Lost Einsteins

Innovation and Opportunity in America

Alex Bell
Raj Chetty
Xavier Jaravel
Neviana Petkova
John van Reenen

The opinions expressed in this paper are those of the authors alone and do not necessarily reflect the views of the Internal Revenue Service or the U.S. Treasury Department.

How Can We Increase Innovation and Growth in America?

- Innovation is widely viewed as the engine of economic growth

- How can we **increase the rate of innovation**?
  - Policy approaches range from **STEM education to tax incentives**
  - Effectiveness of these policies is debated, partly because of a **lack of data on who innovates** in America

We Use Big Data to Study Who Becomes an Inventor in America

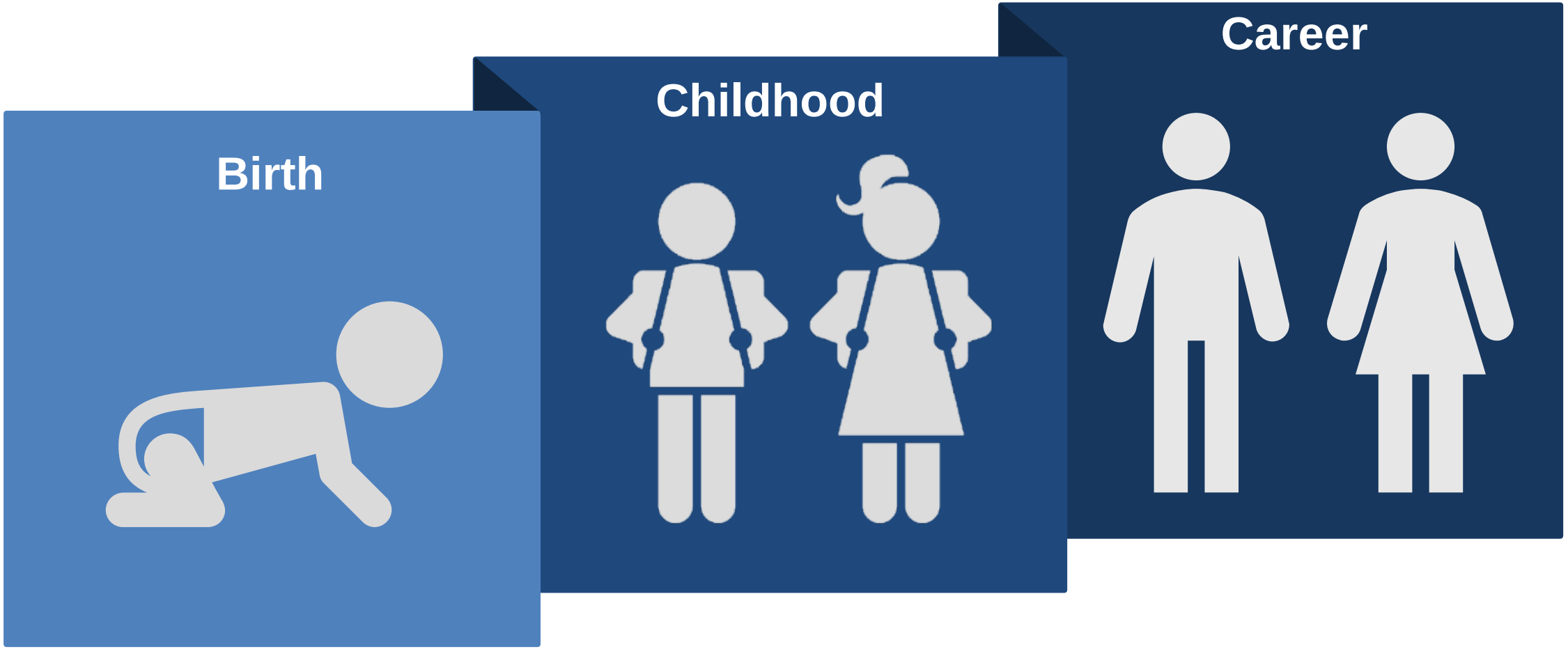
Patent Data — 1.2 million inventors

Tax Records — Parents, College, Earnings

School District Data — Test scores

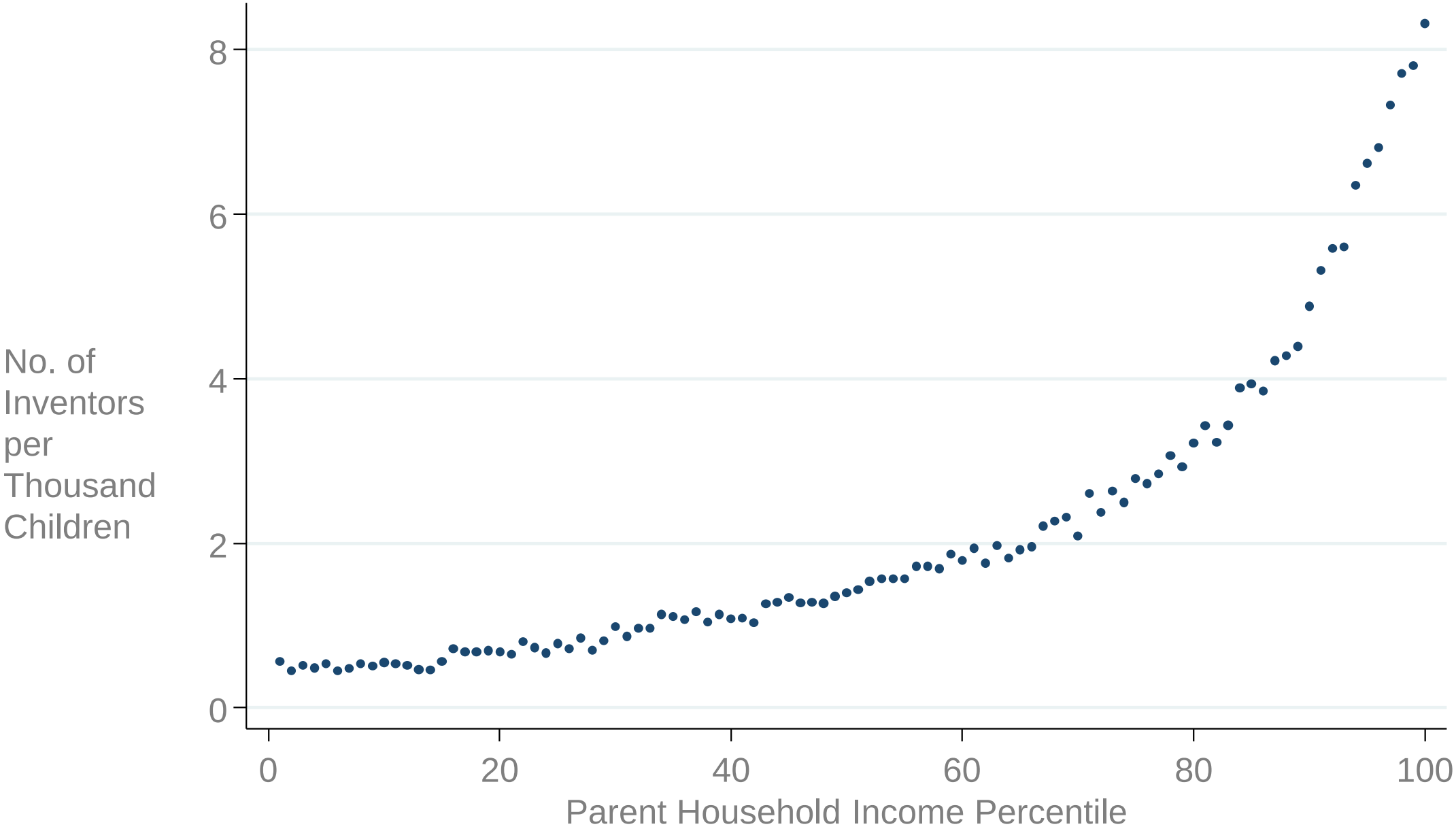
Source: Bell, Chetty, Jaravel, Petkova, van Reenen 2017

We track inventors from birth to adulthood to understand the factors that determine who invents

