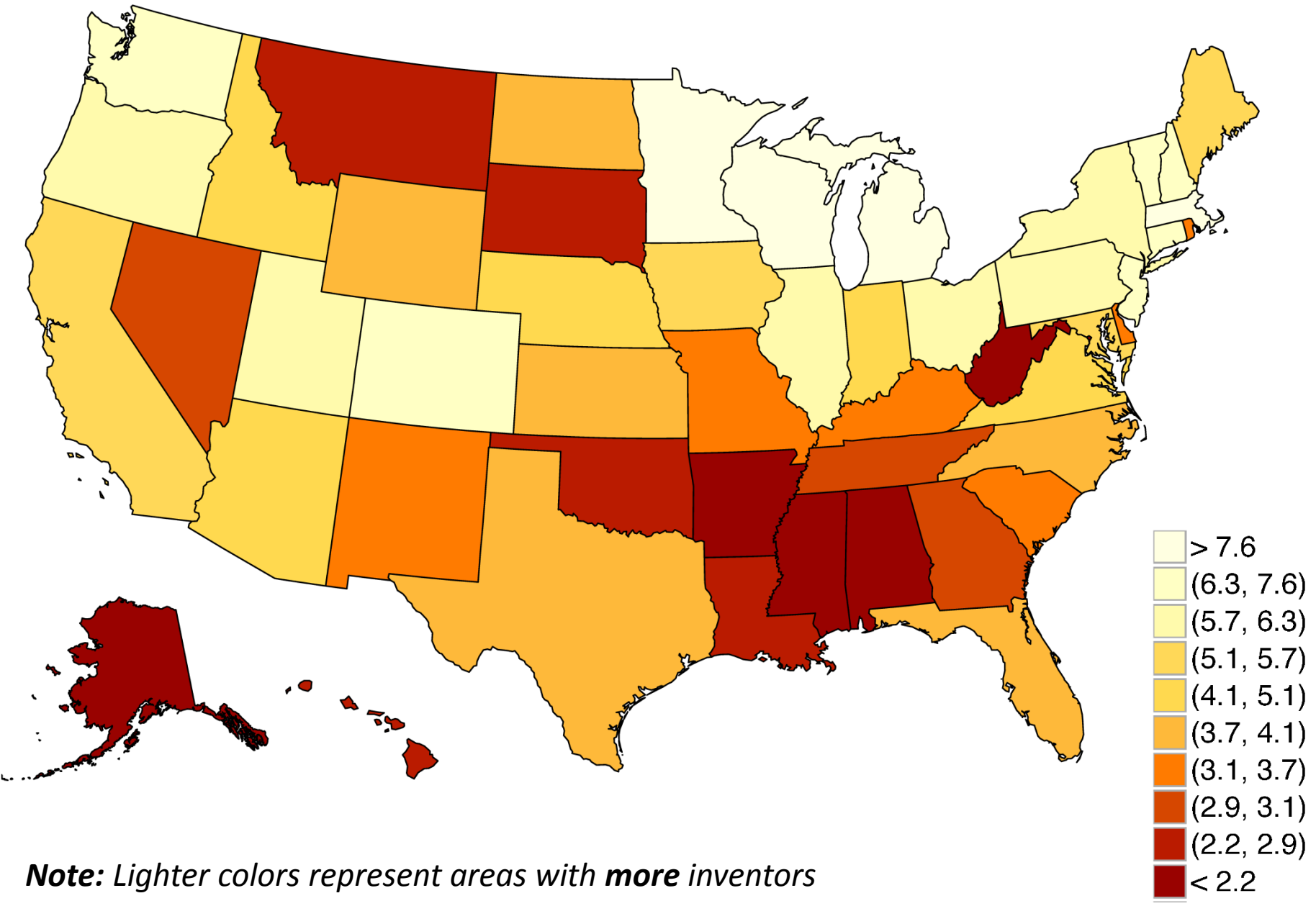
- Organize analysis around the chronology of an inventor's life



