Who Becomes an Inventor in America? The Importance of Exposure to Innovation

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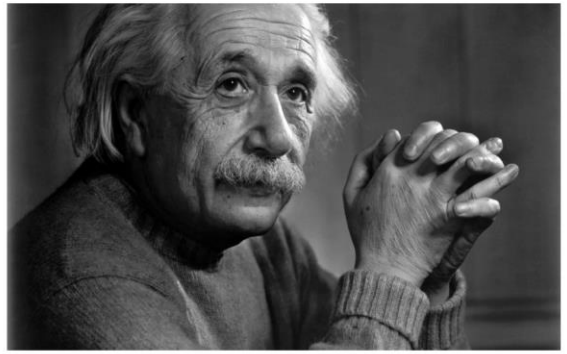

IGL Conference, June 13th 2018

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Introduction

- Many policies used to spur innovation
  - Traditionally a “demand side” focus – e.g. financial incentives via R&D tax credits; top income tax cuts
  - But more effective to increase **supply** of inventors? Increase innovation and social inclusion
- Our approach: study the determinants of who becomes an inventor
  - What type of people become inventors today?
  - What does this teach us about who becomes a successful inventor?
- Create database tracking US individuals over life-cycle
  - Match population of inventors from US Patent Office (USPTO) to de-identified IRS tax records 1996-2014

This Paper

- Track inventors' lives from birth to adulthood, in three parts:
  1. Gaps in innovation by characteristics at birth
  2. Childhood environment and causal effects of exposure
  3. Labor market careers and effects of financial incentives

Summary

- Children from **low income backgrounds**, women & minorities much less likely to become inventors even controlling for measured early ability (e.g. 3rd grade math test scores)

- **Exposure** to innovation in childhood (from parents; parent's colleagues; neighborhoods) a key influence on propensity to become an inventor
  - True even in **very narrow** technology classes
  - Robust to "movers" design

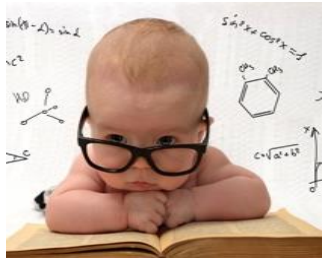
- Develop and calibrate model of occupational choice with barriers to skill acquisition and limited exposure to innovation.
  - **Use model to examine policies:** e.g. Inventor Education programs for disadvantaged more effective than top income tax policy

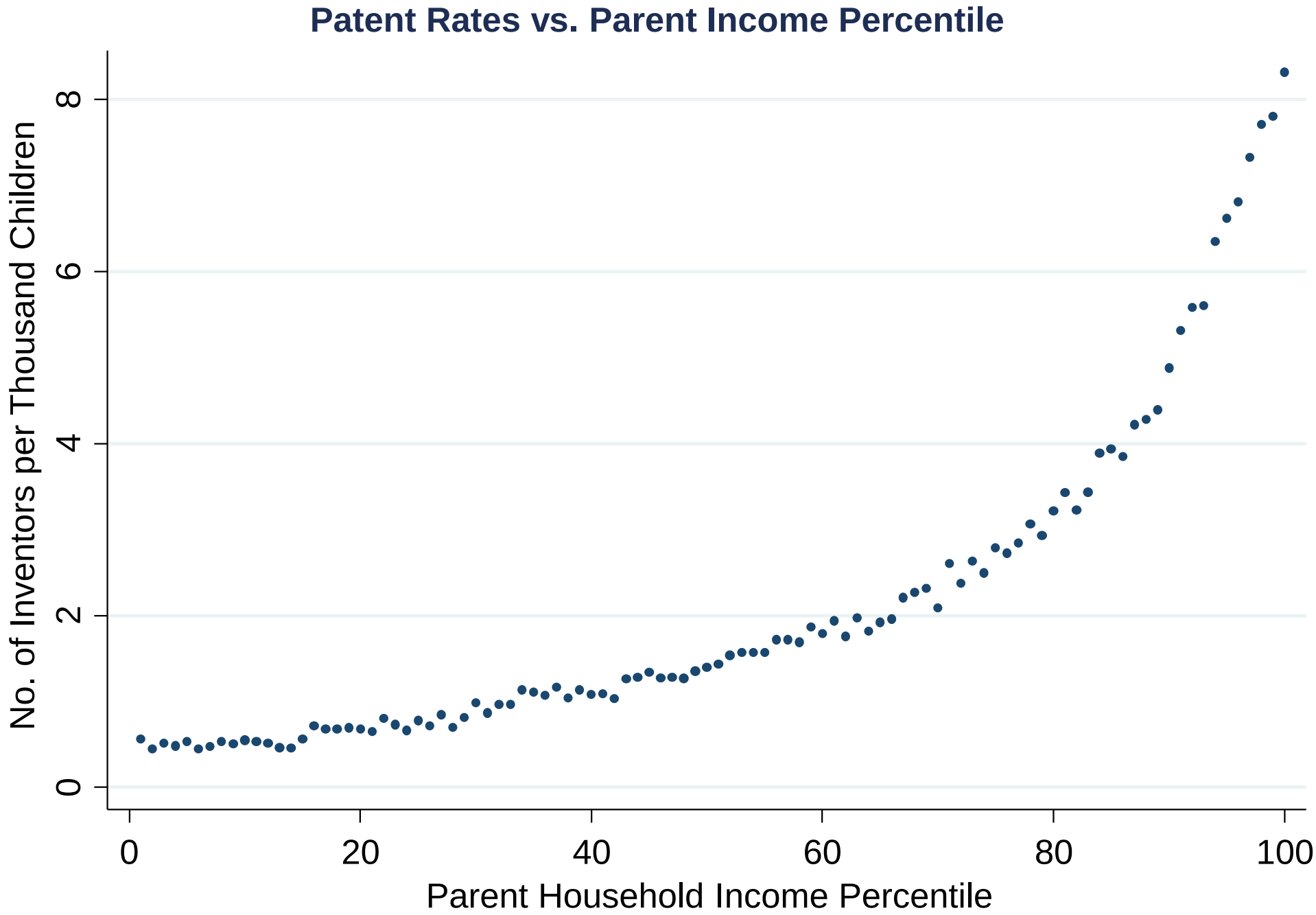
Data

- Patents grants from 1996-2014 from USPTO (Google XML files) and applications from 2001
- Federal income tax returns covering U.S. population from 1996-2012
- Patent data were linked to tax data by inventor name, city, and state at time of patent application
  - 86% of people in patent files linked to tax data (balanced on observables)
  - 1,200,689 unique inventors in linked patent-tax data