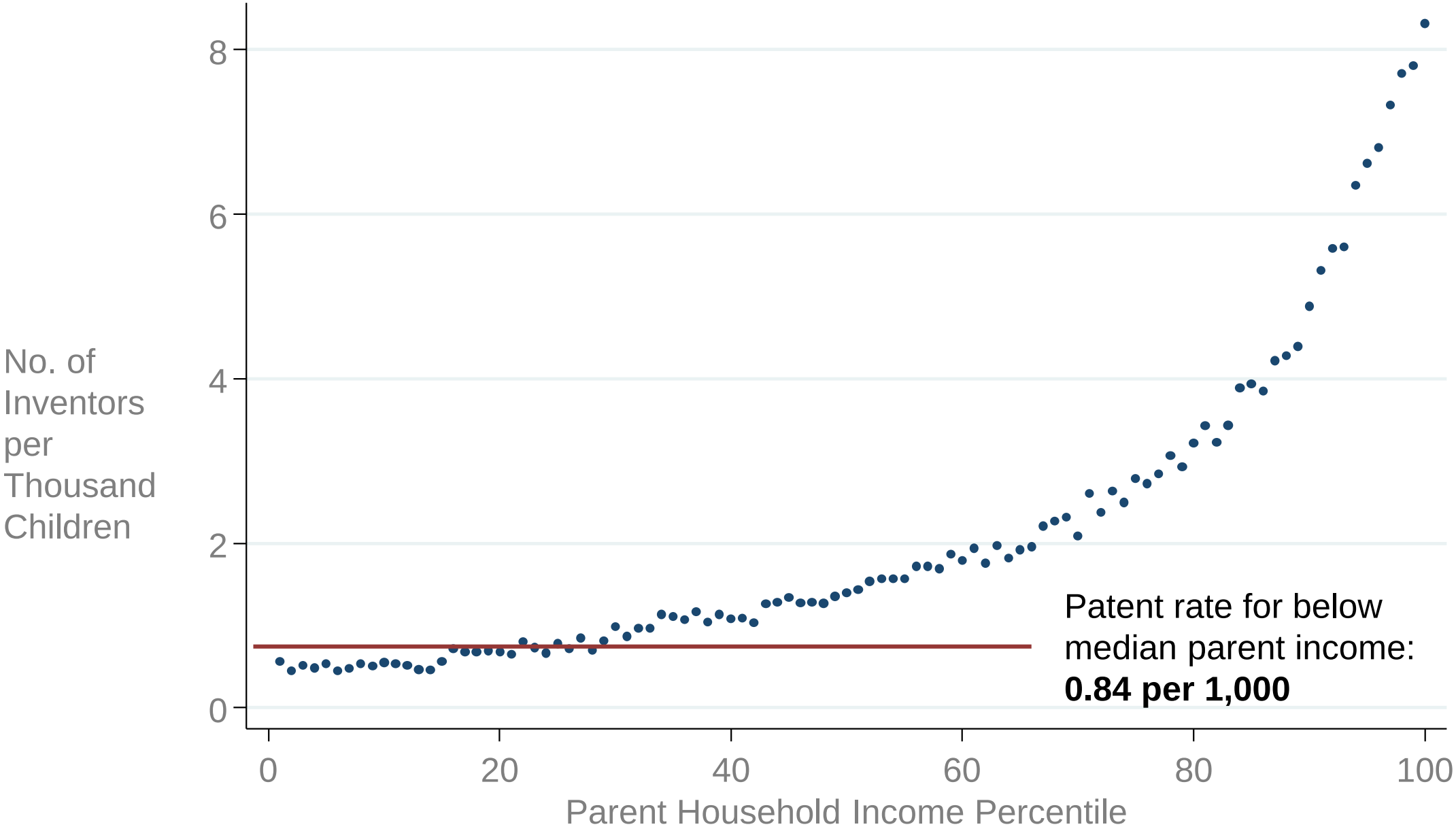


Begin by analyzing inventors' characteristics at birth

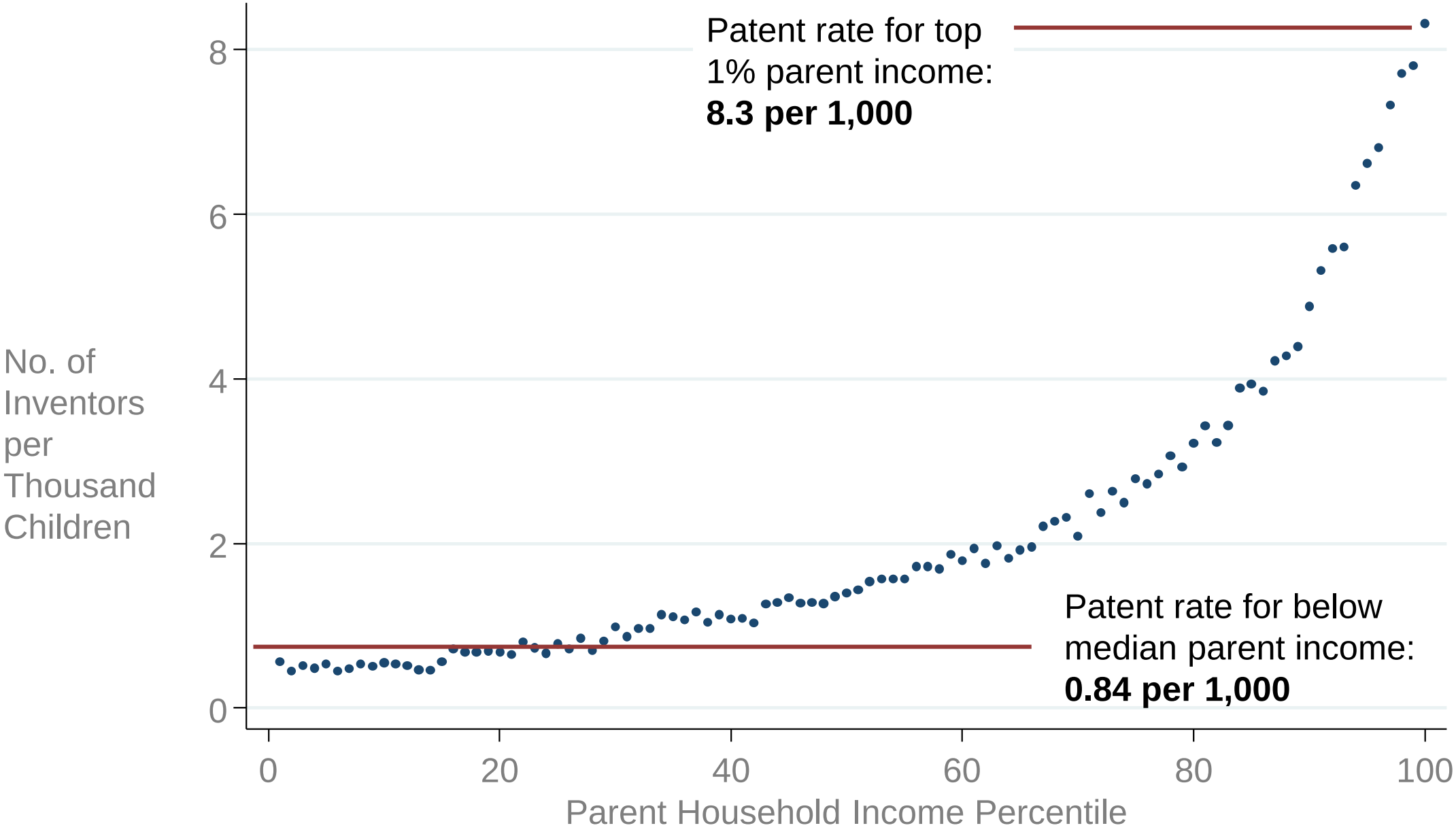
Patent Rates vs. Parent Income



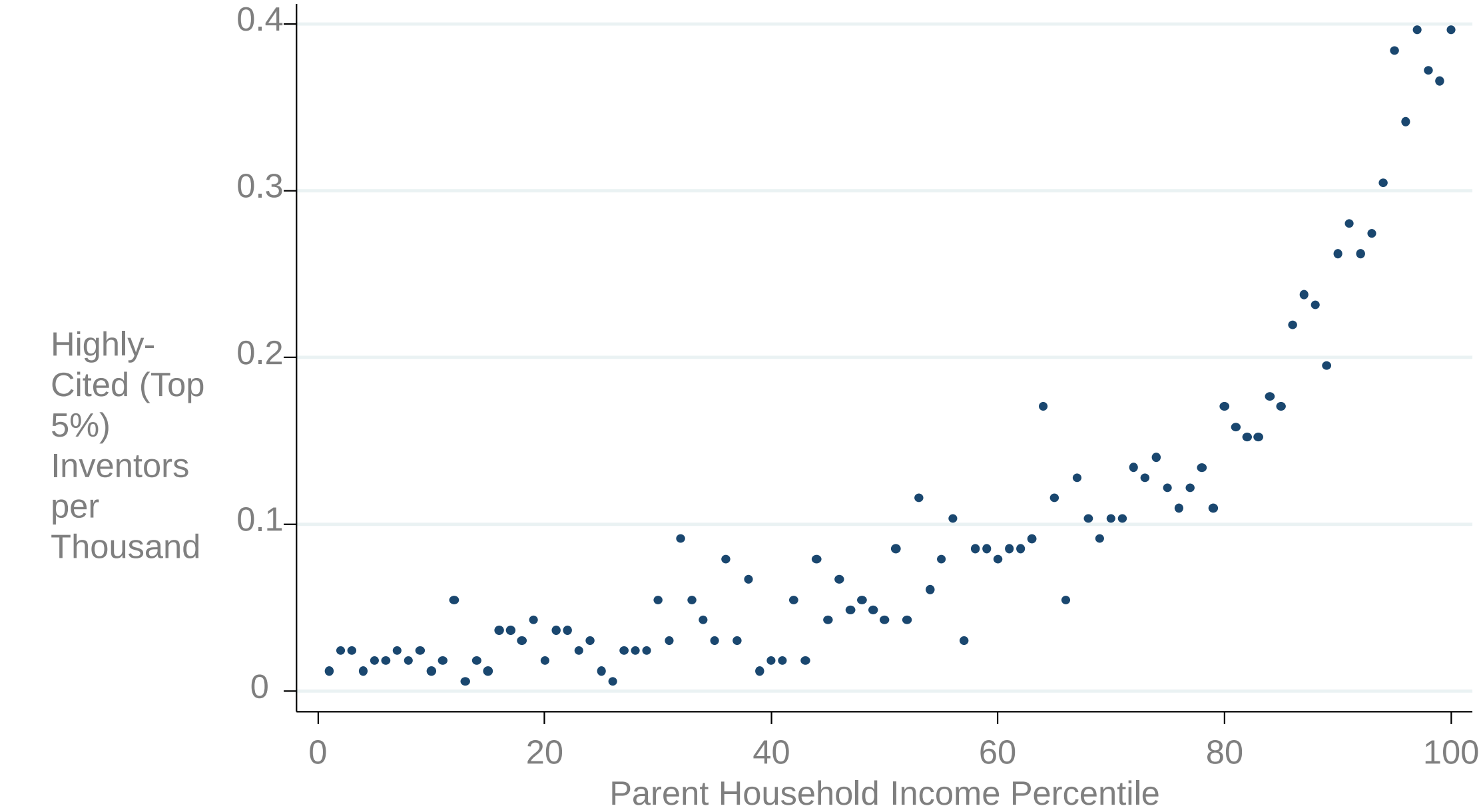
Patent Rates vs. Parent Income



Patent Rates vs. Parent Income

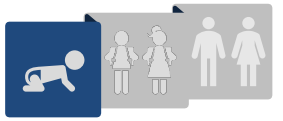


Lost Einsteins? Highly-Cited Patents vs. Parent Income



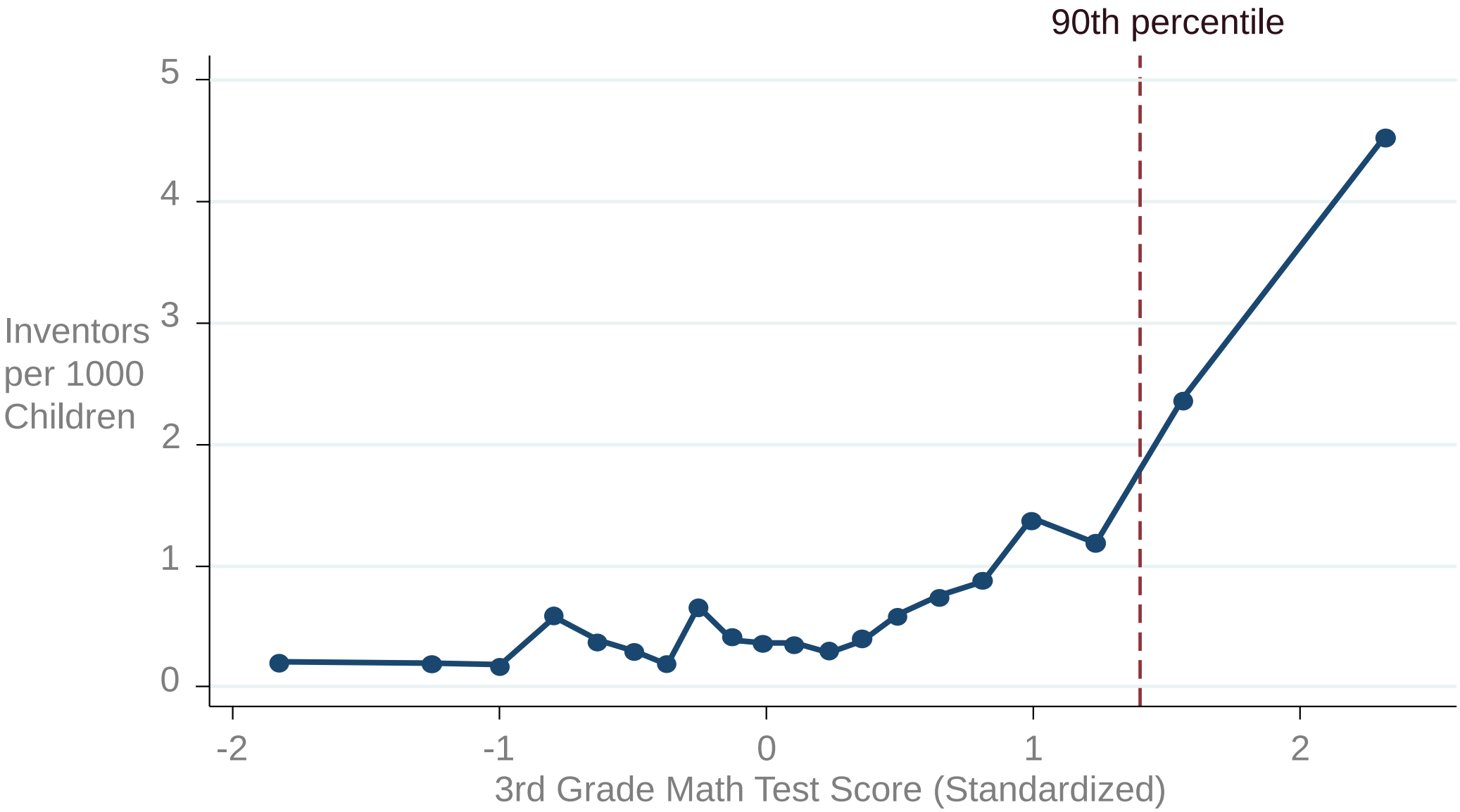
Why do patent rates vary with parent income?