Neighborhoods

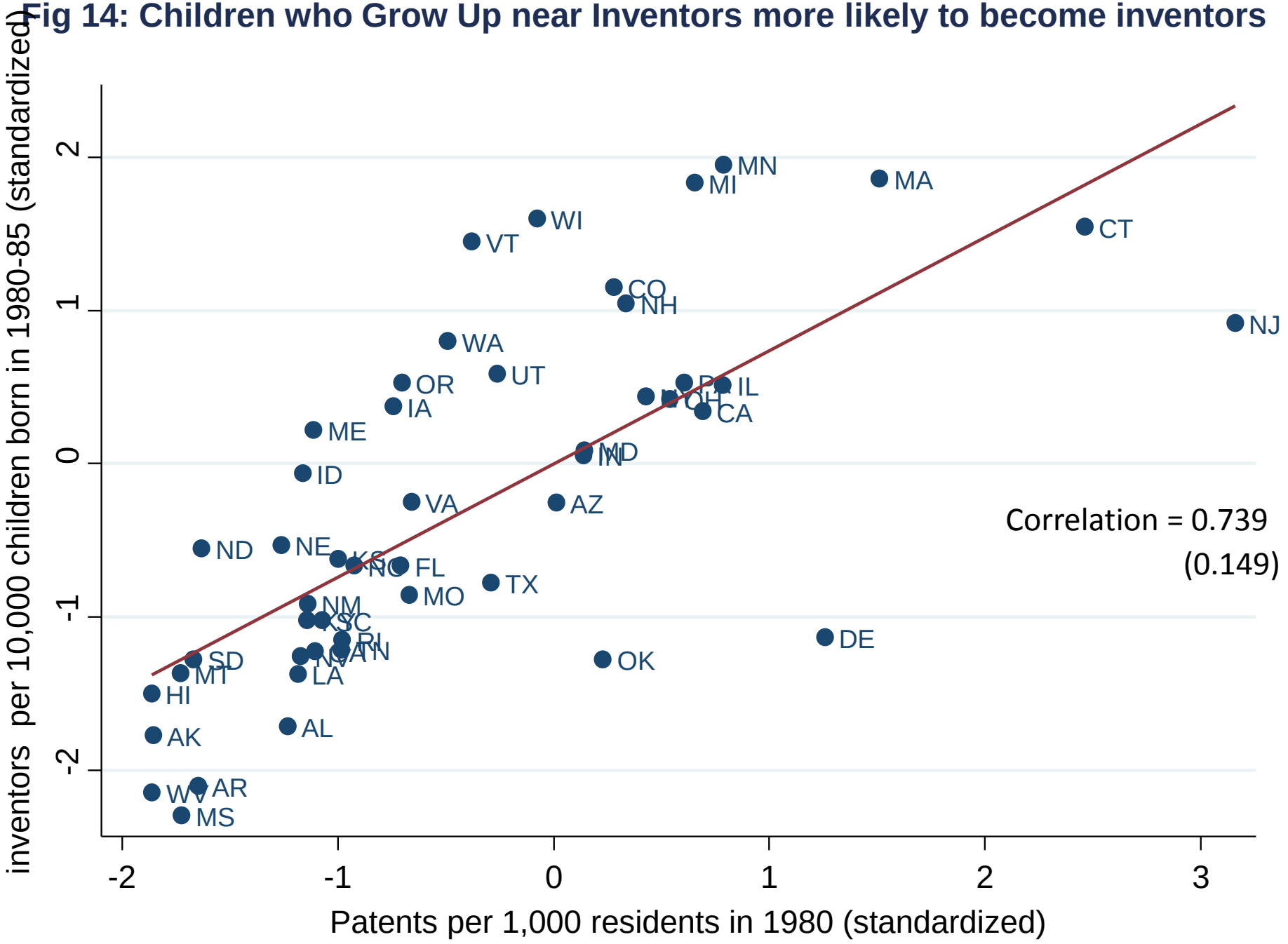
- To what extent are rates of innovation affected by childhood environment?
- As a first step, classify children into states based on where they *grew up* (not necessarily where they currently live)
- Correlate patent rate for children in 1980-85 birth cohorts with patent rate for residents in 1980

Figure 13: The Origins of Inventors Patent Rates (per 10,000 Children) by State where Child Grew Up (Light colors mean LOWER patent rates)



