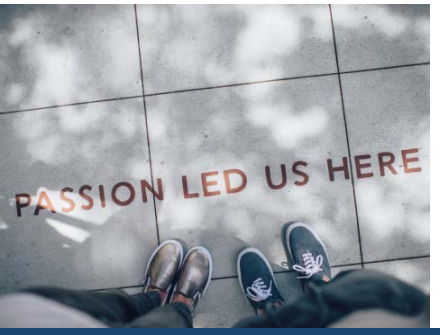


Using Big Data to Solve Economic and Social Problems

Professor Raj Chetty
Head Section Leader: Gregory Bruich, Ph.D.

Spring 2019

HARVARD UNIVERSITY

OPPORTUNITY INSIGHTS

Upward Mobility, Innovation, and Economic Growth

Equality of Opportunity and Economic Growth

- How does increasing equality of opportunity affect economic growth?

- Difficult to measure effects on growth directly

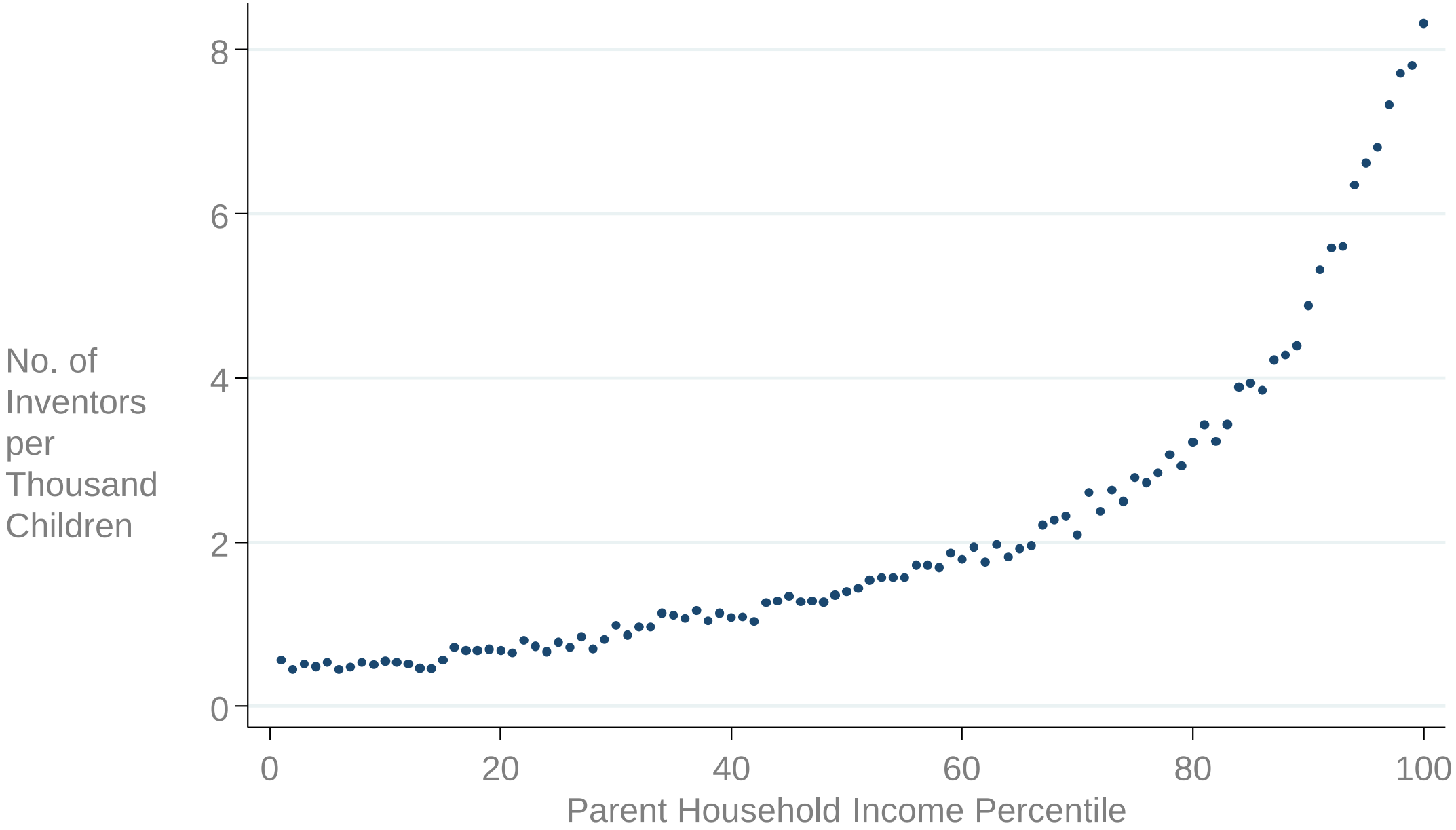
  - Instead, focus here on a channel that many economists think is the key driver of economic growth: innovation