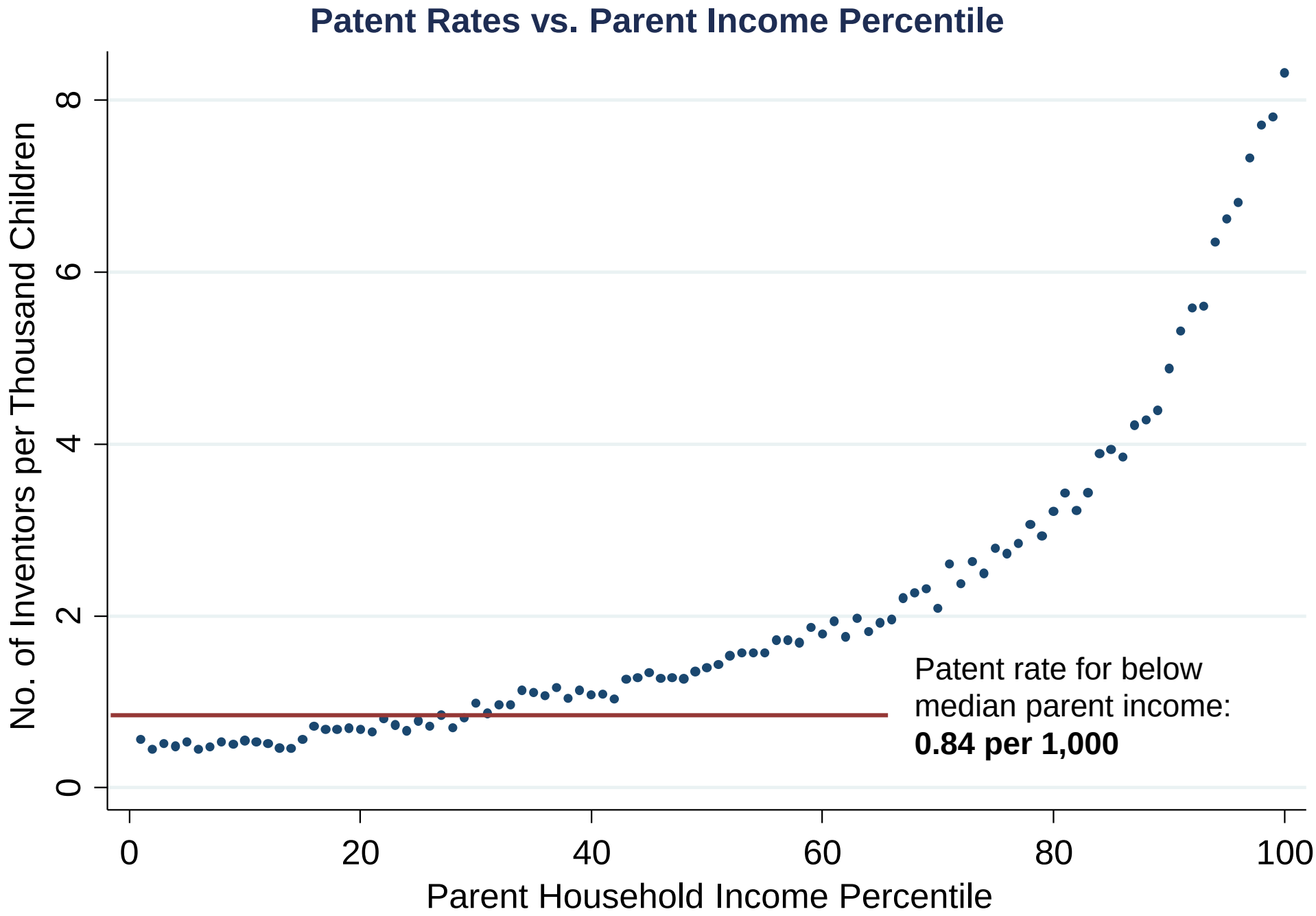
The Lifecycle of Inventors

Birth



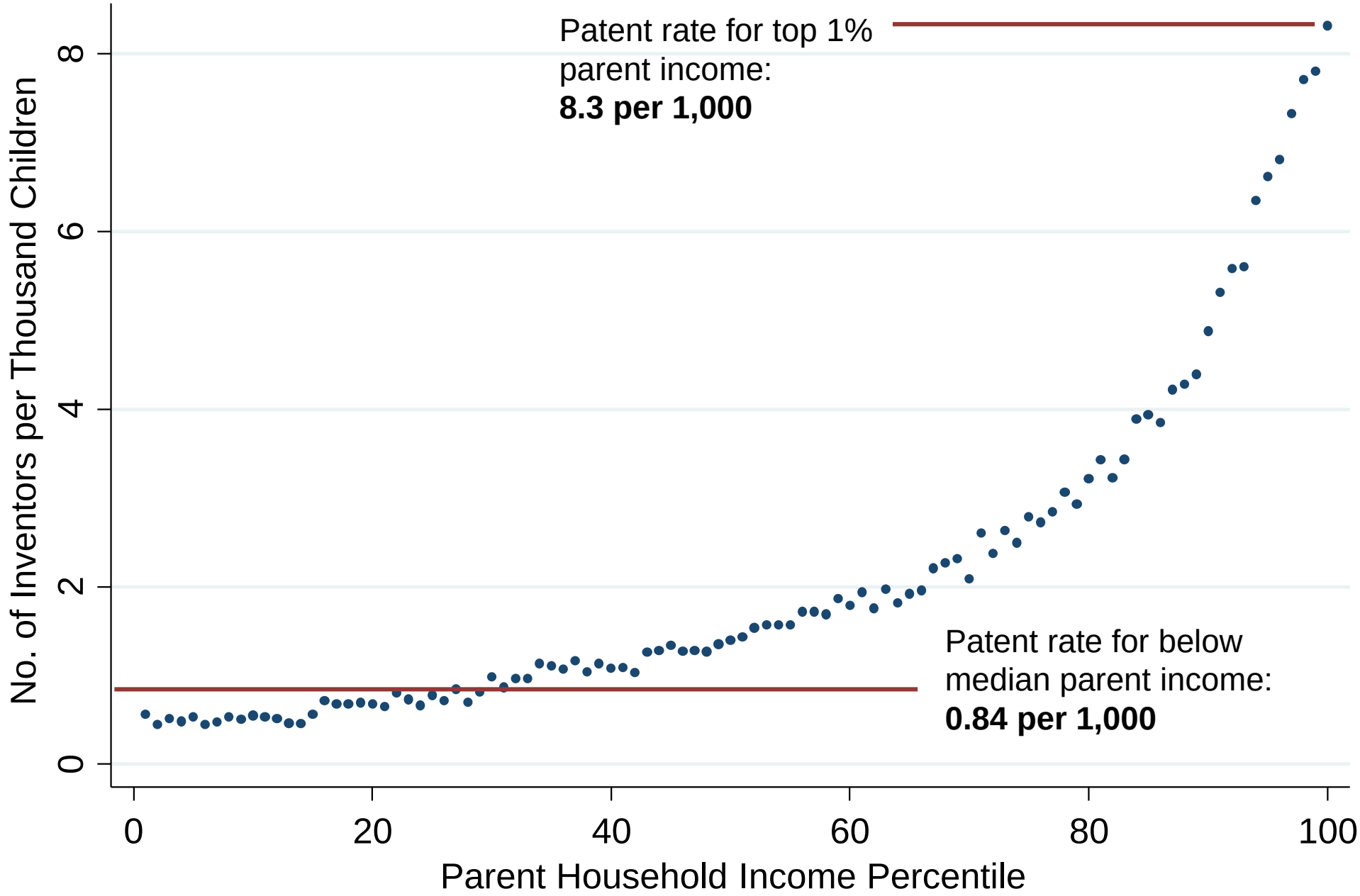


Notes: Sample of children is 1980-84 birth cohorts. Parent Income is mean household income from 1996-2000.



Notes: Sample of children is 1980-84 birth cohorts. Parent Income is mean household income from 1996-2000.

Patent Rates vs. Parent Income Percentile



Notes: Sample of children is 1980-84 birth cohorts. Parent Income is mean household income from 1996-2000.

Why Do Patent Rates Vary with Parent Income?

- In economic models, behavior can be traced to three factors:

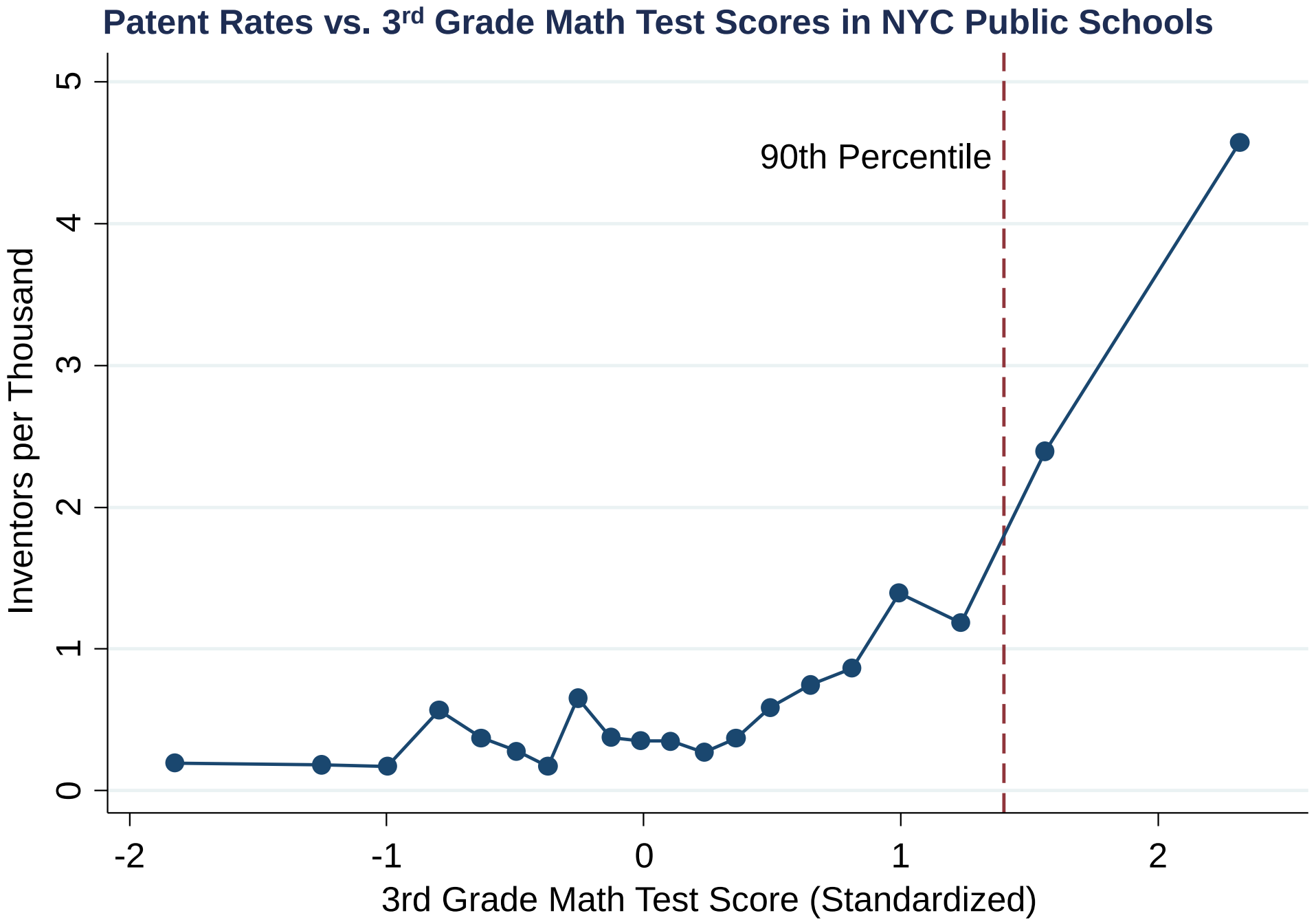
1. **Endowments**: Children from high-income families may have greater ability to innovate