Three potential explanations

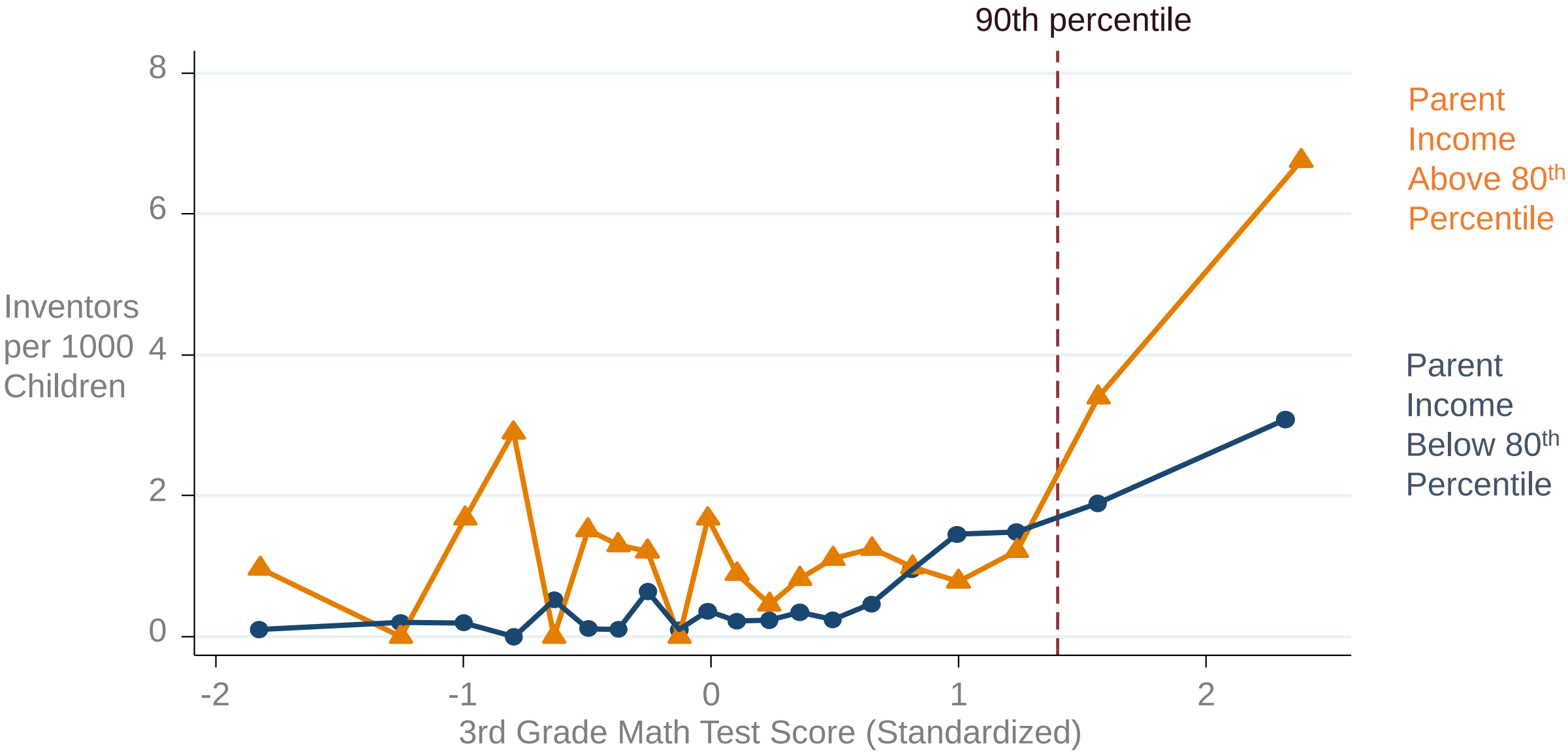


1	**Ability**	Children from high-income families have greater ability to innovate
2	**Preferences**	Lower income children prefer other occupations (e.g., to avoid risk)
3	**Constraints**	Lower income children have comparable talent and preferences but lack resources or exposure

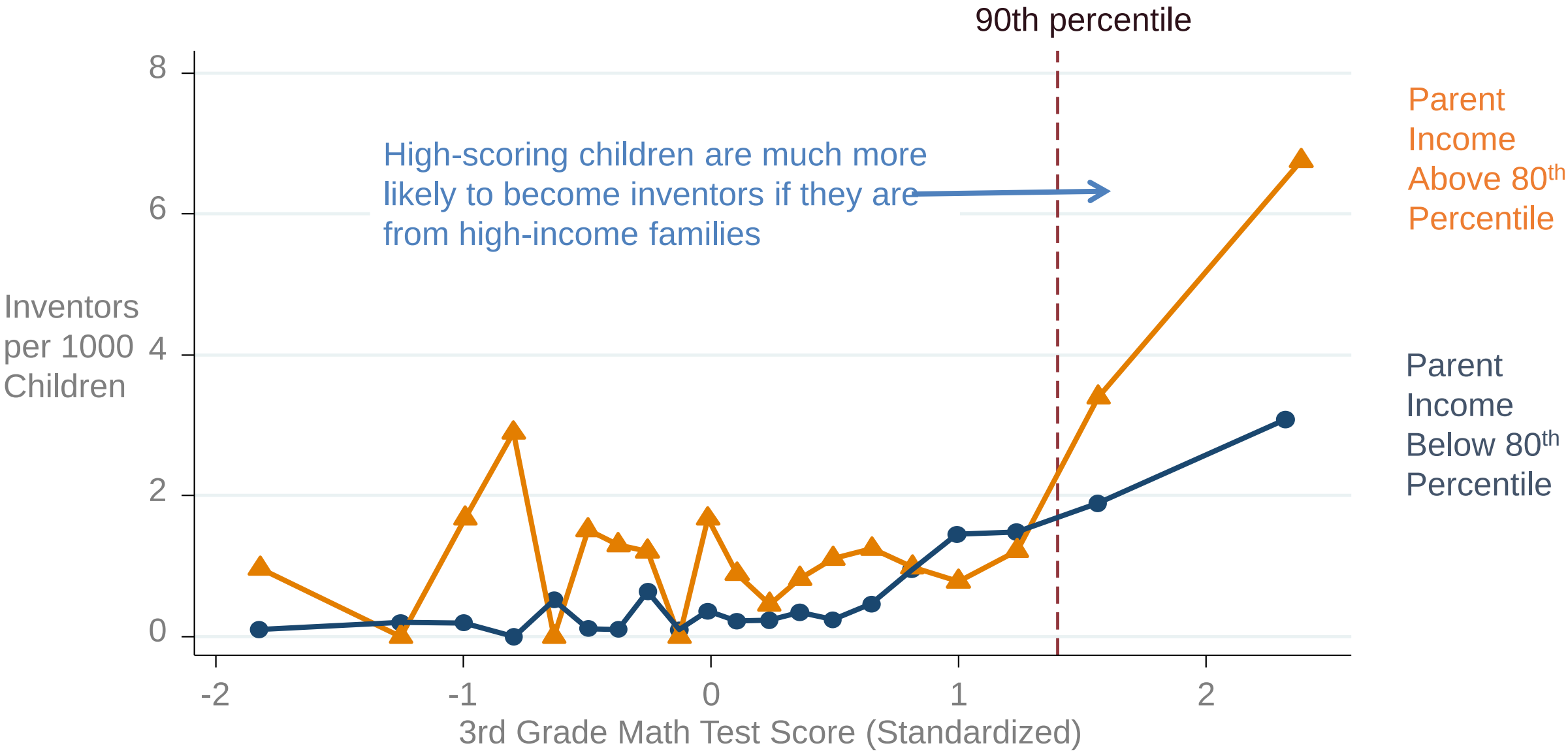
Patent Rates vs. 3rd Grade Math Test Scores