Reference: Bell, Chetty, Jaravel, Petkova, and van Reenen. “Who Becomes an Inventor in America? The Importance of Exposure to Innovation” *QJE* 2018

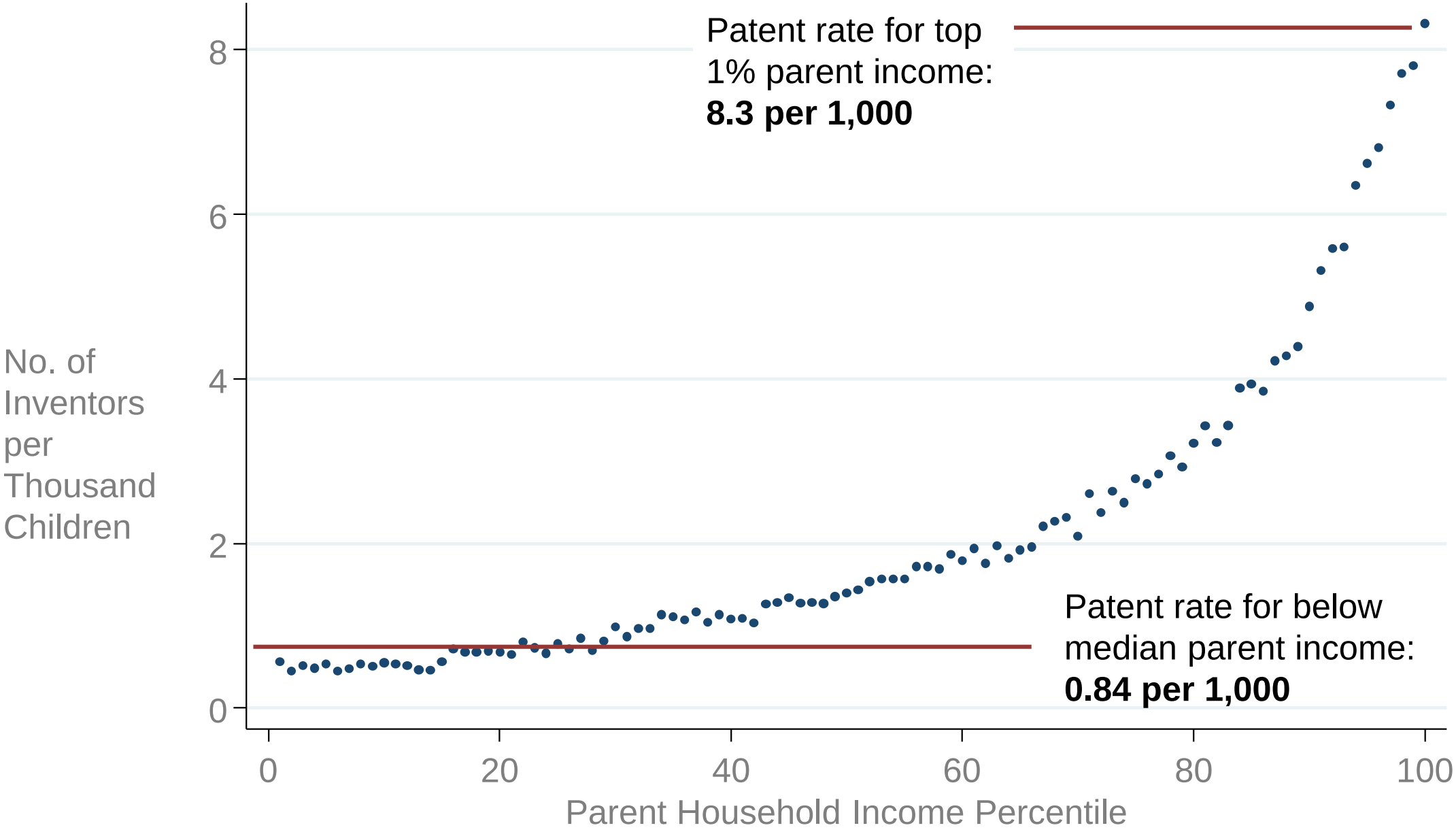
Using Big Data to Study Who Becomes an Inventor in America