Note: *Lighter colors represent areas with* ***more*** *inventors*

Fig 14: Children who Grow Up near Inventors more likely to become inventors



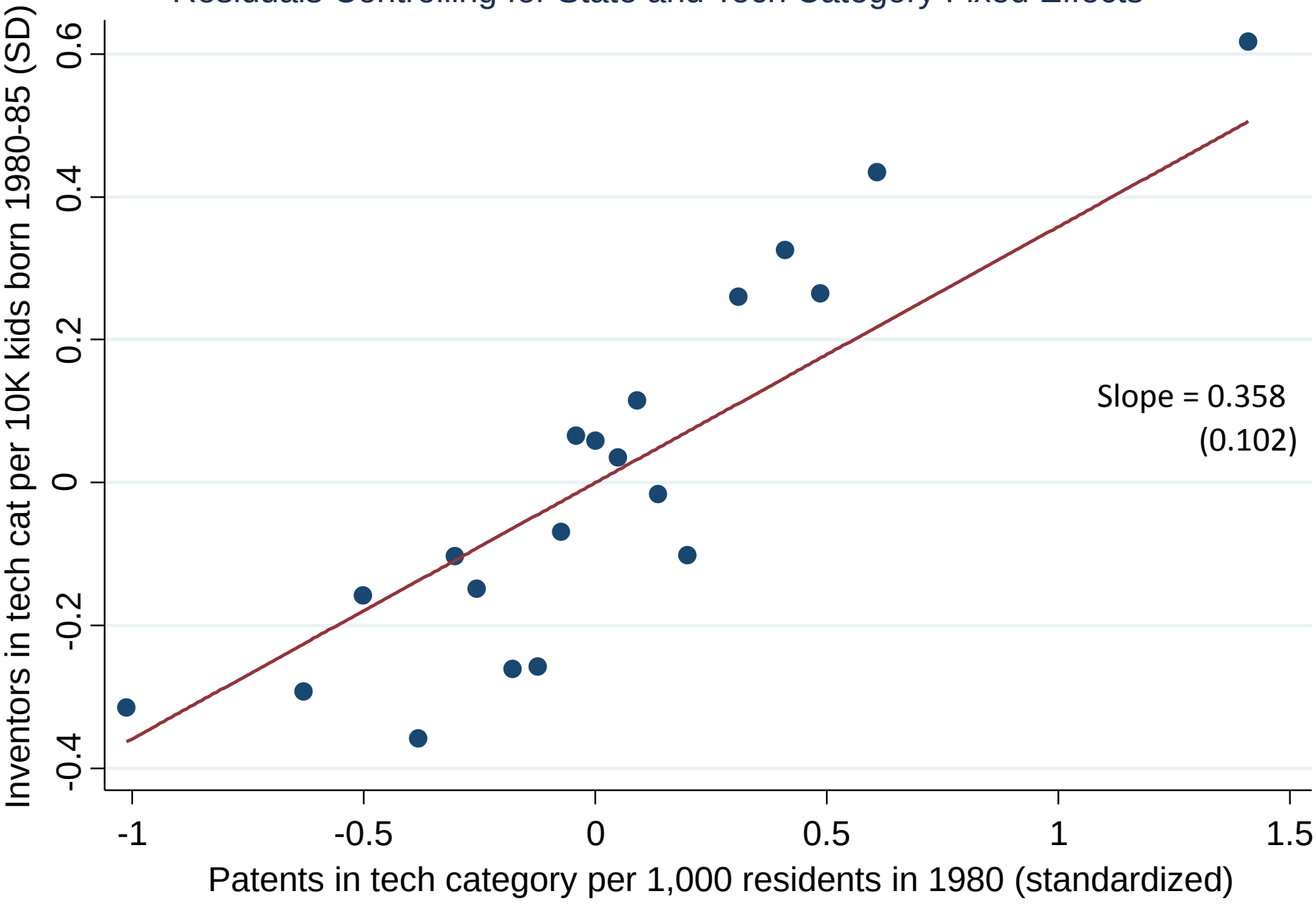
Neighborhoods

- Children raised in areas with more inventors are more likely to be inventors themselves
  - Could be driven by numerous factors (One potential mechanism: mentoring/peer effects)
  - Currently studying **movers** to distinguish selection from causal effects of place, as in Chetty and Hendren (2014)

- Suggestive evidence: study patterns *within* technological class
  - Does Minnesota (Mayo Clinic) raise medical innovators?
  - Does the Bay Area (Silicon Valley) raise information technology innovators?