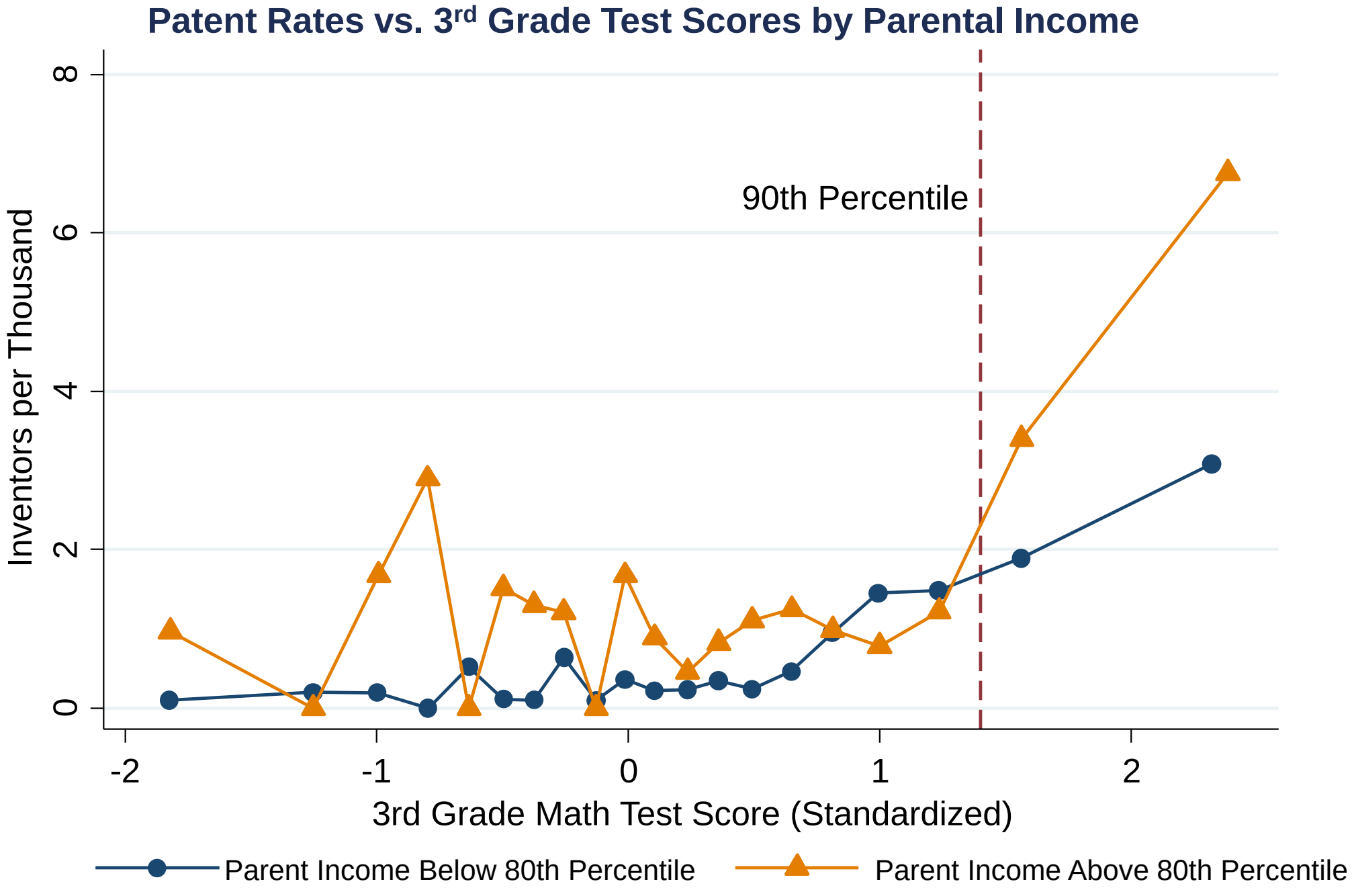
2. **Preferences**: lower income children prefer other occupations (e.g., because of higher risk aversion due to financial constraints)

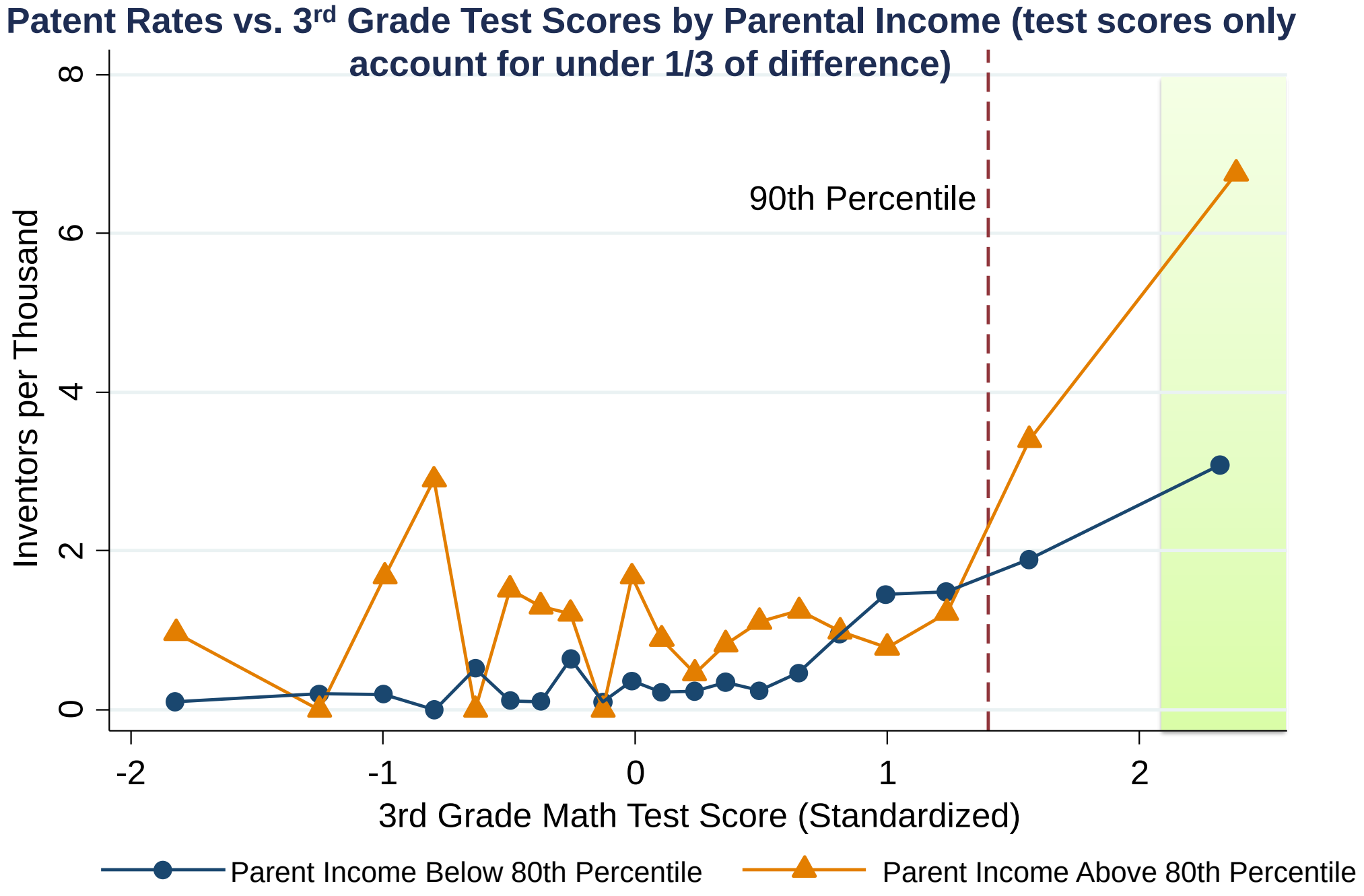
3. **Constraints**: lower income children have comparable talent and preferences but face higher barriers to entry or a lack of exposure