Patent Data	1.2 million inventors
Tax Records	Parents, College, Earnings
School District Data	Test scores

Patent Rates vs. Parent Income



Patent Rates vs. Parent Income

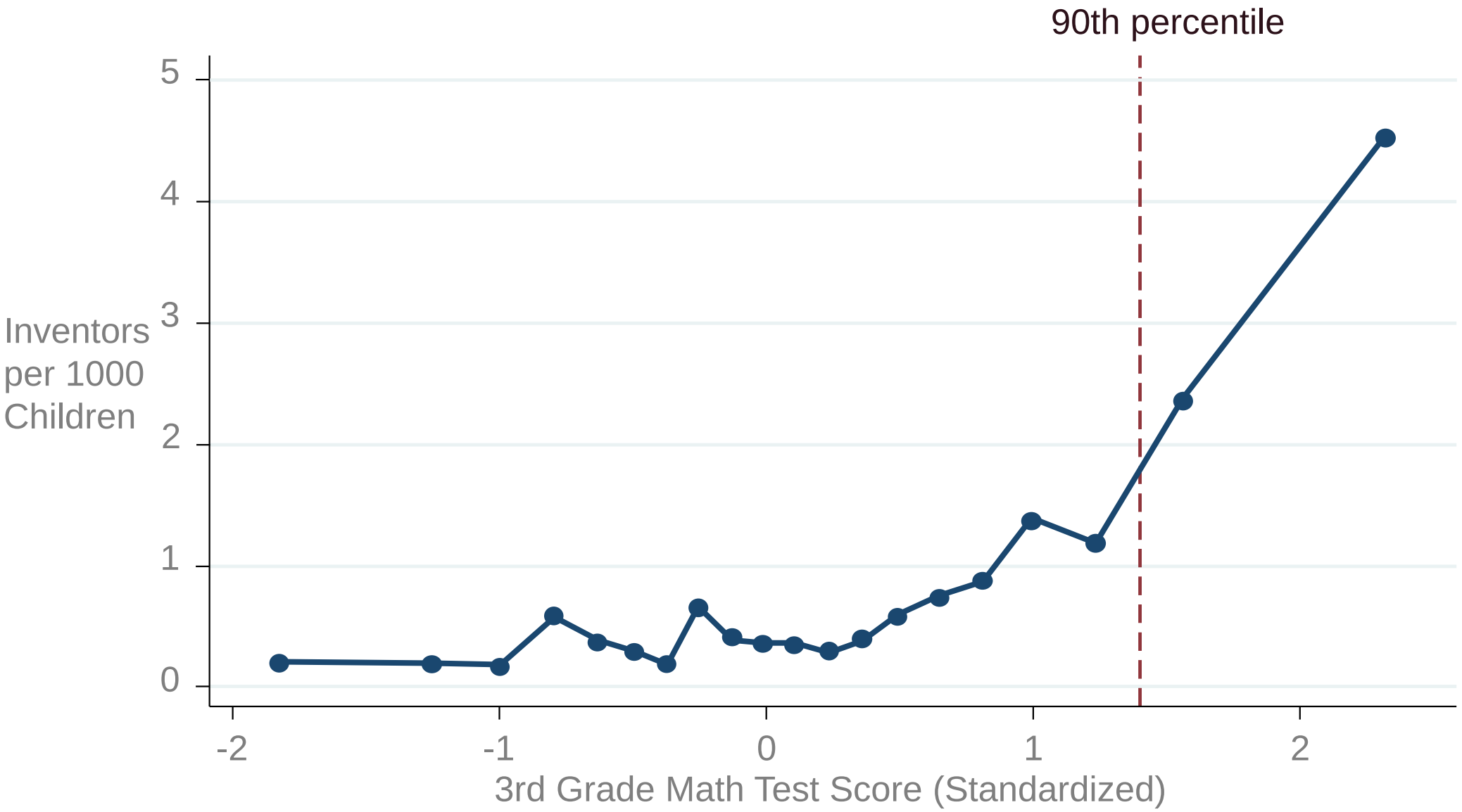


Why do Patent Rates Vary with Parent Income?