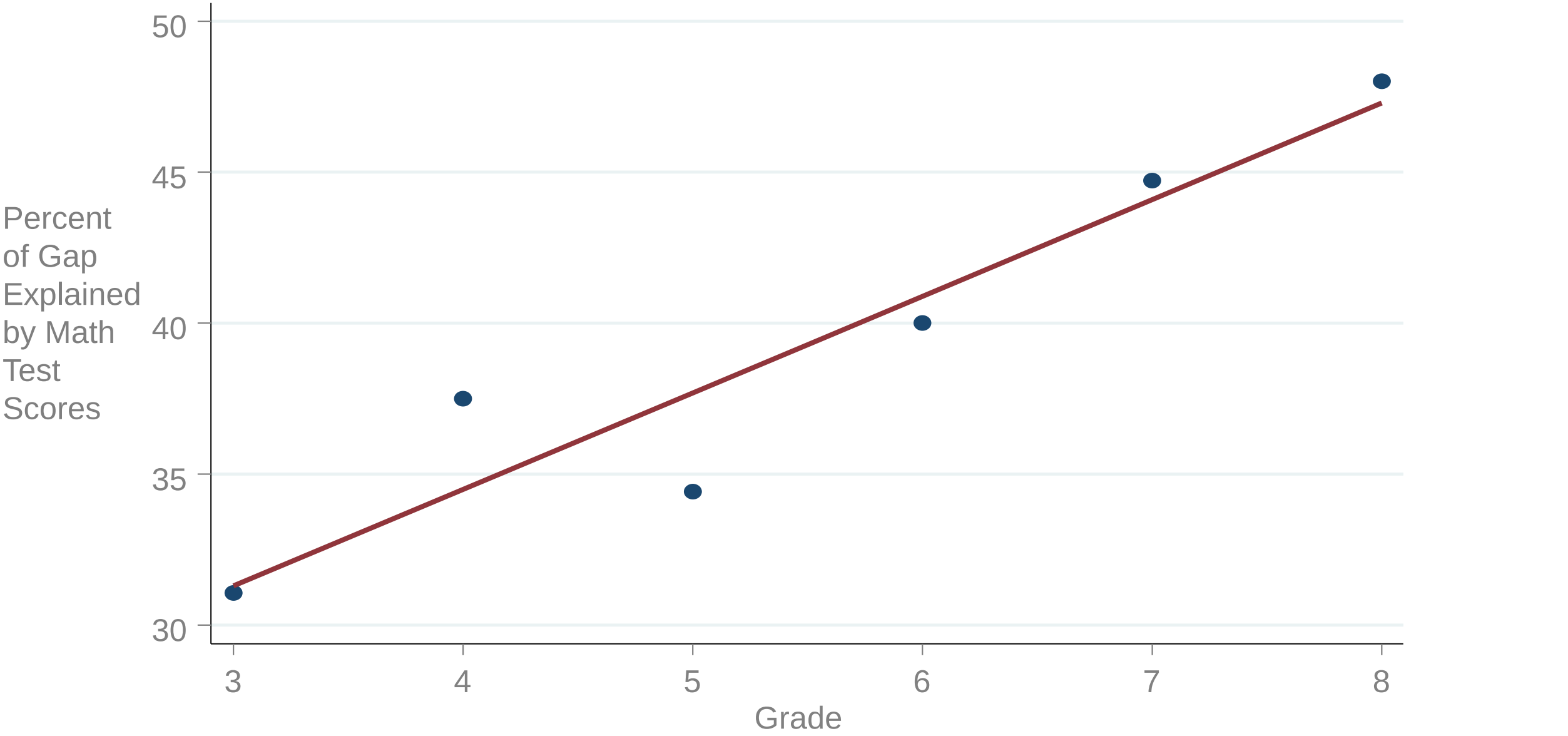
Patent Rates vs. 3rd Grade Math Test Scores



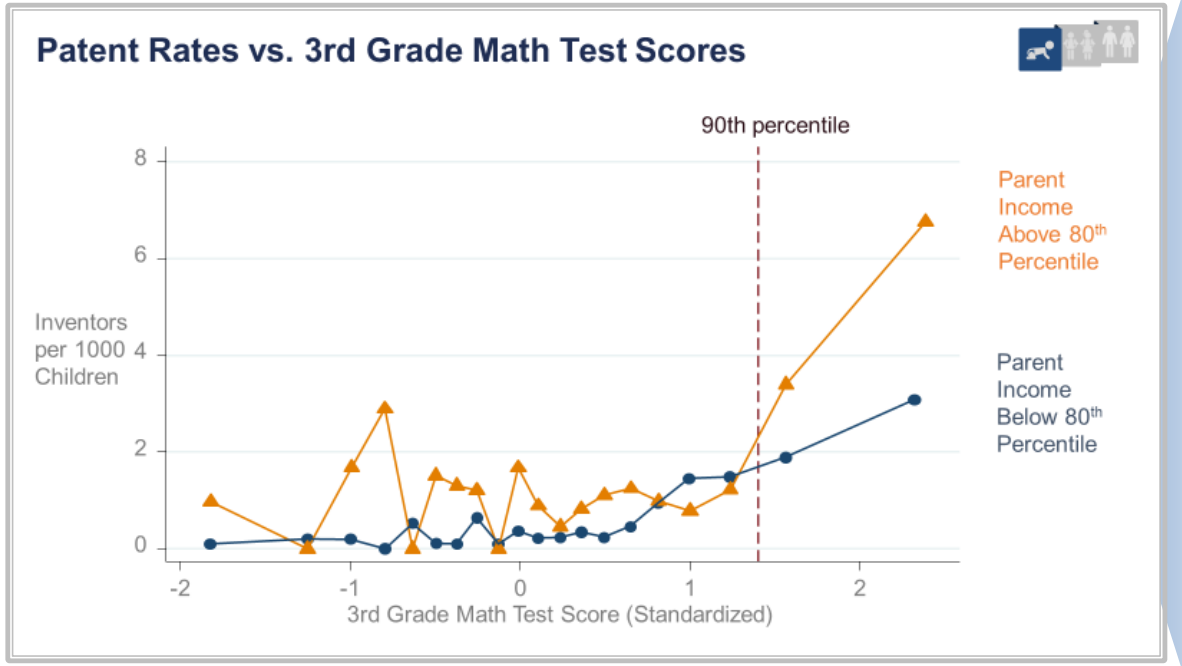
Patent Rates vs. 3rd Grade Math Test Scores



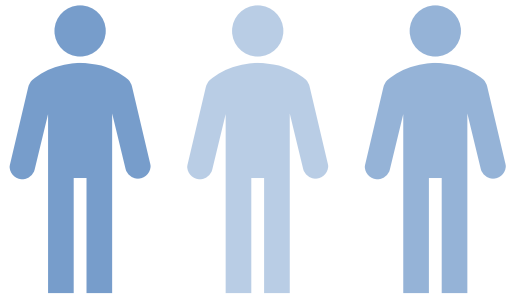
The Gap in Patent Rates Explained by Test Scores Grows as Children Progress Through School