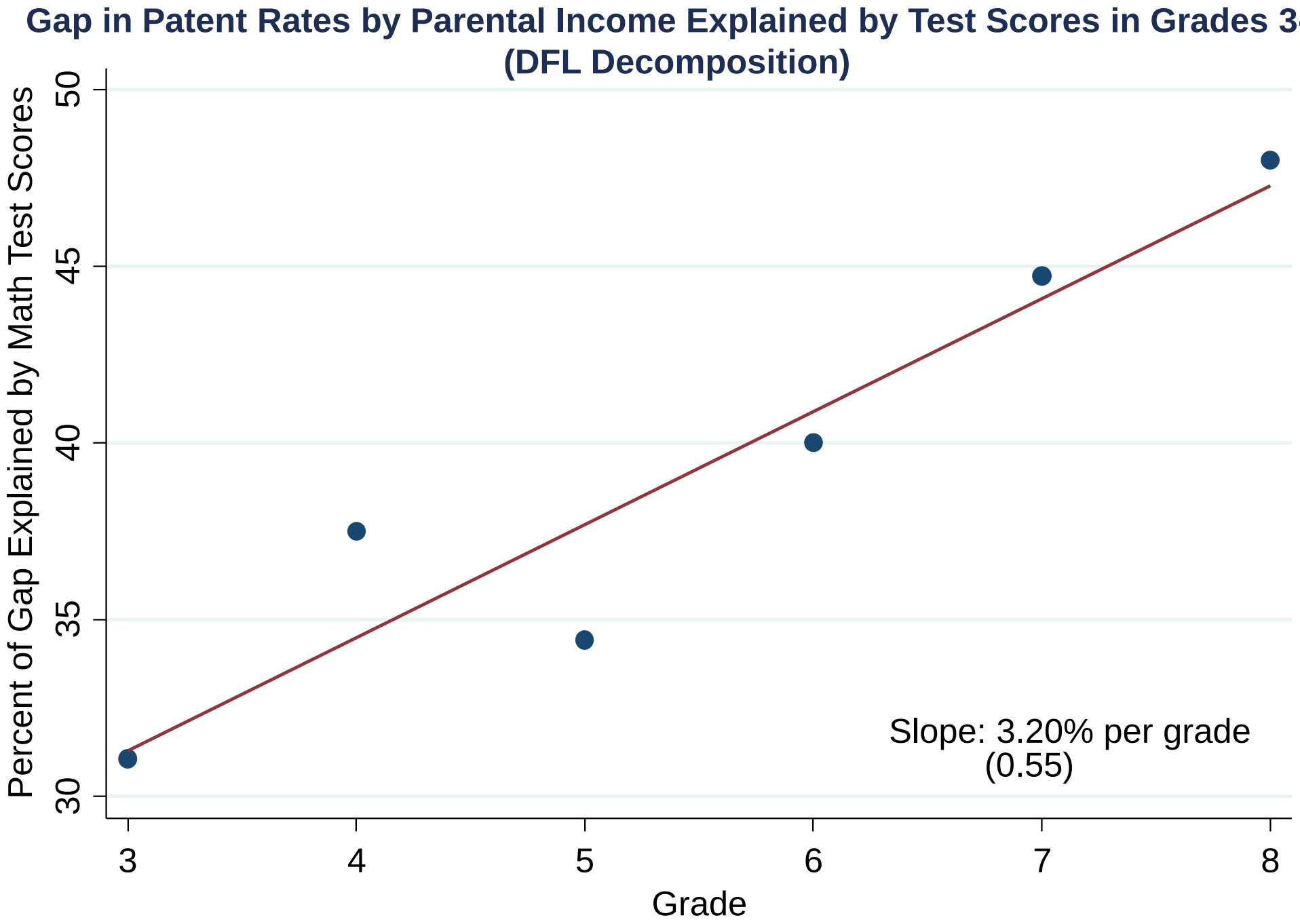
Why Do Patent Rates Vary with Parent Income?

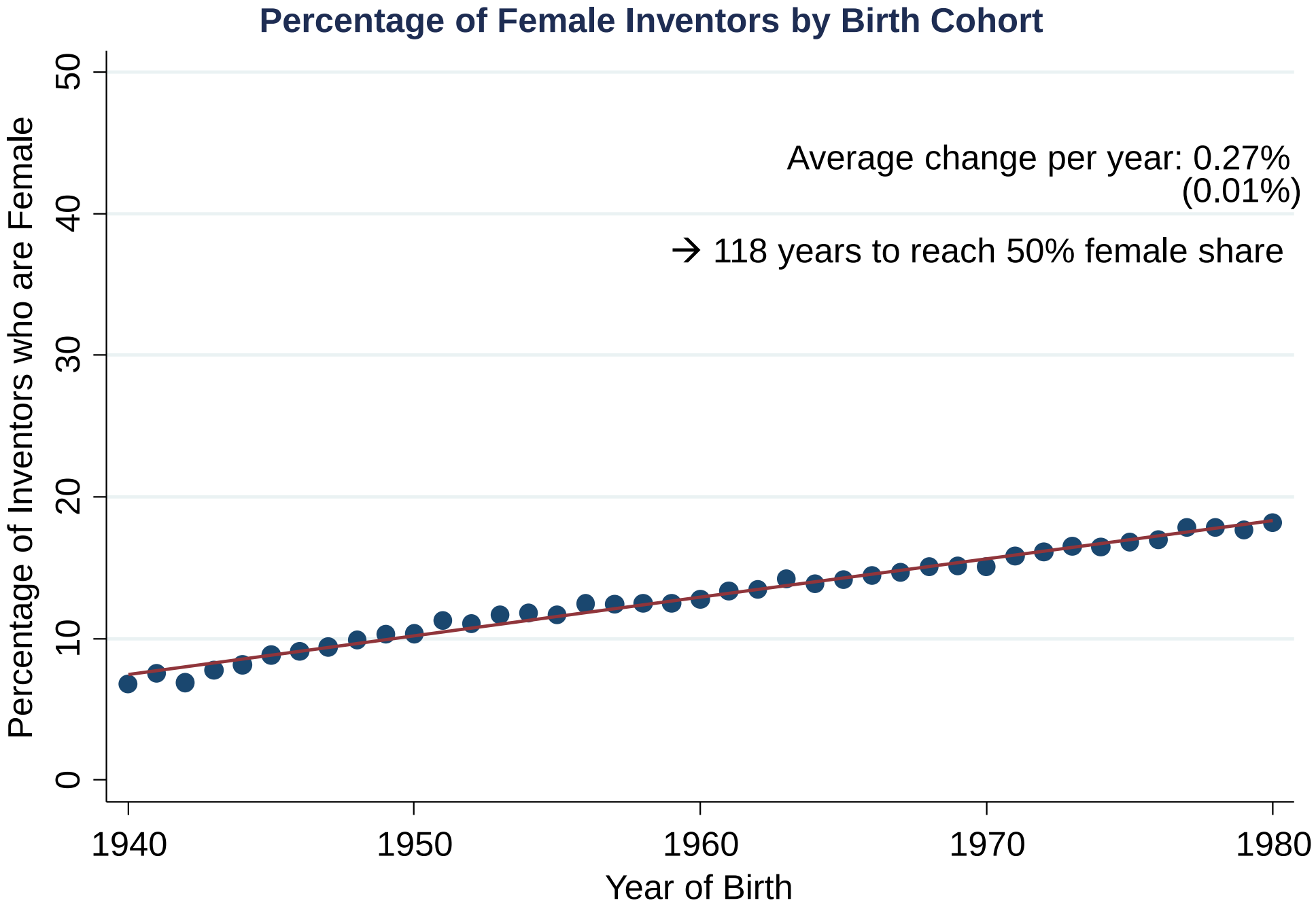
- First step to distinguish between these explanations: measure ability using data on test scores for all children in NYC public schools