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



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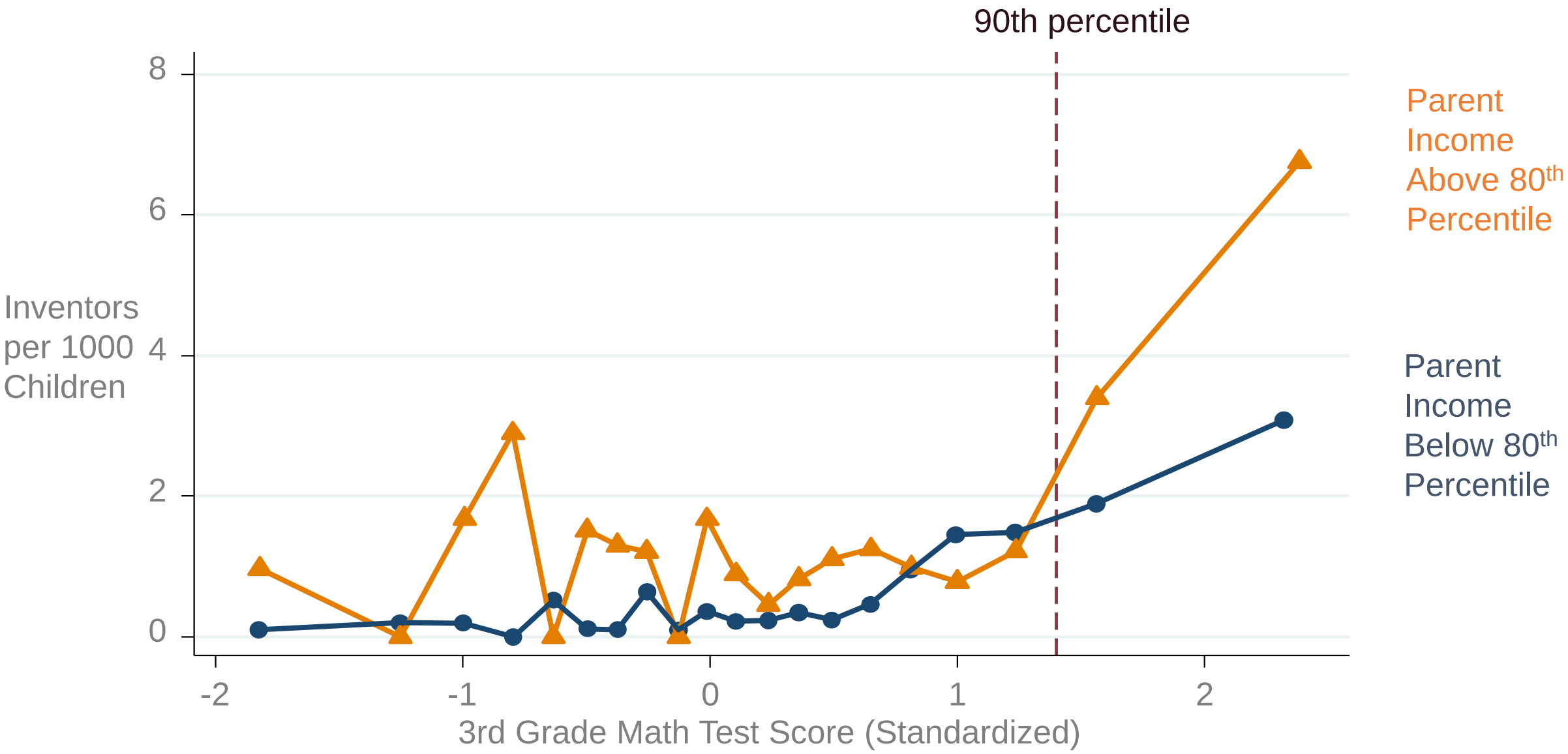