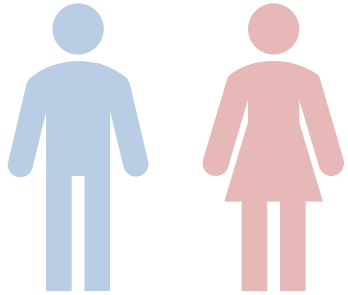
Gaps in Innovation by Race and Gender



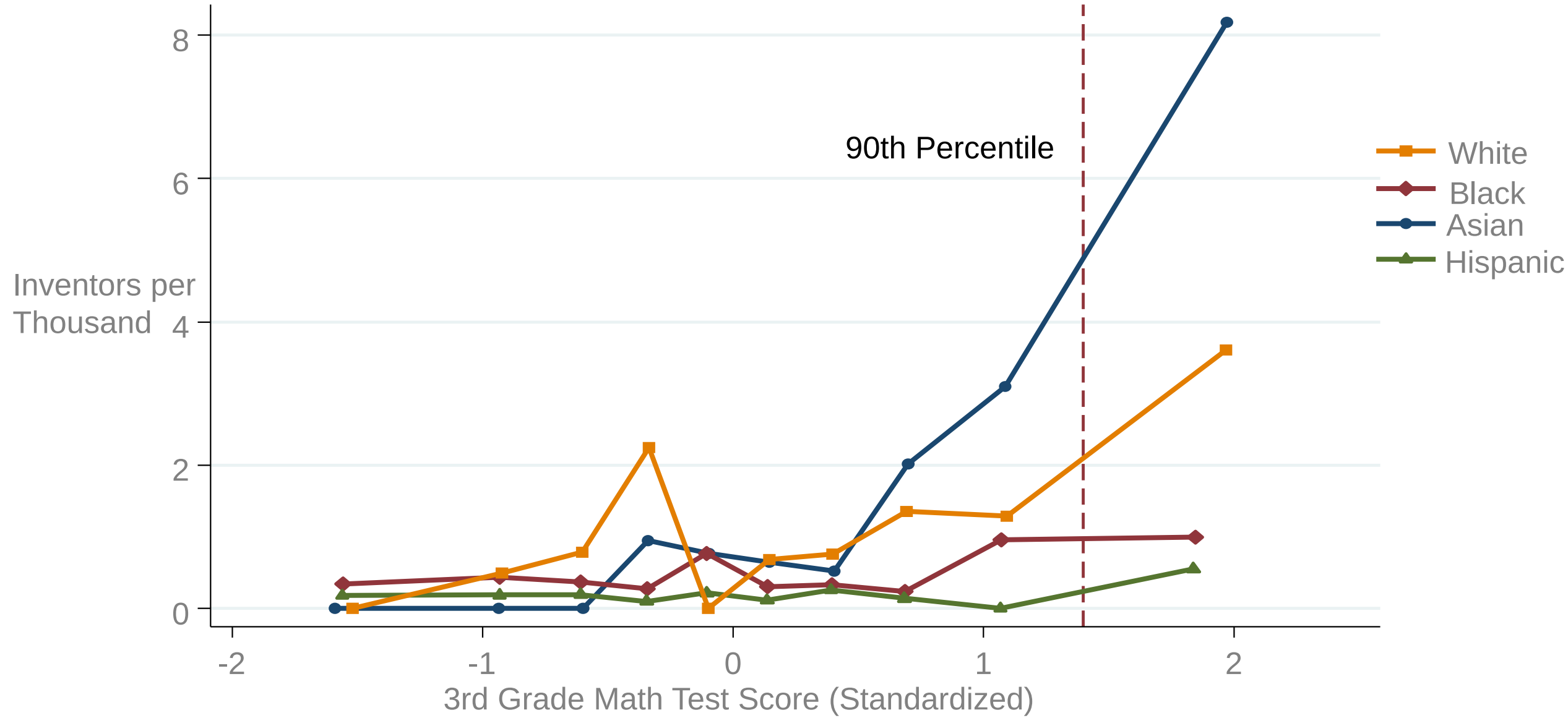
- We find analogous gaps by **race**…



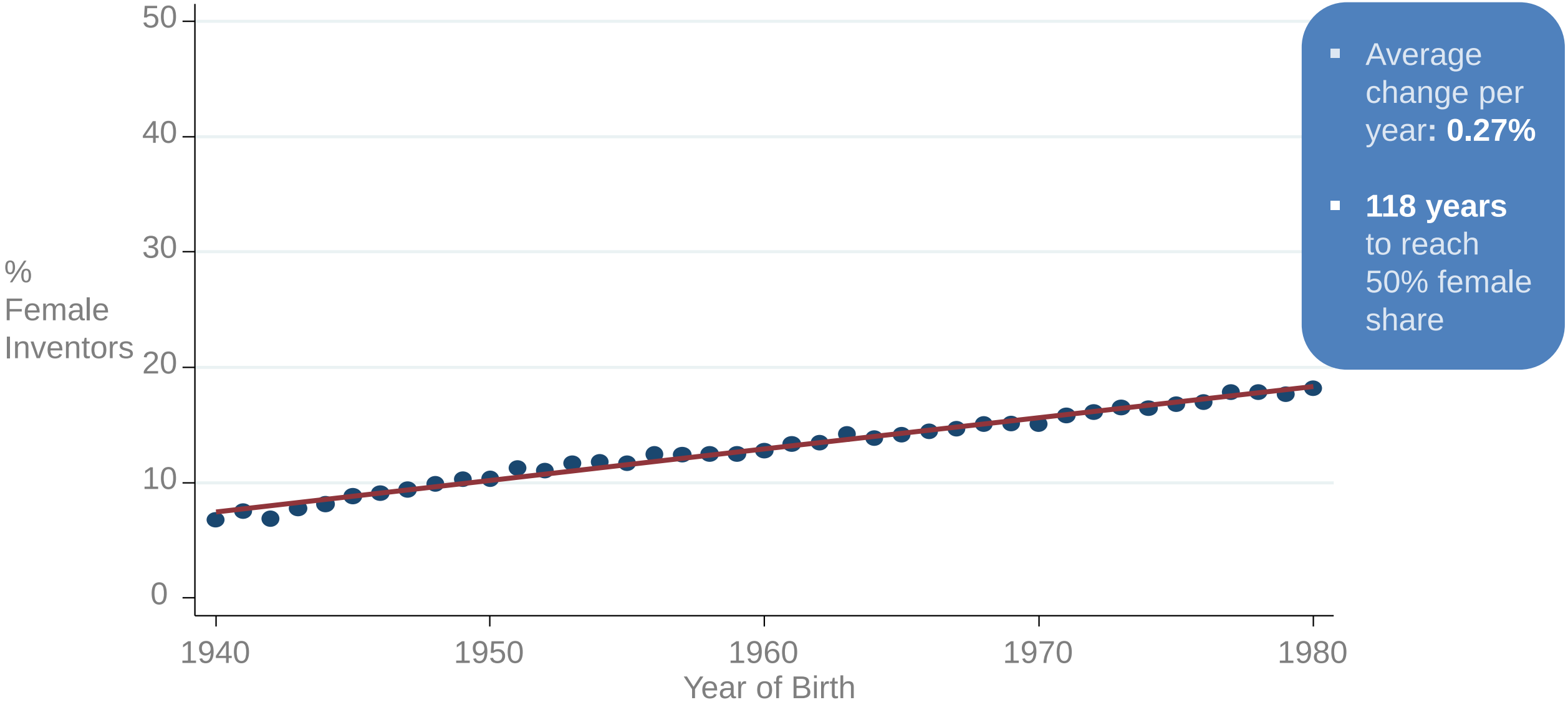
- … and **gender**



Patent Rates vs. 3rd Grade Test Scores by Race & Ethnicity

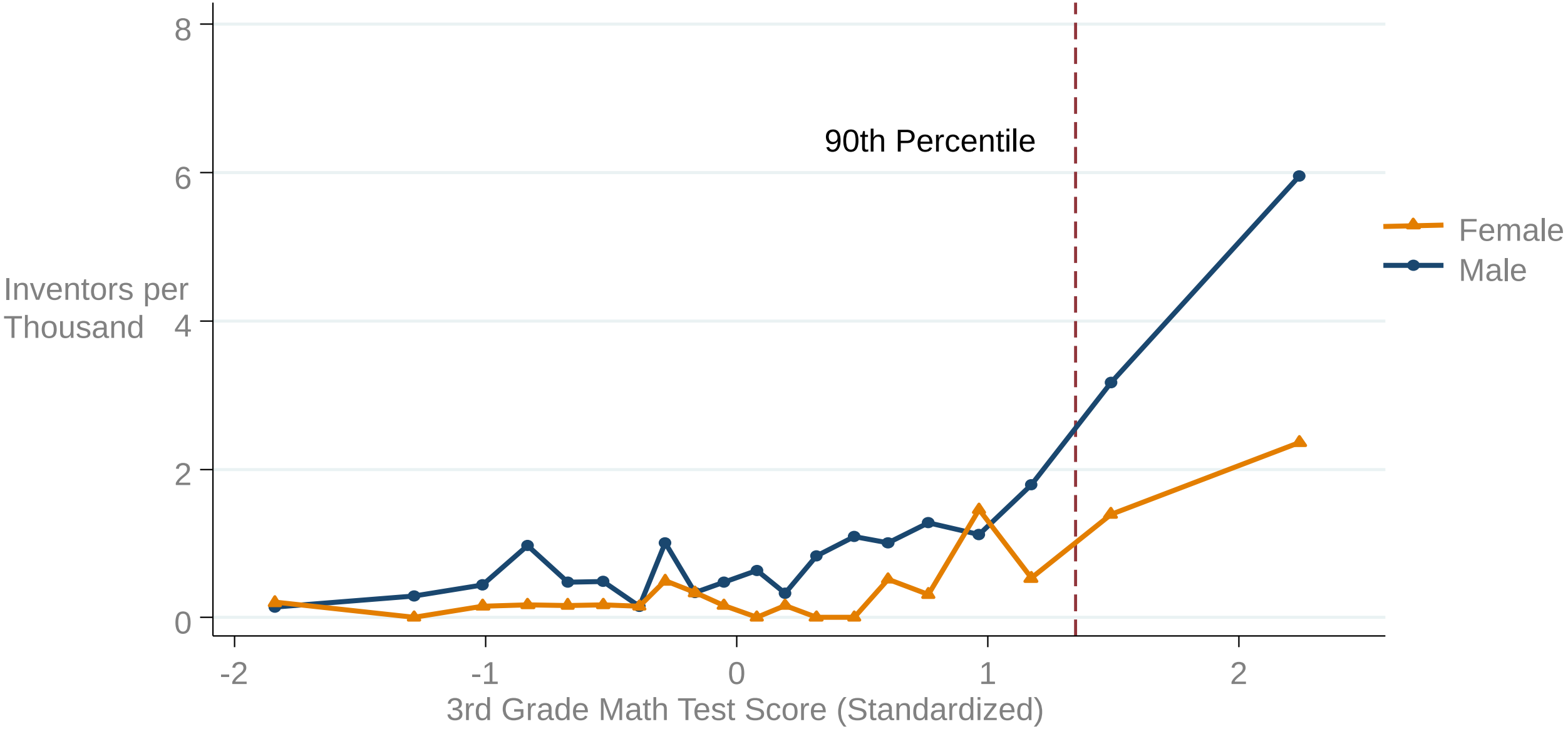


Percentage of Female Inventors by Year of Birth



- Average change per year: **0.27%**
- **118 years** to reach 50% female share

Patent Rates vs. 3rd Grade Math Test Scores by Gender



Effects of Childhood Environment on Innovation

Impacts of Exposure to Innovation

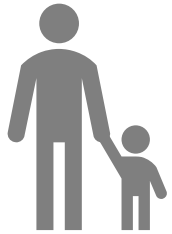
Study impacts of childhood environment by focusing on effect of **exposure to innovation** during childhood through family and neighbors

Start by analyzing relationship between **children's** and their own **parents' patent rates**

Patent Rates for Children of Inventors vs. Non-Inventors

Parents Inventors

18.0



Parents not Inventors

2.0

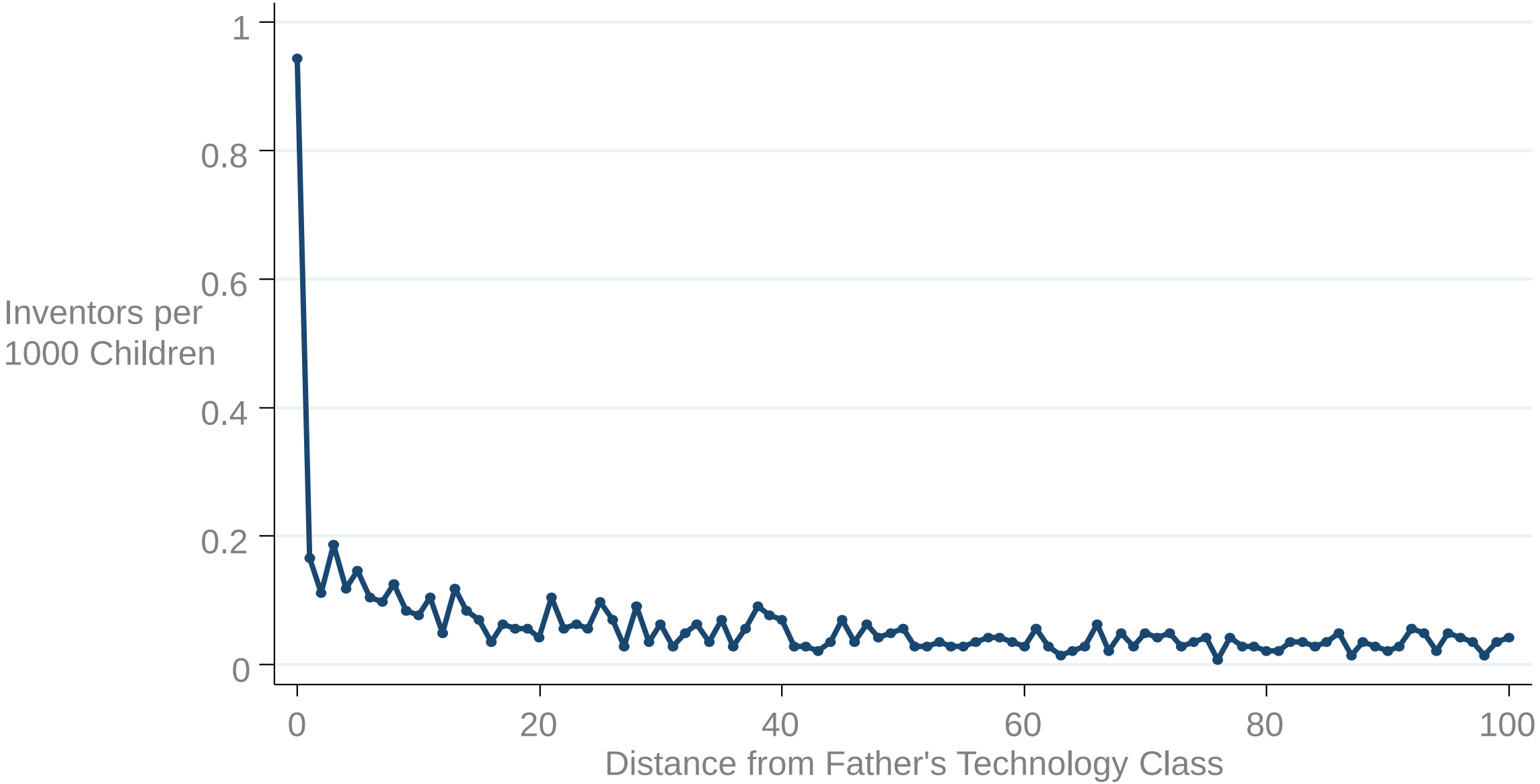
Exposure or Genetics?