Fig. 15: Correlation between Patent Rates of Children and Prior Residents

Residuals Controlling for State and Tech Category Fixed Effects



The Lifecycle of Inventors

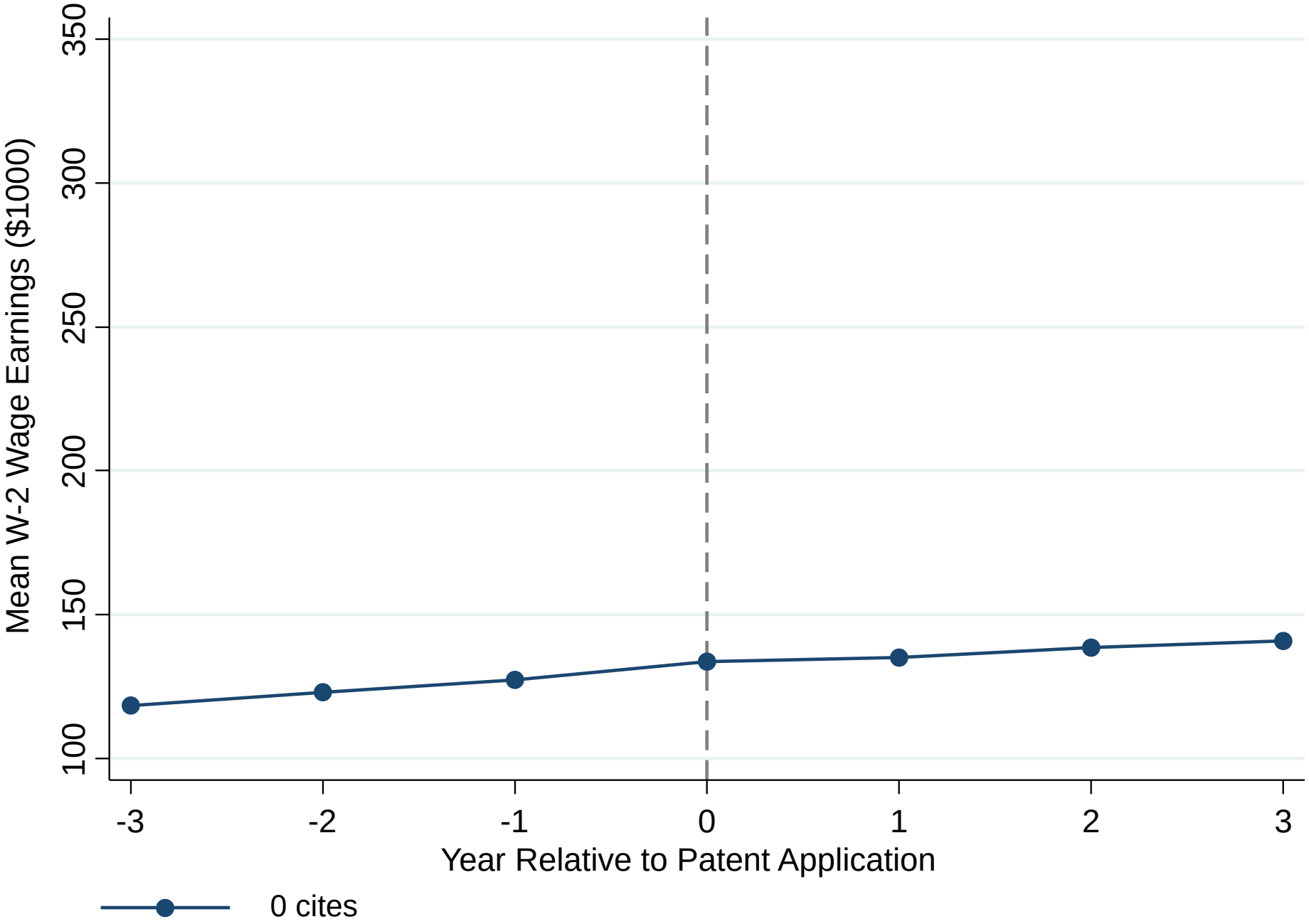
- Organize analysis around the chronology of an inventor's life

Birth
Parents
Gender
Ability

Childhood
Nbhd.
Mentors
College

Career
Earnings
Employers

Fig 17: Returns to Innovation: Event Studies of Earnings Around Patent Application