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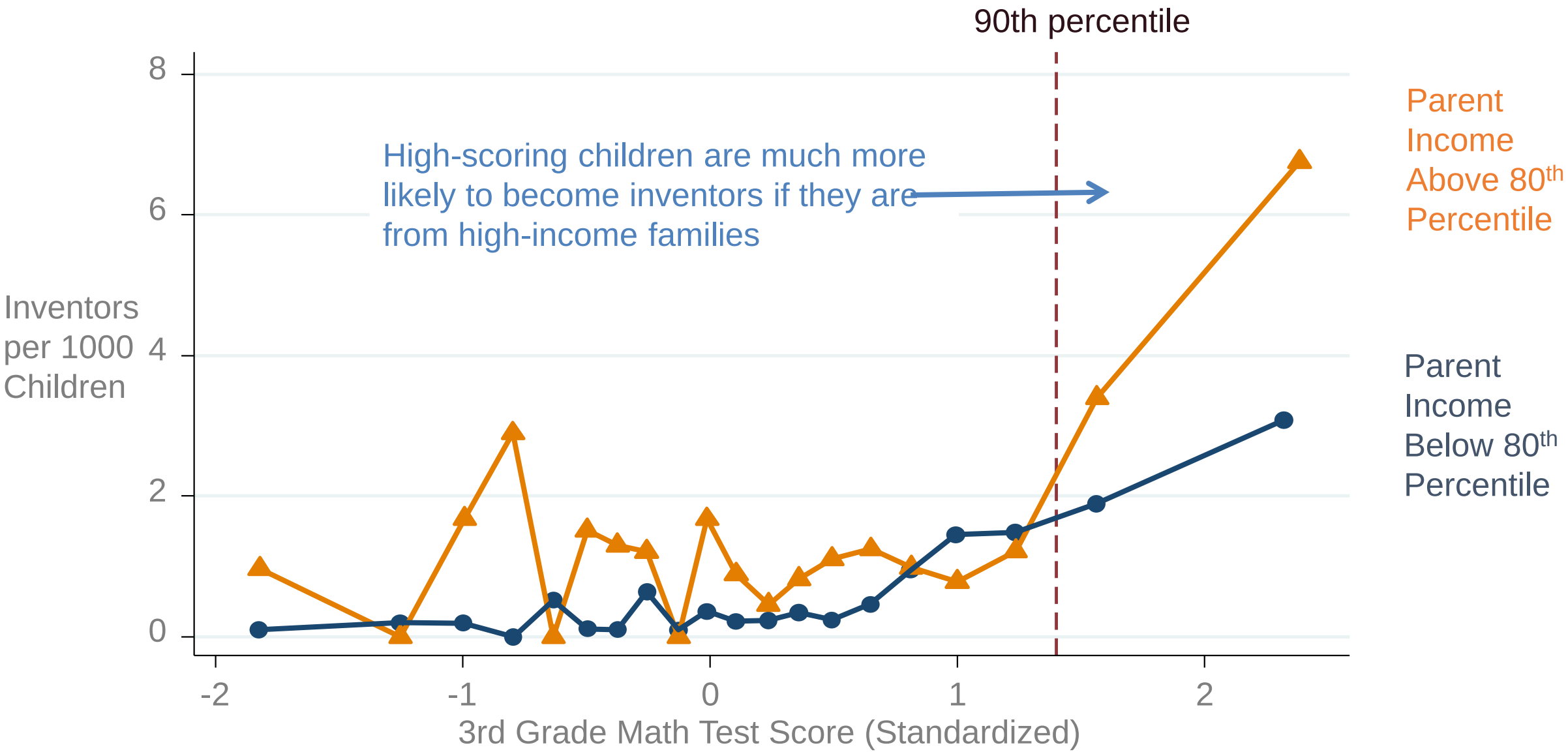
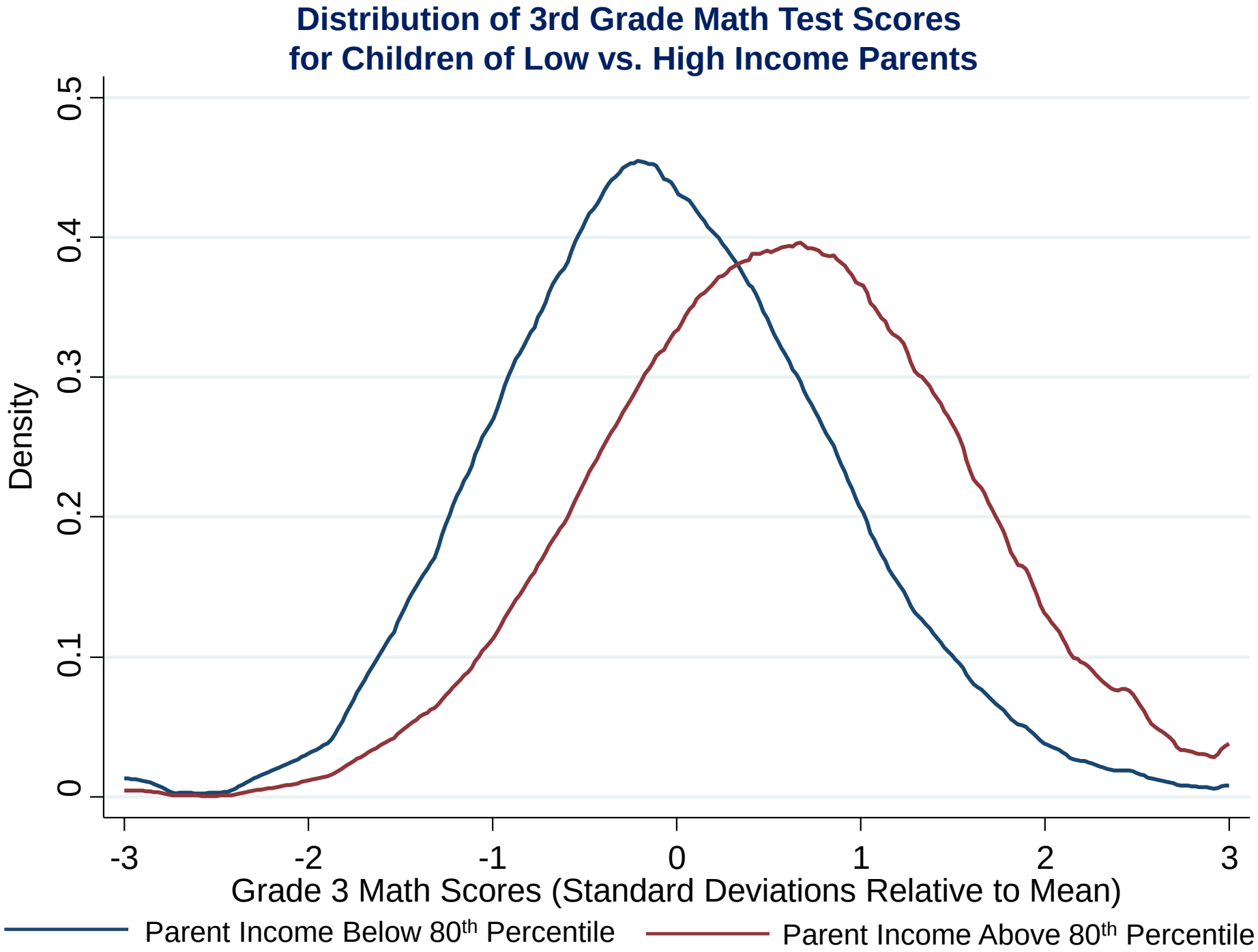