- Correlation between child and parent's propensity to patent **could be driven by genetics or by exposure** (environment)
  - Isolate **causal effect of exposure** by analyzing 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**

Distance Between Technology Classes

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

Innovation Rates by Technology Class

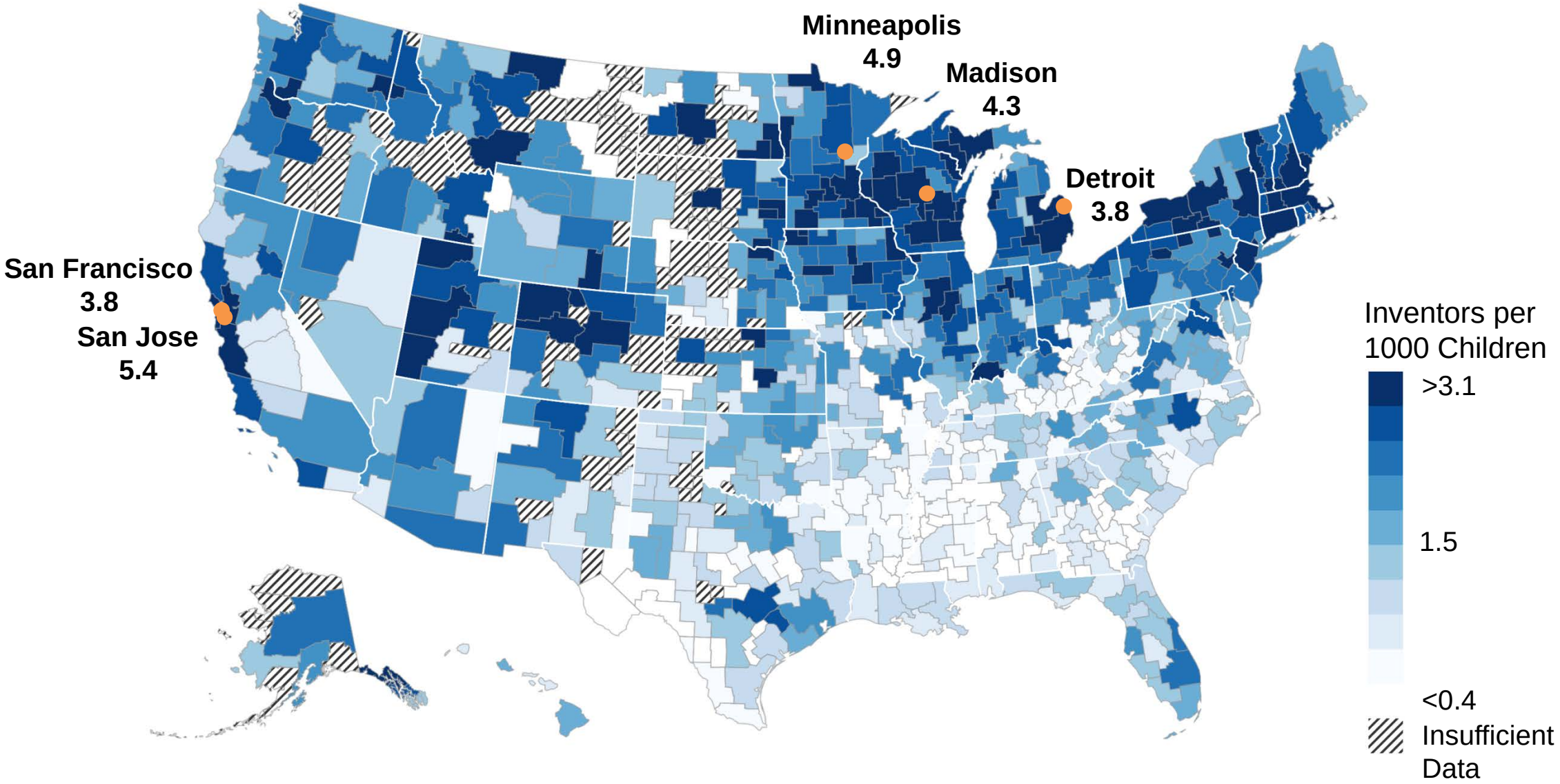


Exposure Effects Across Neighborhoods

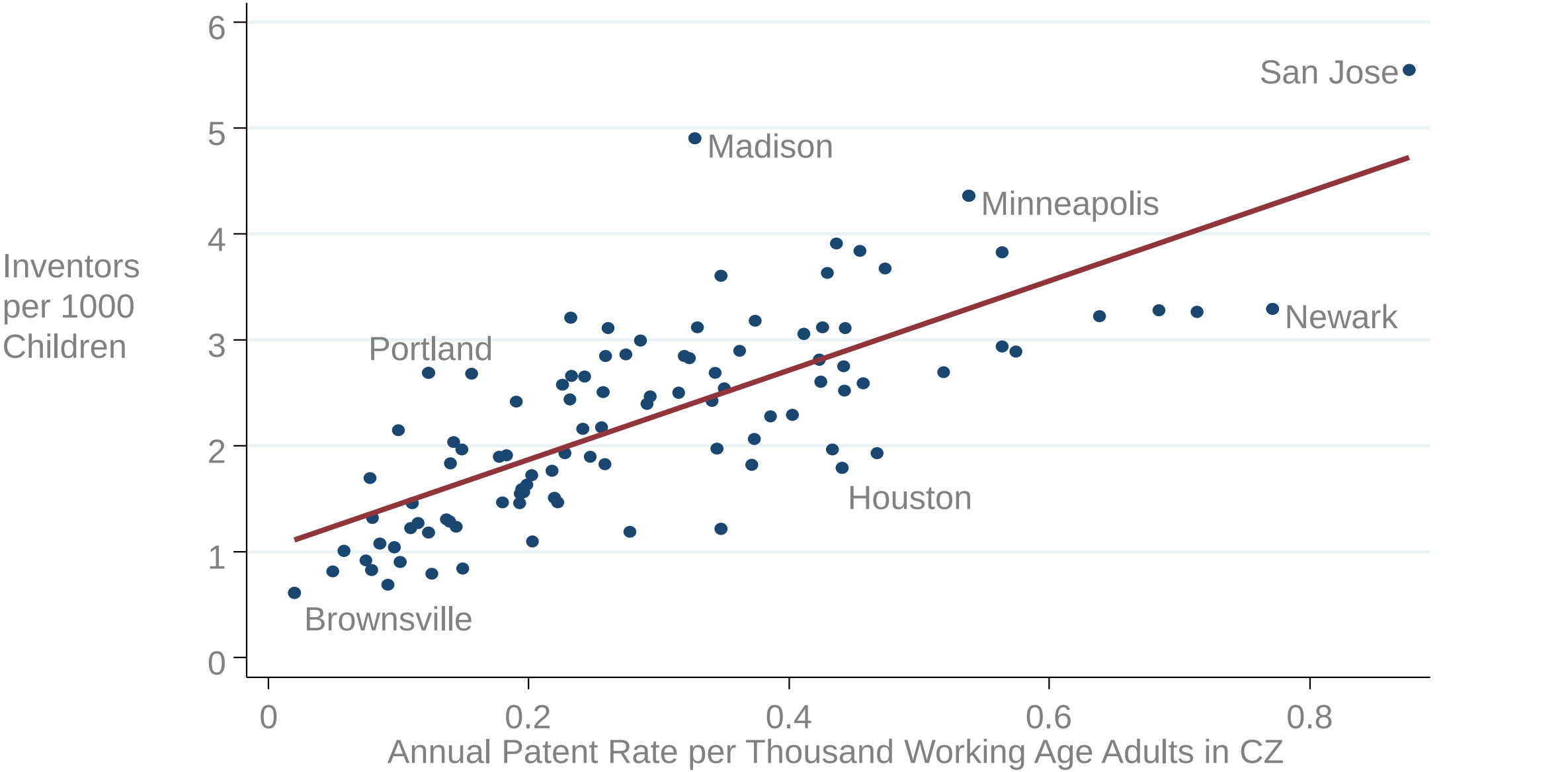
- Parents are not an easily replicable source of exposure to innovation
- Next, analyze a broader source of influence: **neighbors**
- Examine patent rates by commuting zone (aggregation of counties analogous to metro area) **where child grows up**

The Origins of Inventors in America

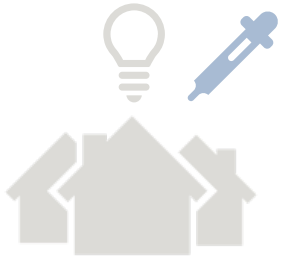
Patent Rates by Childhood Commuting Zone



Patent Rates of Children who Grow up in a CZ vs. Patent Rates of Adults in that CZ