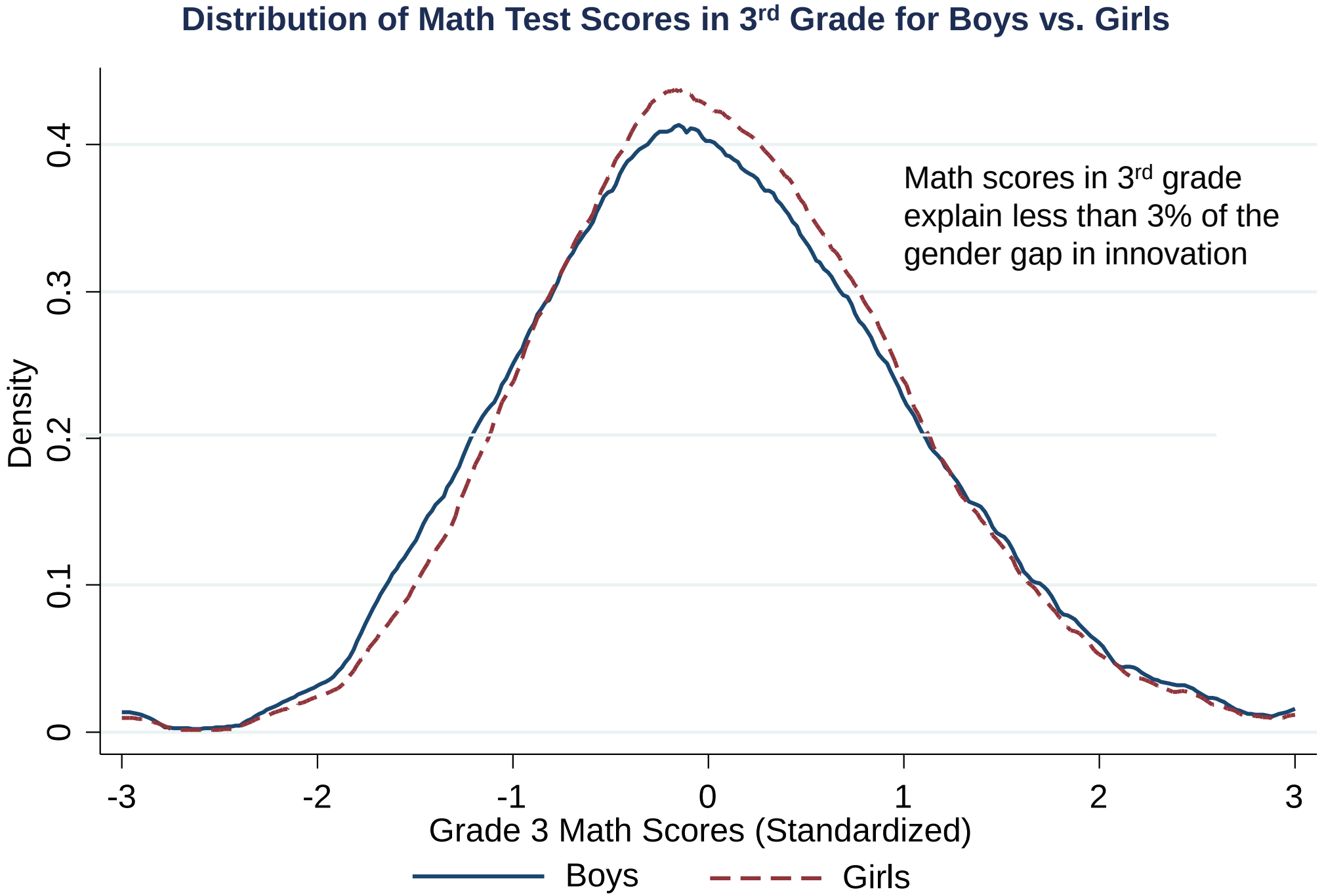

Patent Rates vs. 3rd Grade Math Test Scores in NYC Public Schools
90th Percentile
Inventors per Thousand
0
1
2
3
4
5
-2
-1
0
1
2
3rd Grade Math Test Score (Standardized)

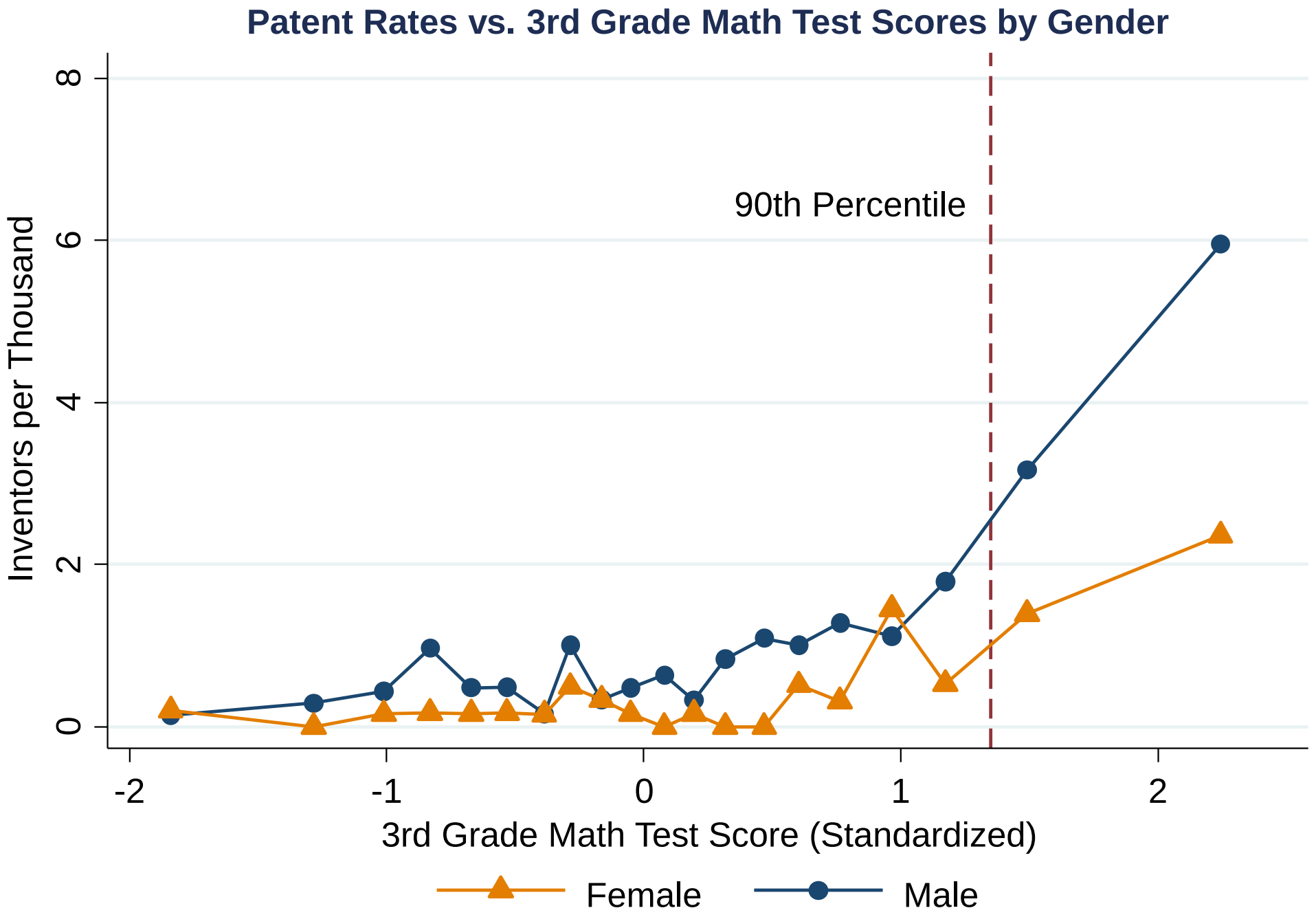

Patent Rates vs. 3rd Grade Test Scores by Parental Income
Inventors per Thousand
0
2
4
6
8
90th Percentile
-2
-1
0
1
2
3rd Grade Math Test Score (Standardized)
Parent Income Below 80th Percentile
Parent Income Above 80th Percentile


Patent Rates vs. 3rd Grade Test Scores by Parental Income (test scores only account for under 1/3 of difference)
90th Percentile
Inventors per Thousand
0
2
4
6
8
-2
-1
0
1
2
3rd Grade Math Test Score (Standardized)
Parent Income Below 80th Percentile
Parent Income Above 80th Percentile


Gap in Patent Rates by Parental Income Explained by Test Scores in Grades 3-8
(DFL Decomposition)
Percent of Gap Explained by Math Test Scores
30
35
40
45
50
3
4
5
6
7
8
Grade
Slope: 3.20% per grade
(0.55)


Percentage of Female Inventors by Birth Cohort
Average change per year: 0.27%
(0.01%)
→ 118 years to reach 50% female share
Percentage of Inventors who are Female
0
10
20
30
40
50
1940
1950
1960
1970
1980
Year of Birth


Distribution of Math Test Scores in 3rd Grade for Boys vs. Girls
Math scores in 3rd grade explain less than 3% of the gender gap in innovation
Density
0
0.1
0.2
0.3
0.4
-3
-2
-1
0
1
2
3
Grade 3 Math Scores (Standardized)
Boys
Girls


Patent Rates vs. 3rd Grade Math Test Scores by Gender
Inventors per Thousand
0
2
4
6
8
90th Percentile
-2
-1
0
1
2
3rd Grade Math Test Score (Standardized)
Female
Male