Distribution of 3rd Grade Math Test Scores
for Children of Low vs. High Income Parents
Density
0
0.1
0.2
0.3
0.4
0.5
-3
-2
-1
0
1
2
3
Grade 3 Math Scores (Standard Deviations Relative to Mean)
Parent Income Below 80th Percentile
Parent Income Above 80th Percentile

How Much of the Innovation Gap is Explained by 3rd Grade Test Scores?

- Estimate how much of the gap in innovation by parent income is explained by test scores using **propensity score reweighting**
- Suppose there are only two levels of test scores (letter grades): A and B
  - Out of 300 low-income students: 150 get an A and 150 get a B
  - Out of 300 high-income students, 200 get an A and 100 get a B
- To adjust for test-score differences, count students who got an A twice as much as those who got a B when calculating average patent rate for low-income kids
  - Tells us what patent rate for low-income kids would be if they had the same grades as high-income kids

How Much of the Innovation Gap is Explained by 3rd Grade Test Scores?

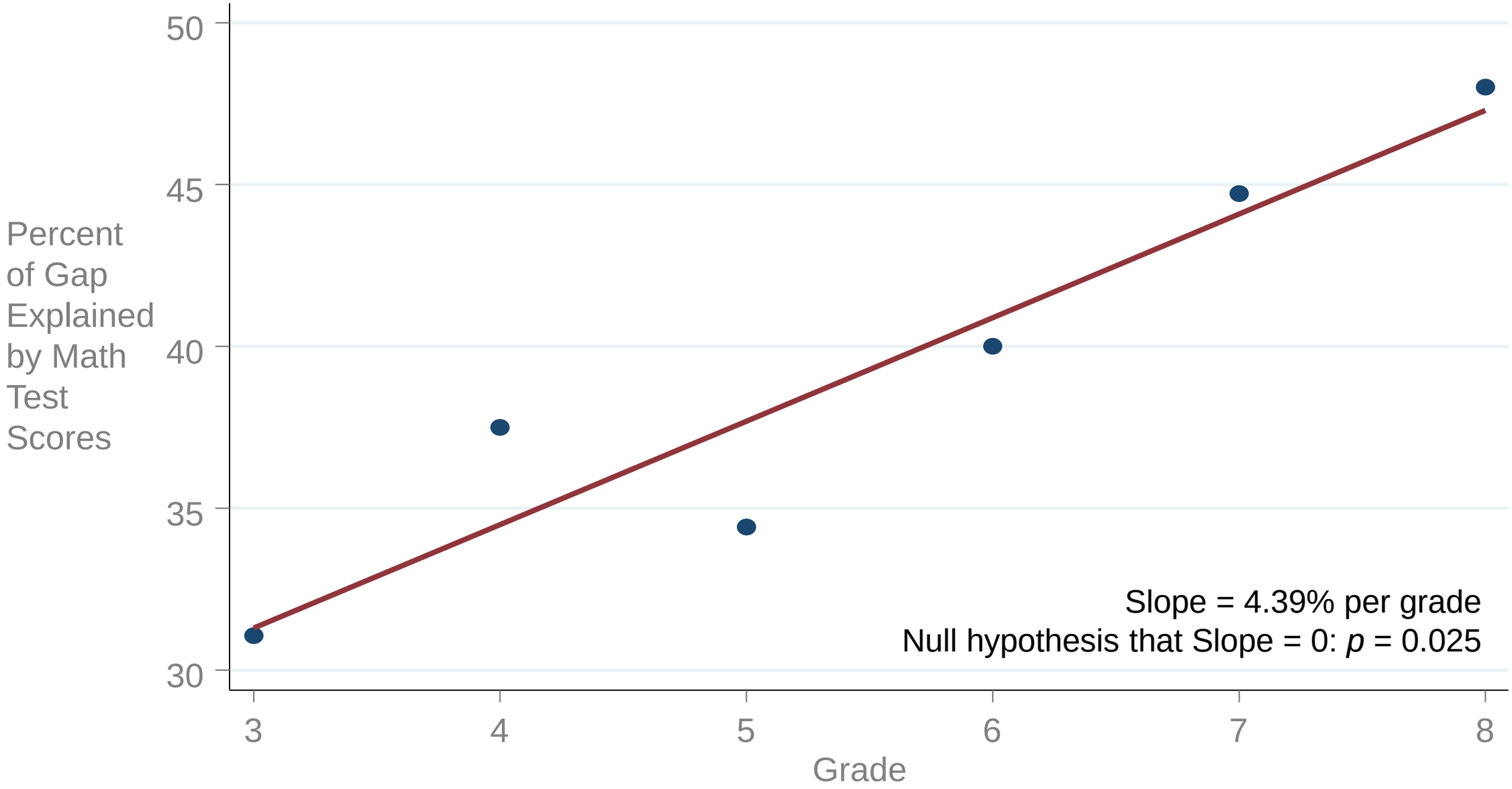
- Result: if low-income children had same test score distribution as high-income (top quintile) children, gap in patent rates would fall by 31%

- That is, differences in 3rd grade test scores account for **31%** of the income gap in innovation

  - Given that there are substantial differences in environment for low vs. high-income kids even by 3rd grade, this suggests that relatively little of gap is explained by ability

- How does this change if we use test scores in later grades?