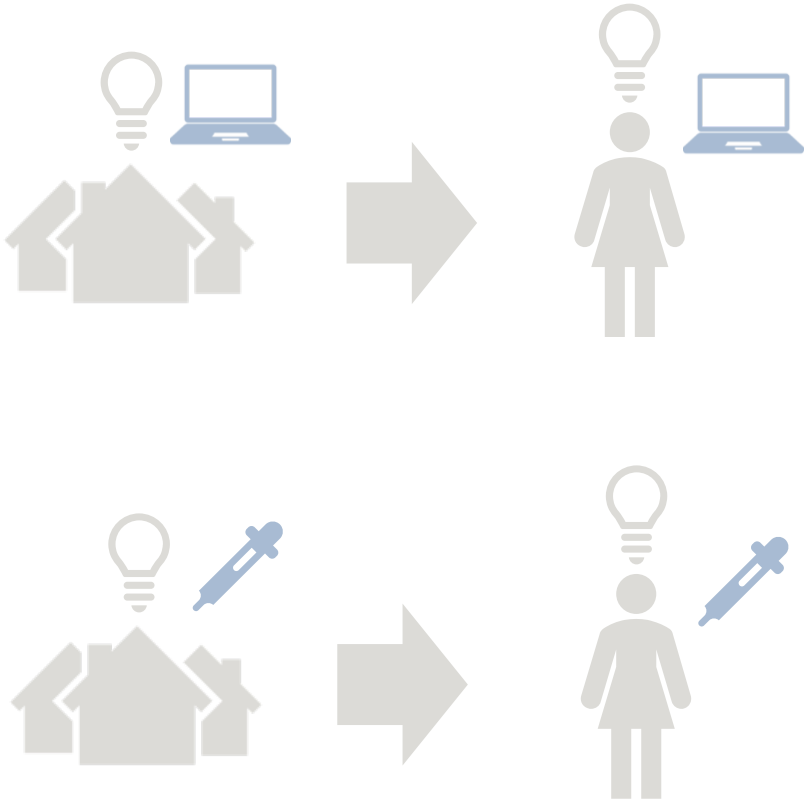
Differences Across Areas are Driven by Exposure Effects



- **Neighborhood exposure effects are technology-class specific**

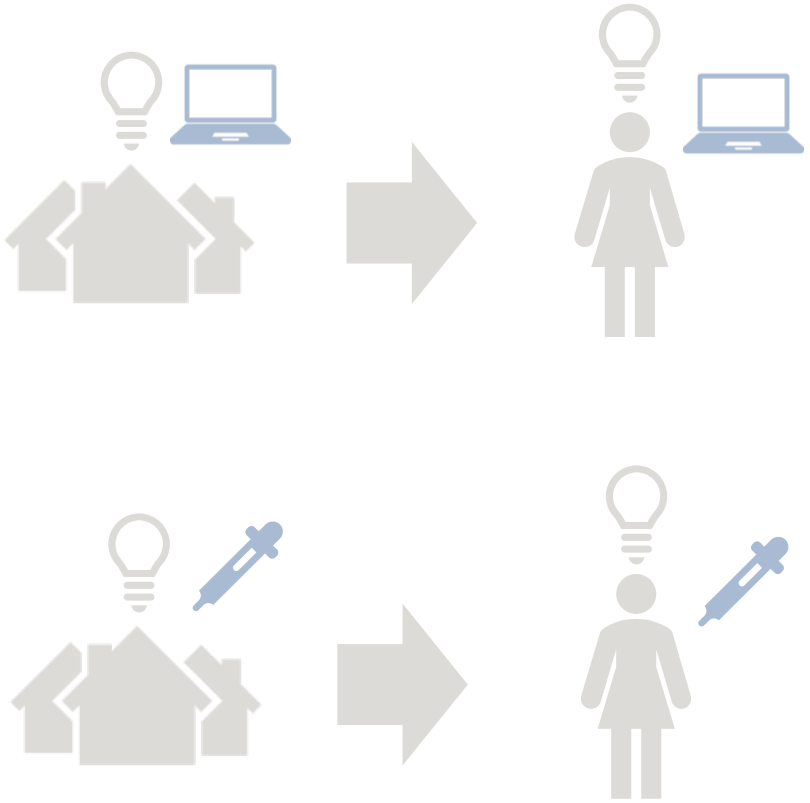
- Consider two people currently living in Boston, one from Silicon Valley and one from Minneapolis (a medical device hub)

Differences Across Areas are Driven by Exposure Effects



- **Neighborhood exposure effects are technology-class specific**
- Consider two people currently living in Boston, one from Silicon Valley and one from Minneapolis (a medical device hub)
  - The one from Silicon Valley is most likely to patent in computers
  - The one from Minneapolis is most likely to patent in medical devices

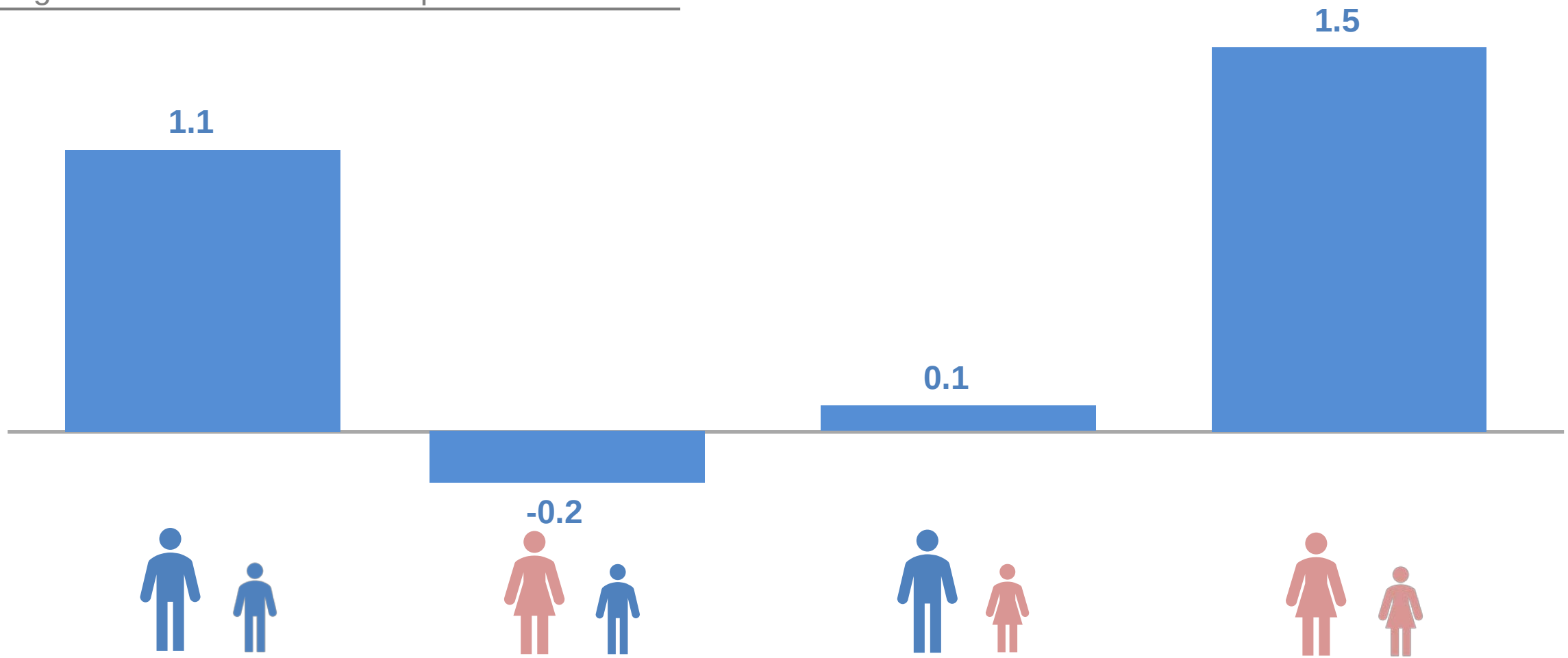
Differences Across Areas are Driven by Exposure Effects



- **Neighborhood exposure effects are technology-class specific**
- Consider two people currently living in Boston, one from Silicon Valley and one from Minneapolis (a medical device hub)
- Moreover, these patterns are **gender-specific**

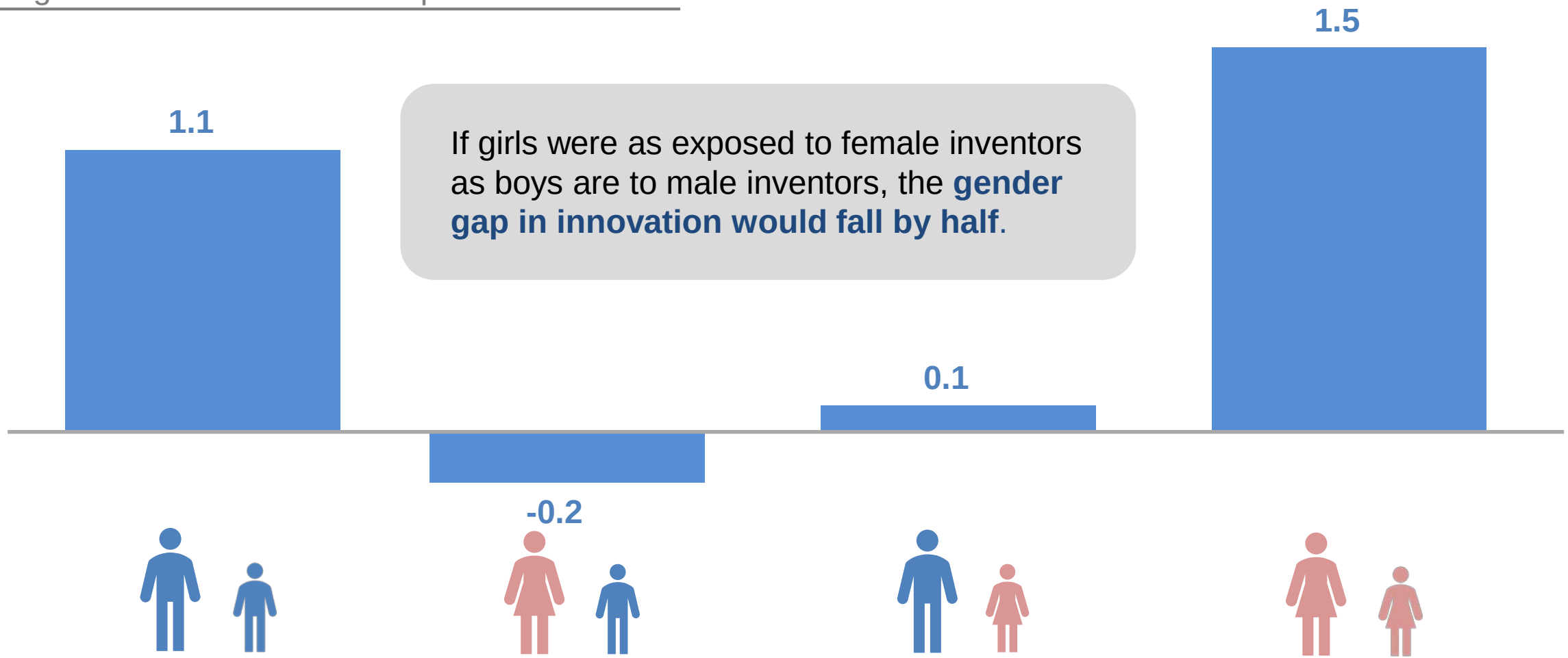
Gender-Specific Innovation Exposure Effects