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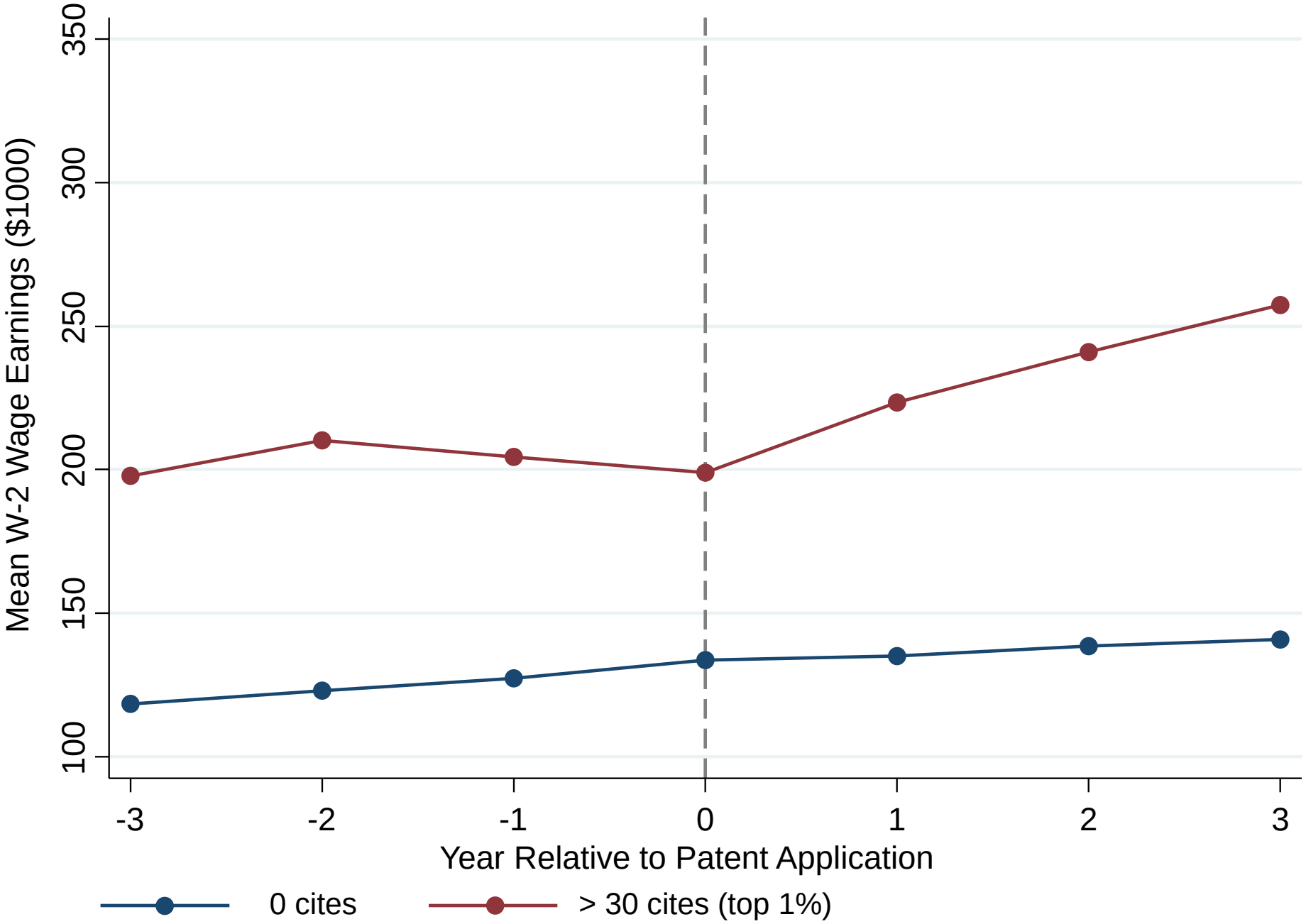

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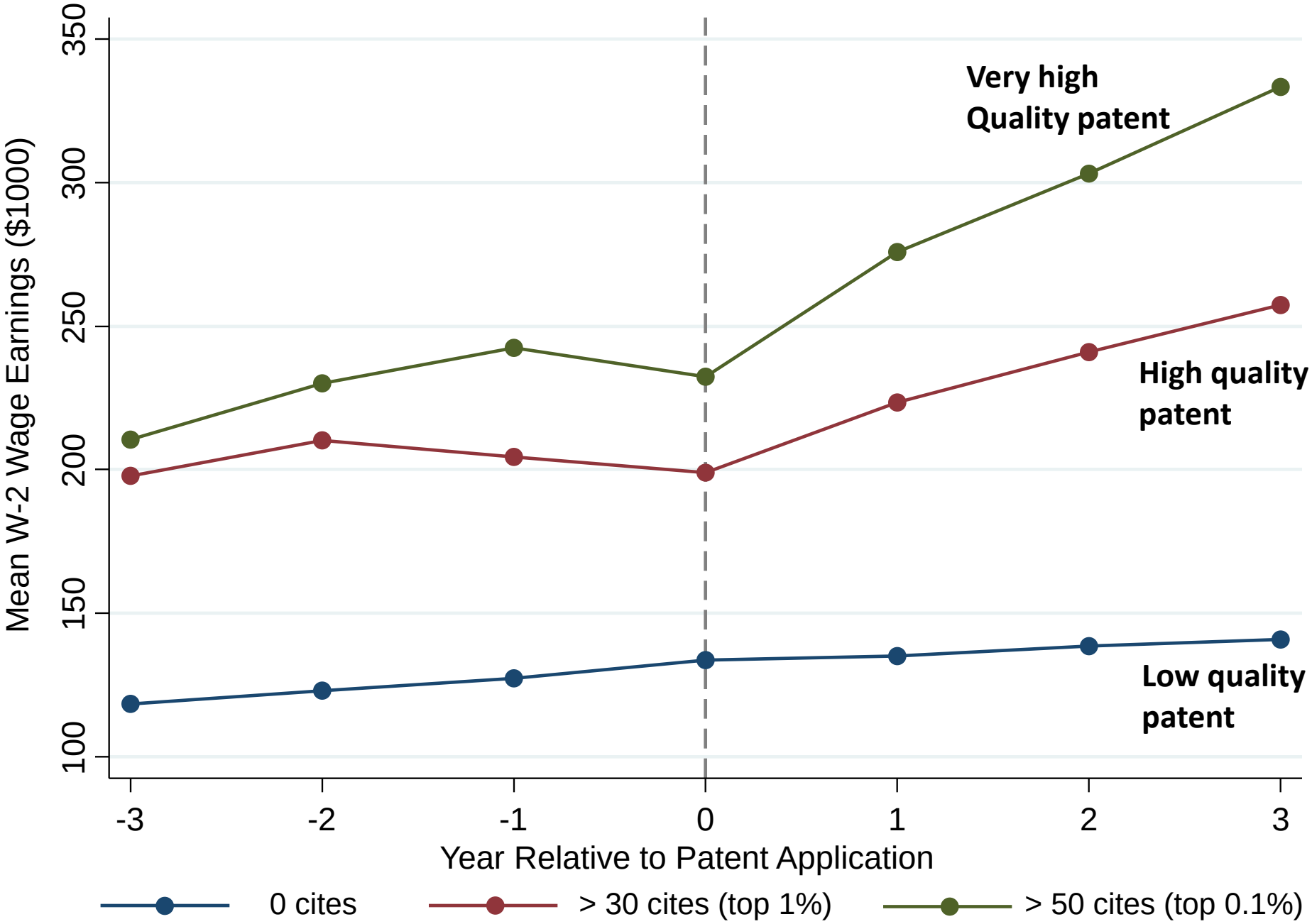