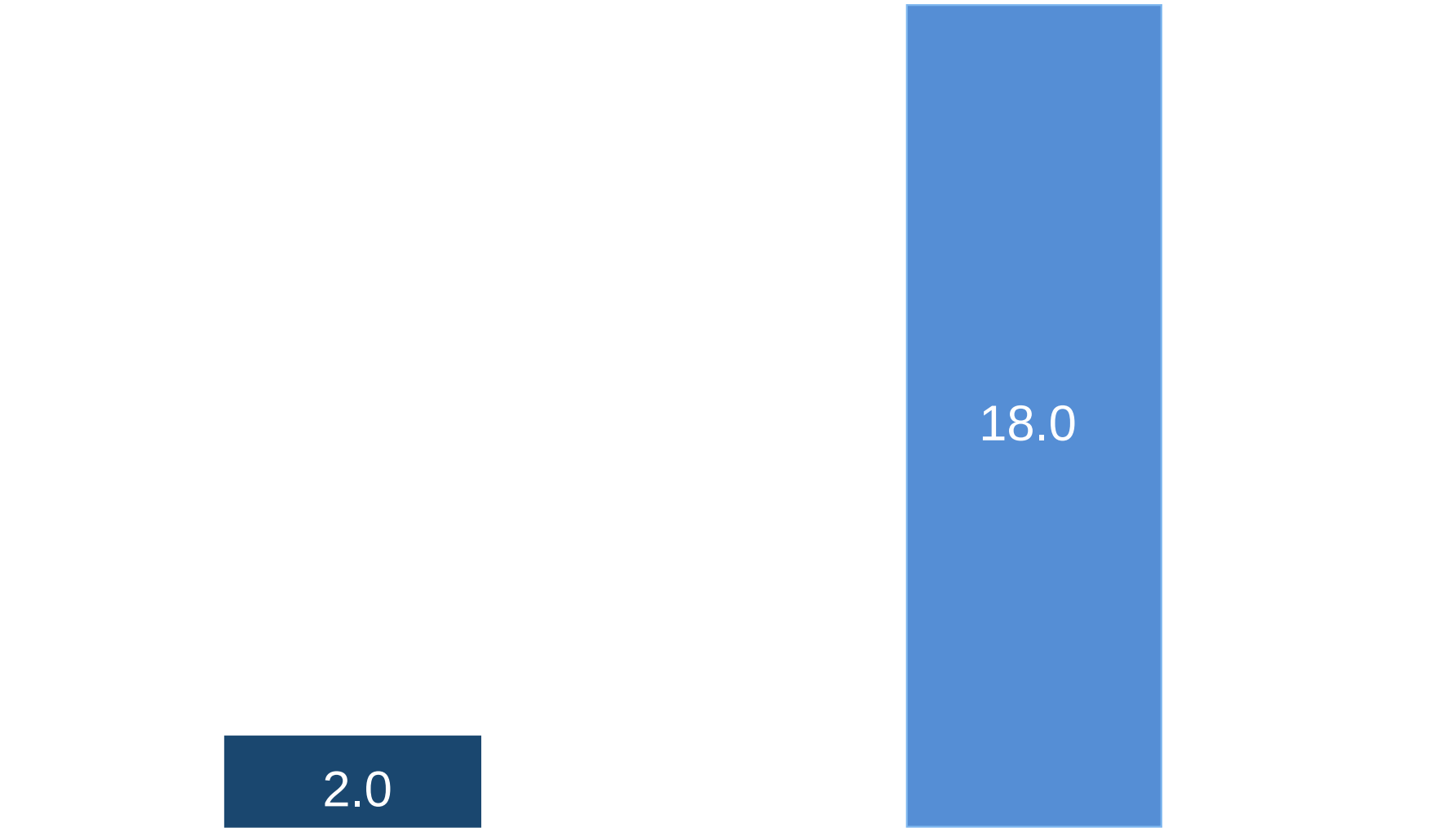
The Lifecycle of Inventors

Birth **Childhood**

Effects of Childhood Environment

- Study impacts of childhood environment by focusing on effect of *exposure to innovation* during childhood
    - Exposure to innovation: contact with inventors in one's family or neighborhood while growing up
- Start by analyzing relationship between children's and parents' patent rates

Patent Rates for Children of Inventors vs. Non-Inventors



Exposure vs. Genetics

- Correlation between child and parent's propensity to patent could be driven by genetics or/and by exposure effects (environment)

- Research design to isolate causal effect of exposure: analyze propensity to patent by narrow technology class

  - *Intuition:* genetic ability to innovate is unlikely to vary significantly across similar technology classes

- Define "similarity" of two technology classes based on the fraction of inventors who hold patents in both classes

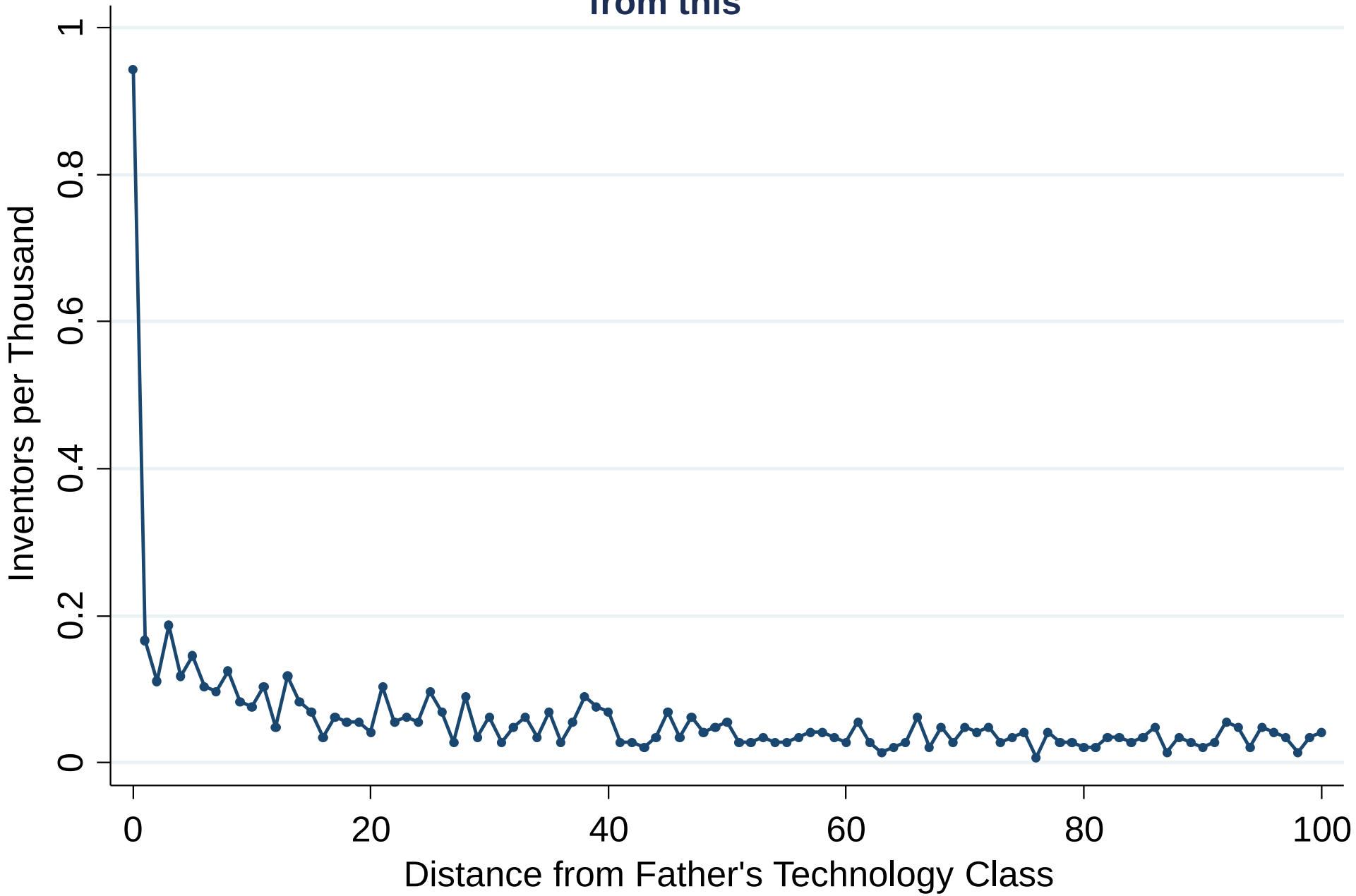
Illustration of Technology Classes and Distance

Category: Computers + Communications

Subcategory: Communications

Technology Class	Distance Rank
Pulse or digital communications	0
Demodulators	1
Modulators	2
Coded data generation or conversion	3
Electrical computers: arithmetic processing and calculating	4
Oscillators	5
Multiplex communications	6
Telecommunications	7
Amplifiers	8
Motion video signal processing for recording or reproducing	9
Directive radio wave systems and devices (e.g., radar, radio navigation)	10