Change in Number of Inventors per 1000 Children



Gender-Specific Innovation Exposure Effects

Change in Number of Inventors per 1000 Children



Differences Across Areas are Driven by Exposure Effects

- Findings are consistent with other evidence that **neighborhood environment in childhood matters** greatly for long-term success

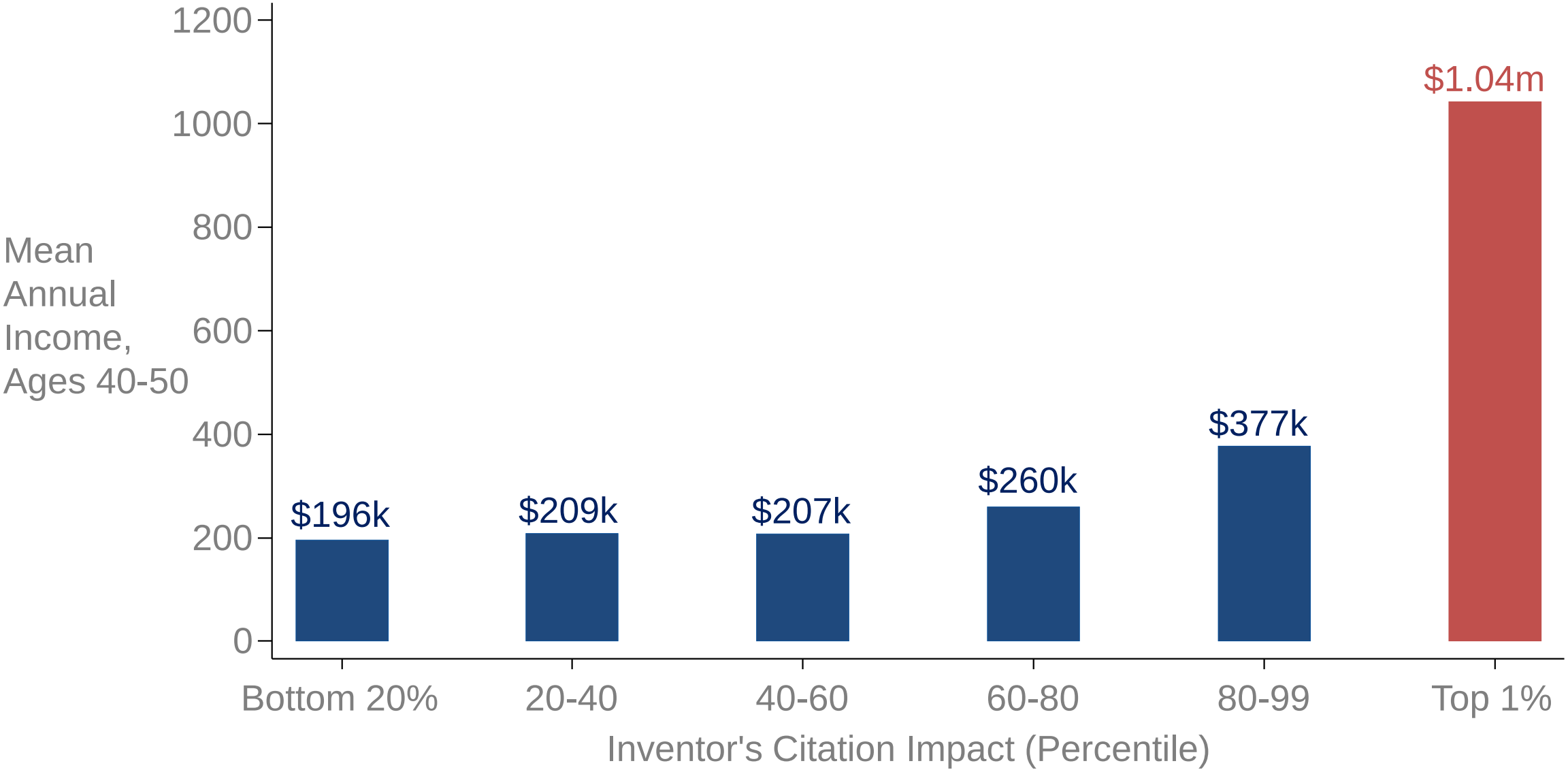
- But differences across areas in production of inventors are **unlikely to be due to broad differences in school quality or resources**

  – Technology-class and gender-specific patterns are **more likely due to direct exposure effects** (mentoring, role models)

Finally, characterize inventors' careers to understand how financial incentives affect individuals' decisions to pursue innovation

Distribution of Inventors' Income Ages 40-50

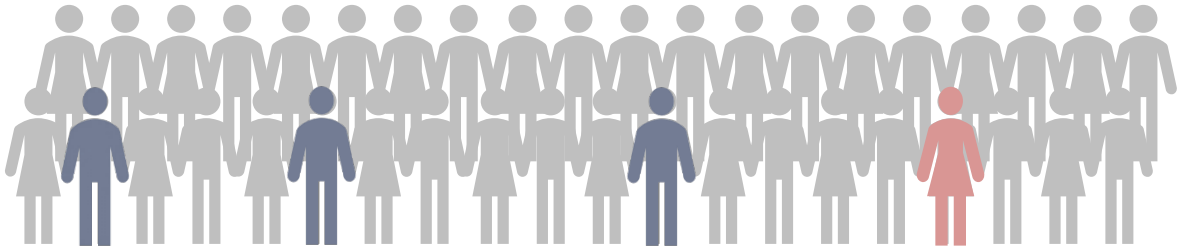
Inventors' Incomes vs. Patent Citations



Changes in financial incentives have limited potential to increase innovation

Changes in financial incentives are **unlikely to influence star inventors**, who earn more than $1 million per year

And they **can affect *only* the relatively few people who have exposure** to innovation



Lost Einsteins: The Importance of Exposure to Innovation

If women, minorities, and children from low-income families invent at the same as high-income white men, the innovation rate in America would **quadruple**

How can we recover the Lost Einsteins?

1

Identify female, minority, and low-income children who excel in math and science at early ages

2

Increase exposure to innovation through tailored mentoring, internships, and expanding opportunity

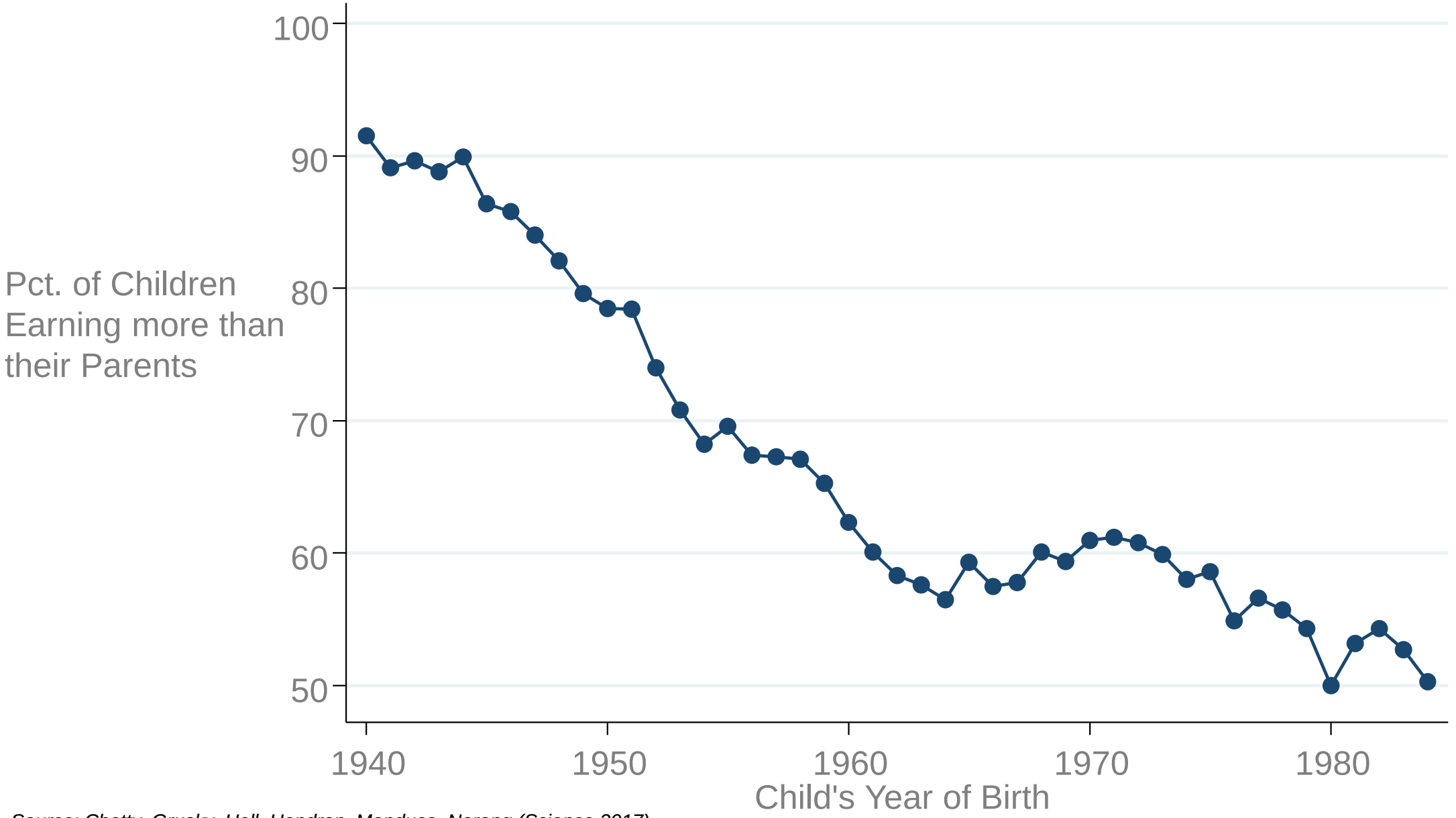
3

Evaluate Impacts of Interventions

Data presented here are available at EOP website

The Fading American Dream

Percent of Children Earning More than Their Parents, by Year of Birth



Source: Chetty, Grusky, Hell, Hendren, Manduca, Narang (Science 2017)