Returns to Innovation

- Wages grow before time of first patent application (upwards age-earning profile), so need to look at "twist" in profile after patent event

- The returns to innovation are highly skewed by quality

- Returns occur around application rather than granting of patent

- Use the distribution of returns to simulate the effects of different policies on incentive to innovate
  - Skewness implies that effect of top tax rates on innovation likely to be low if utility is concave
  - Concave utility → utility payoff to innovation insensitive to top tax rate
  - "Demand side" policies less effective than supply side policies

Conclusions

- Profile of large-scale US inventor life-cycle using admin data
- Parental income matters for inventor status, mainly via education
- Neighborhoods & place seem also matter (it's not all genes)
- Suggests misallocation of talent. We could boost innovation by getting more high ability but low income kids to be inventors. Unconventional supply side policies
  - Gifted & talented programs in low income schools (e.g. Card, 2014)
  - Improvements in disadvantaged schools (e.g. Fryer, 2014)
  - Improving neighborhoods/mentors (e.g. Chetty et al, 2015)
- Demand side policies less effective in long-run

BACK UP

(19) **United States**

(12) **Patent Application Publication**

Musabji et al.

(10) **Pub. No.: US 2014/0244159 A1**

(43) **Pub. Date: Aug. 28, 2014**

(54) **METHOD OF OPERATING A NAVIGATION SYSTEM USING IMAGES**

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(72) Inventors: **Adil M. Musabji**, Glendale Heights, IL (US); **Jason Borak**, Lombard, IL (US); **James D. Lynch**, Chicago, IL (US); **Narayanan Alwar**, South Barrington, IL (US); **Jon D. Shutter**, Chicago, IL (US)

(73) Assignee: **Navteq North America, LLC**, Chicago, IL (US)

(21) Appl. No.: **14/272,045**

(22) Filed: **May 7, 2014**

Related U.S. Application Data

(63) Continuation of application No. 13/279,537, filed on Oct. 24, 2011, now Pat. No. 8,751,156, which is a continuation-in-part of application No. 12/879,178, filed on Sep. 10, 2010, now Pat. No. 8,301,372, which is a continuation of application No. 12/253,488, filed on Oct. 17, 2008, now Pat. No. 7,818,124, which is a continuation of application No. 10/880,815, filed on Jun. 30, 2004, now Pat. No. 7,460,953.