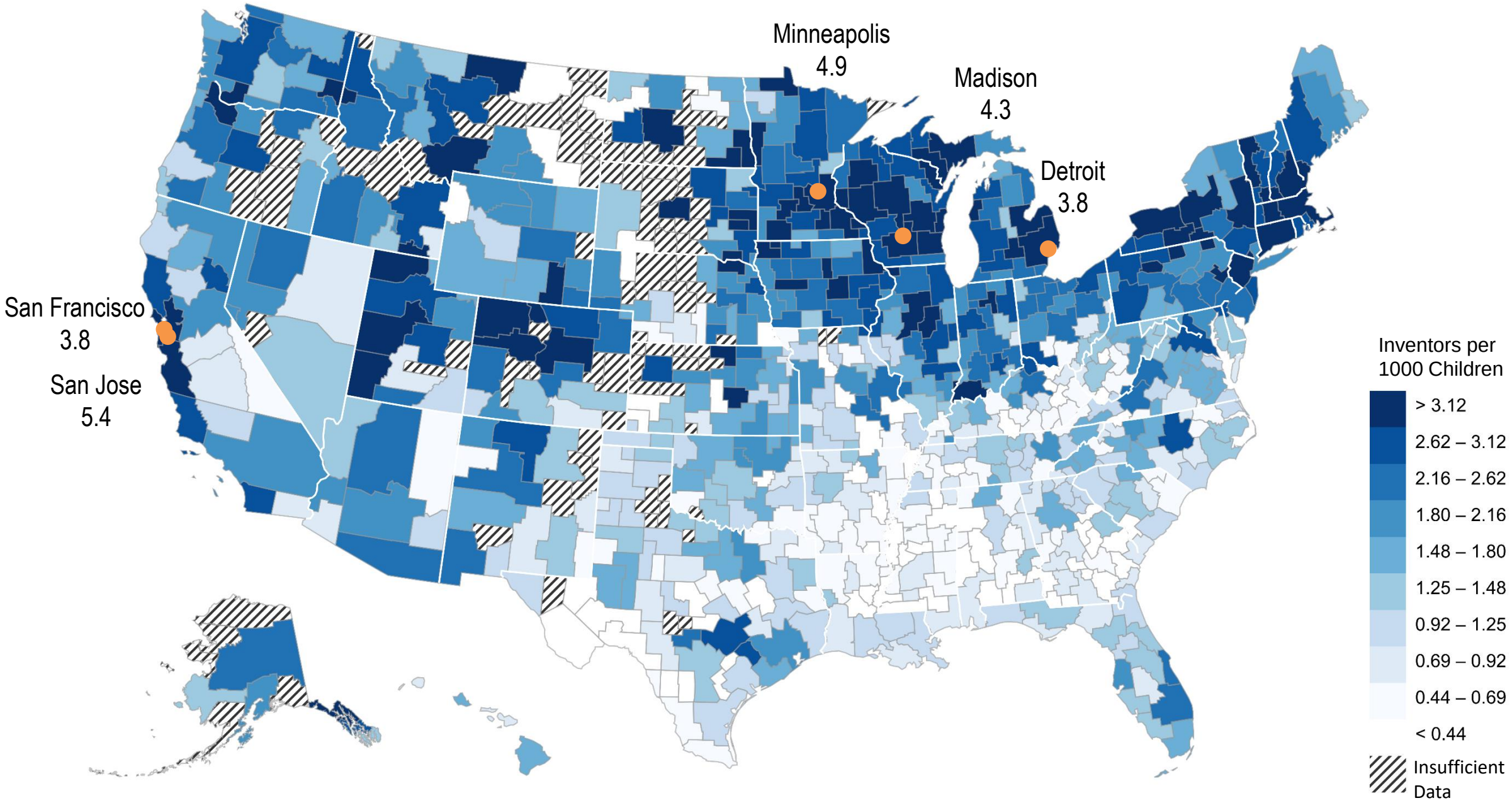
Invention is strong in exactly the same technology class as father & declines in tech distance from this

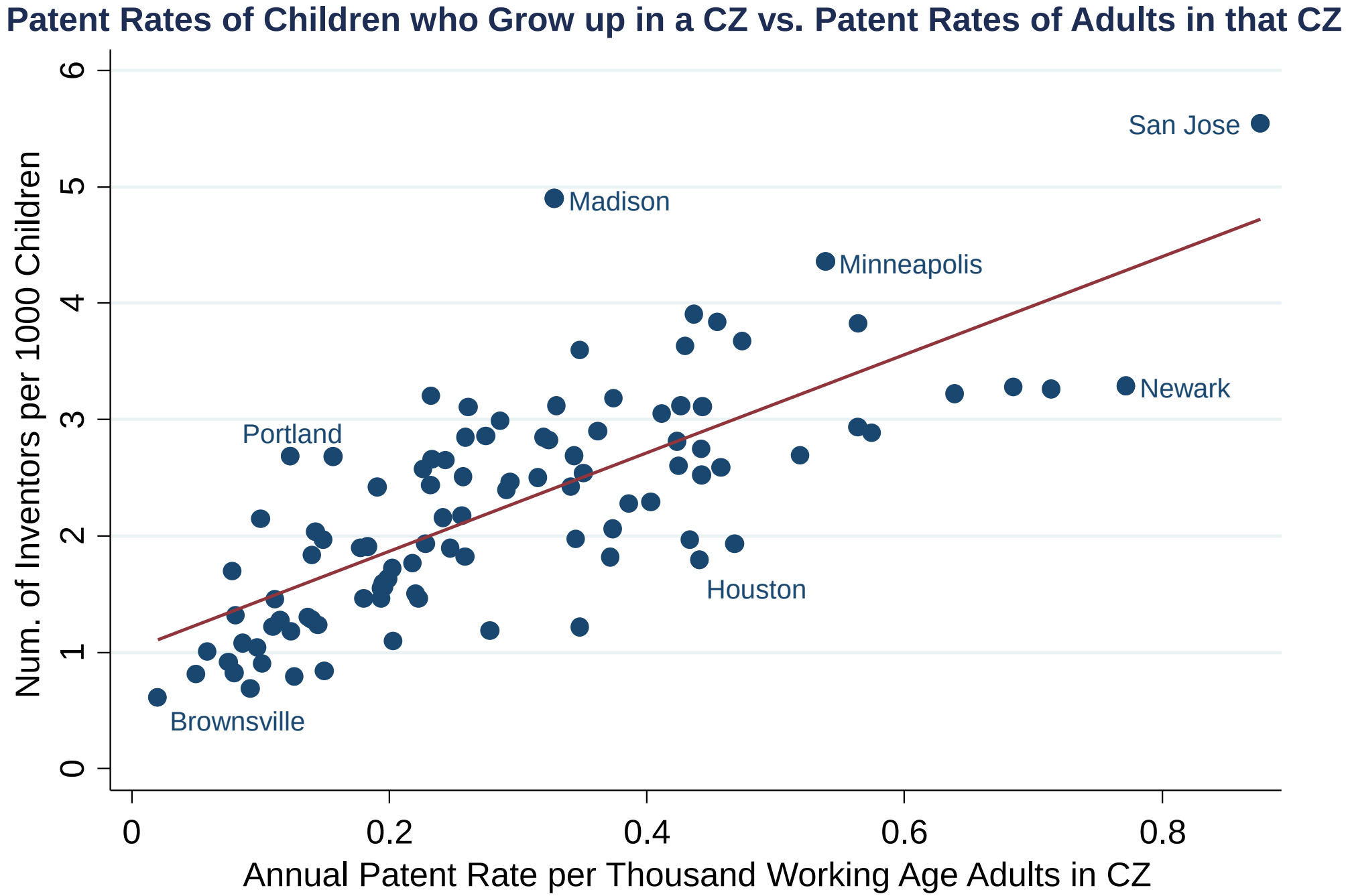


Neighborhoods

- Parents are a very narrow and potentially non-replicable source of "exposure"
- So, analyze influence of neighbors
- Tabulate patent rates by commuting zone (aggregation of counties analogous to metro area) where child *grows up*
  - Differs from literature on clusters of innovation (e.g., Porter and Stern 2001), because this is not necessarily where they live as adults

The Origins of Inventors: Patent Rates by Childhood Commuting Zone




Patent Rates of Children who Grow up in a CZ vs. Patent Rates of Adults in that CZ
Num. of Inventors per 1000 Children
0
1
2
3
4
5
6
0
0.2
0.4
0.6
0.8
Annual Patent Rate per Thousand Working Age Adults in CZ
San Jose
Madison
Minneapolis
Newark
Portland
Houston
Brownsville

Neighborhoods

- Children raised in areas with more inventors are more likely to be inventors themselves

- Again, study patterns *within* technological class
  - Do children who grow up in Silicon Valley tend to become computing innovators?
  - Do children who grow up in Minnesota (with large medical device manufacturers) become medical innovators?
- **Yes: 1** sd increase in exposure raises innovation rates by 28%
  - Holds within a technology class
  - Holds when controlling for where kids live as adults

Variation by Gender across Neighborhoods

- Use an analogous approach to examine variation in exposure effects by gender

- Girls more likely to become inventors if they grow up in an area with more *female* (but not male) inventors

Movers Design

- Compare individuals who moved to high innovation neighborhood in early childhood vs. later childhood

- If moved at a younger age, a higher intensity of exposure and therefore more likely to grow up to become an inventor.

The Lifecycle of Inventors

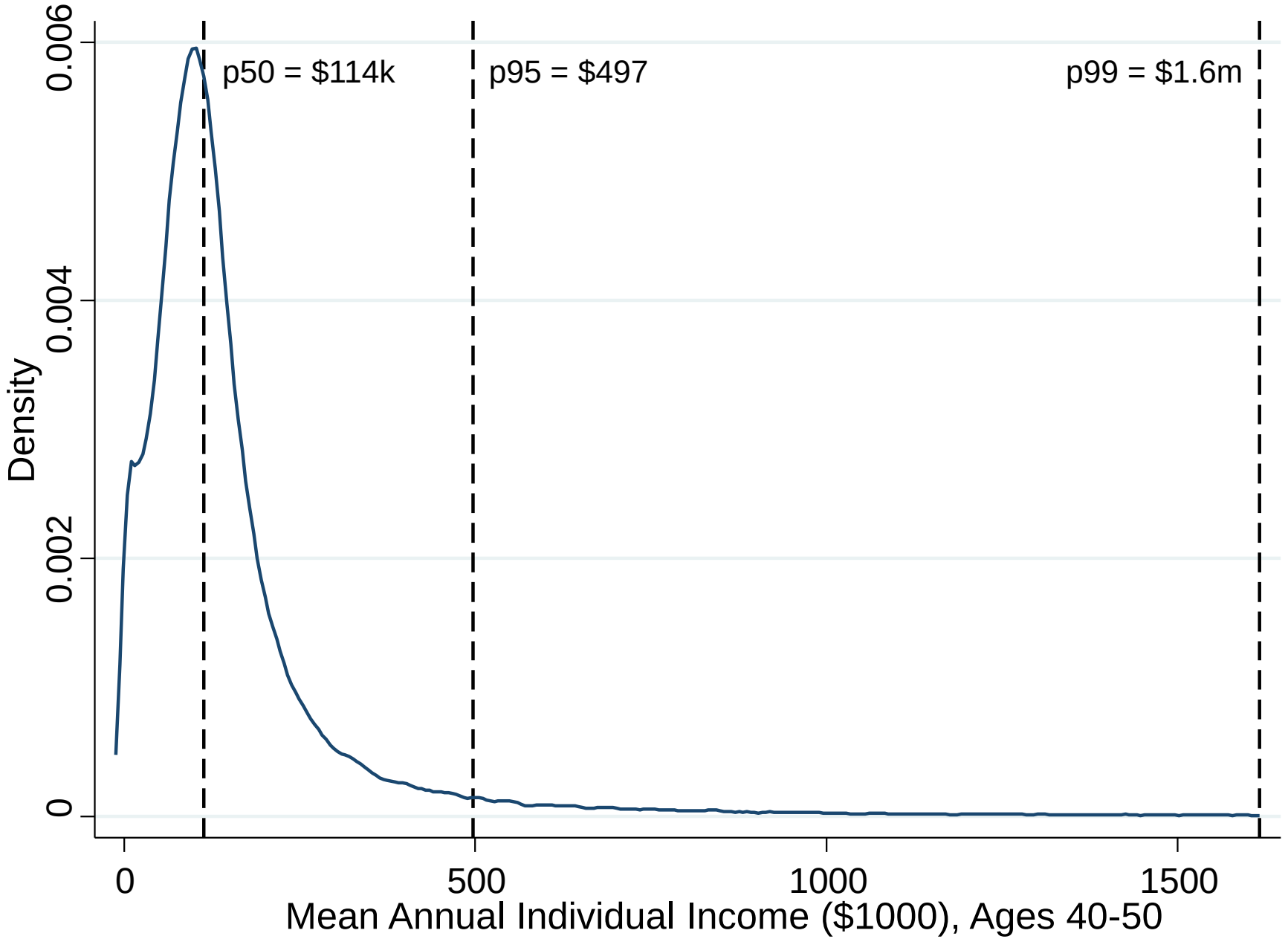
Birth **Childhood** **Career**

Income Distribution of Inventors

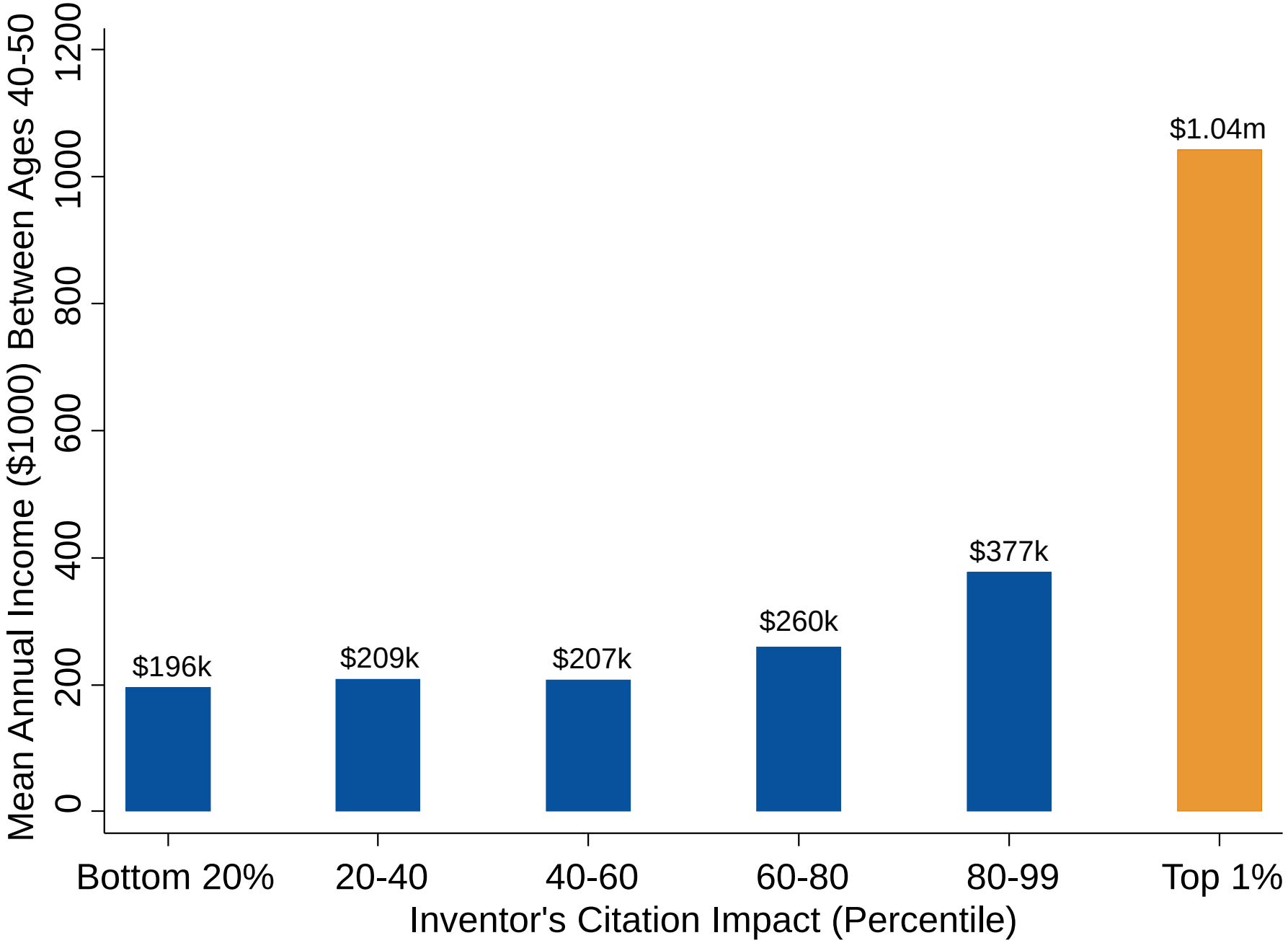
- Characterize careers of inventors to shed light on how financial incentives may affect individuals' decisions to pursue innovation

- Briefly summarize key facts and implications here

Distribution of Inventors' Mean Individual Income Between Ages 40-50



Inventors' Incomes vs. Patent Citations



Career Choice Model

- Analyze implications of our findings for policies to increase innovation using a stylized model of career choice

- Decisions depend upon financial payoffs to innovation, tax rates/barriers to entry, and exposure to innovation

- **Key result:** changes in financial incentives have limited potential to increase quality-weighted innovation, for three reasons:

  1. *[Exposure dampening]* Taxes only affect those exposed to innovation

  2. *[Forecastable returns]* With highly skewed abilities, marginal inventor influenced by tax change has little impact on aggregate innovation

  3. *[Stochastic returns]* With highly uncertain returns, changes in top tax rates do not affect marginal utility in “good” state significantly

Potential Effects of Increasing Exposure

- By contrast, increasing exposure can potentially have much larger effects
  - Draws in not just marginal inventors but highly able “lost Einsteins” among children from low-income families, minorities, and women
  - Example: If these groups invented at the same rate as white men from top-quintile families, innovation rate would **quadruple**

Conclusion and Next Steps

- Exposure to innovation is critical → key question: how can we increase exposure among under-represented groups?
  - Mentorship programs, G&T programs, internships, changes in networks?
- Our analysis does not identify which of these policies are most effective, but does suggest how effective programs should be *targeted*
  - Should be targeted toward women, minorities, and children from low-income families who excel in math/science at early ages
  - Should also be tailored by background: women more likely to be influenced by female inventors
- To facilitate future work, we have posted statistics on patent rates by area, gender, parental income, college, etc. at www.equality-of-opportunity.org/data