Publication Classification

(51) **Int. Cl.**
G01C 21/36 (2006.01)

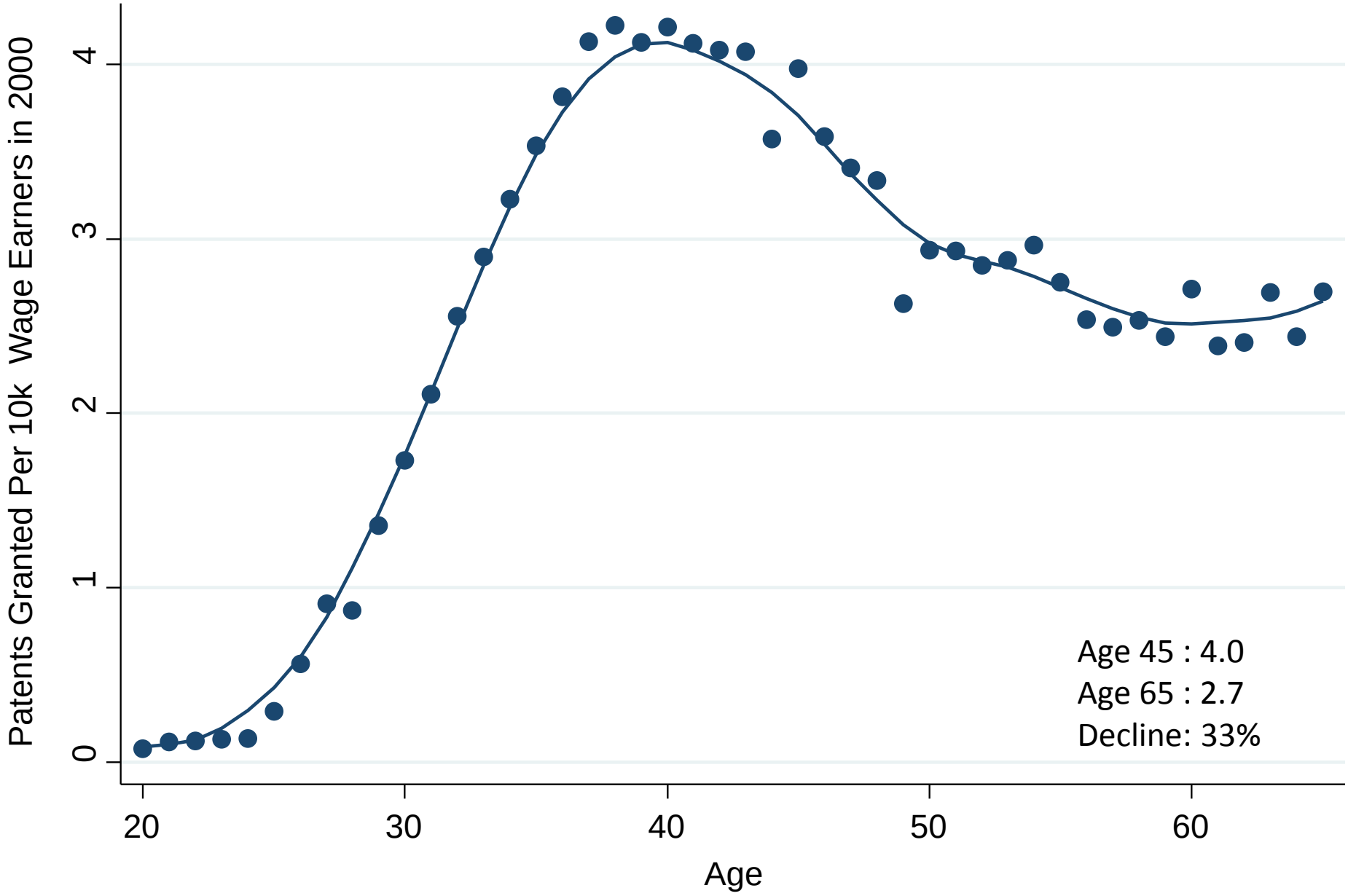
(52) **U.S. Cl.**
CPC ***G01C 21/3647*** (2013.01)
USPC **701/428**

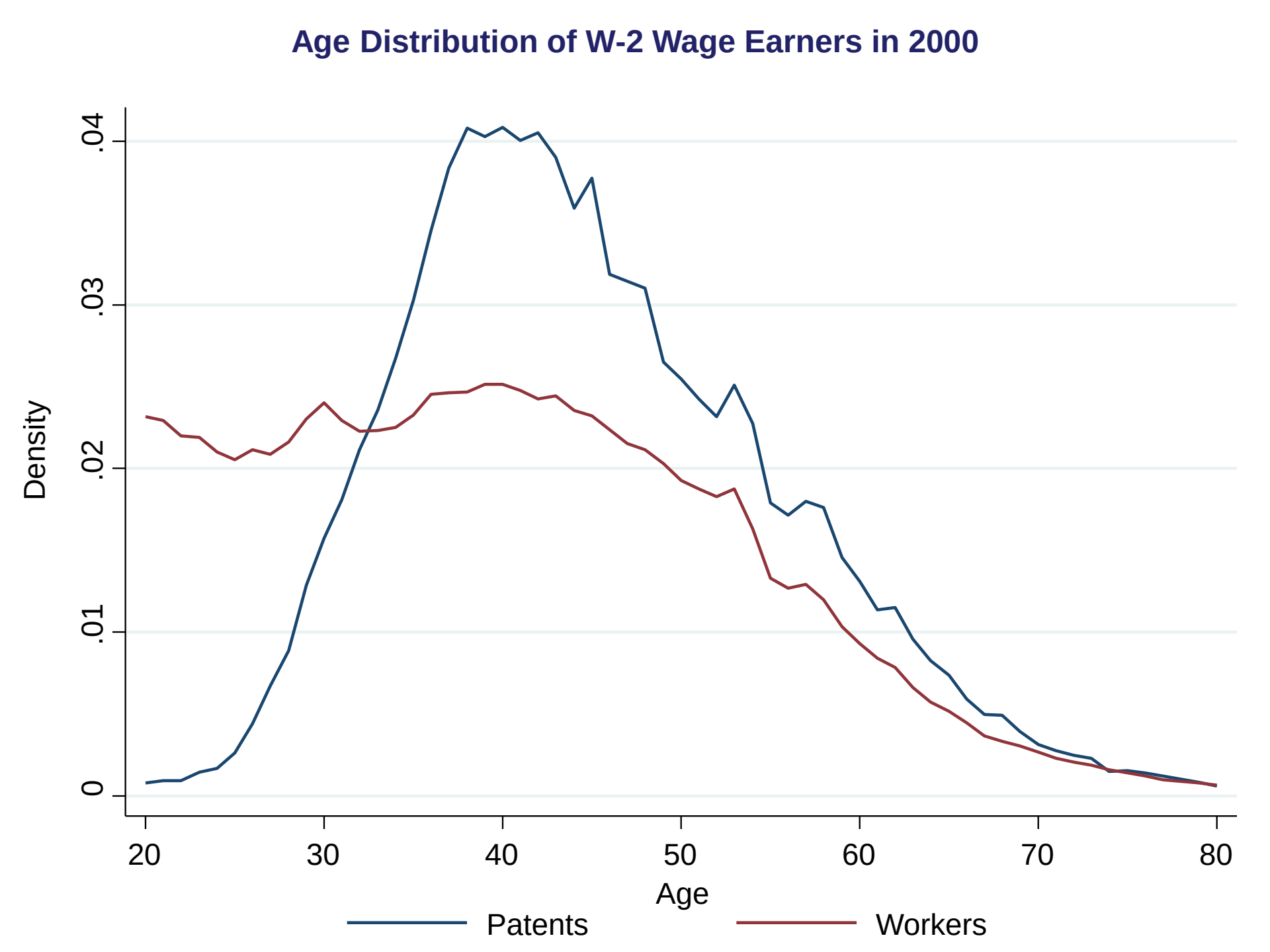
(57) **ABSTRACT**

A navigation system comprises a processor, a geographic database and a guidance application executable on the processor. The guidance application obtains data from the geographic database and obtains a photographic image. The guidance application overlays an advertisement route highlight on said photographic image. The advertisement route highlight graphically illustrates a path corresponding to a route and a direction of travel for the route. The advertisement route highlight includes a series of advertisement decals.

- Rates of patenting rise steeply in inventors' late 20s and 30s
- Then decline starting around age 45
- But the rate of patenting does not decline much more rapidly with age than the propensity to work in general

Figure 3: Highly Cited (Top 20%) Patents Per Wage Earner by Age in 2000




Age Distribution of W-2 Wage Earners in 2000
Density
0
.01
.02
.03
.04
20
30
40
50
60
70
80
Age
Patents
Workers

- Father an engineer & salesman & owned a company that manufactured electrical equipment
- Education as high quality schools in Germany, Italy & Switzerland & attended ETH Zurich
- If Einstein was born poor could he have ended up a factory worker?
- How much poorer would the world be?

Model

- Enter labour market with human capital produced by innate ability; accumulated schooling; post-birth inputs from parents & neighbourhood
- Choose between three sectors
  - Low skill (if human capital low)
  - High skill R&D (if human capital high, depends on preferences)
  - High skill non-R&D (if human capital high, depends on preferences)
- For those above a skills threshold, choice of R&D sector depends on returns. Innovation sector more risky: higher if successful, lower if unsuccessful
- Taxes on high income deter entry into innovation sector (Mankiw)
- But **magnitude** of tax effect is lower the more **skewed** are the returns are (holding expected return constant)
  - For reasonable calibrations from our data the tax effect is close to zero