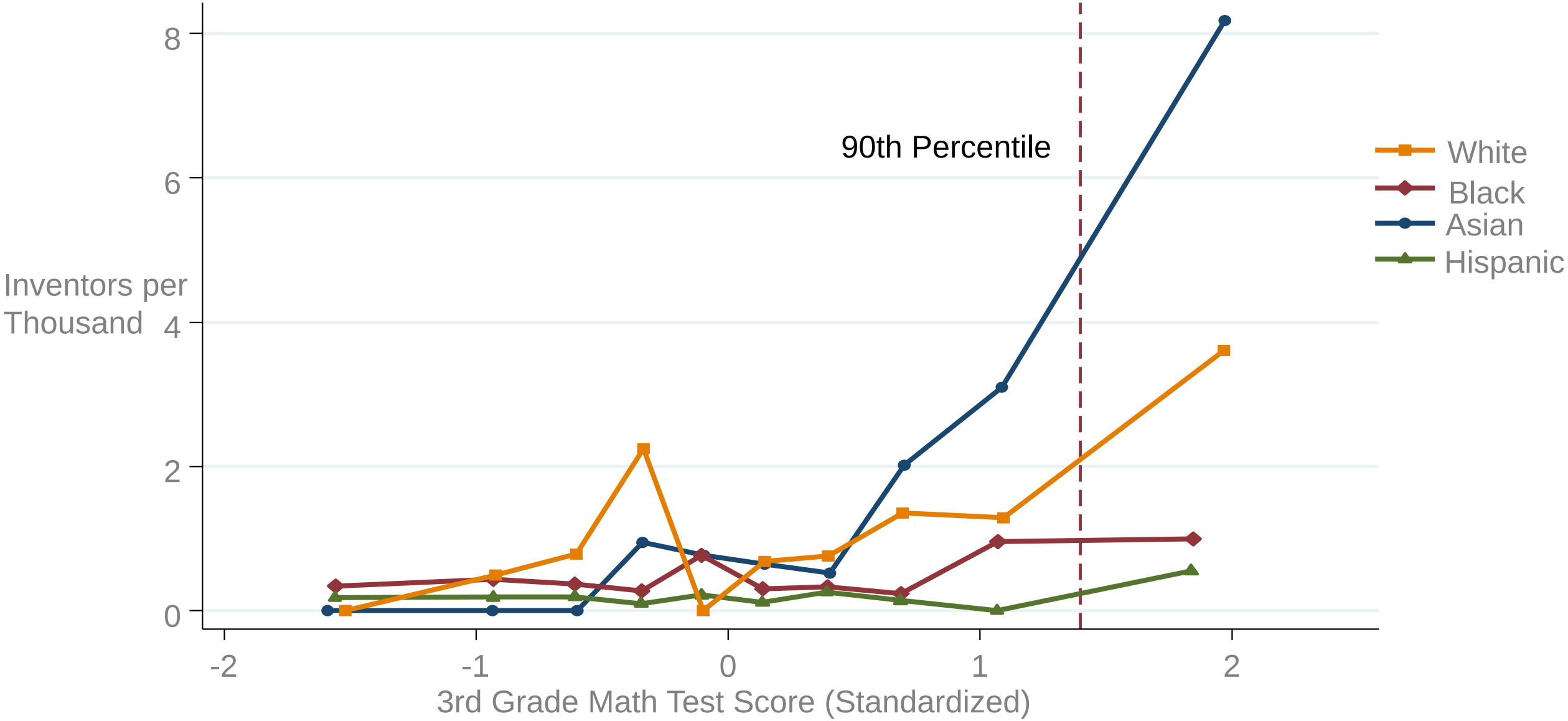
The Gap in Patent Rates Explained by Test Scores Grows as Children Progress Through School



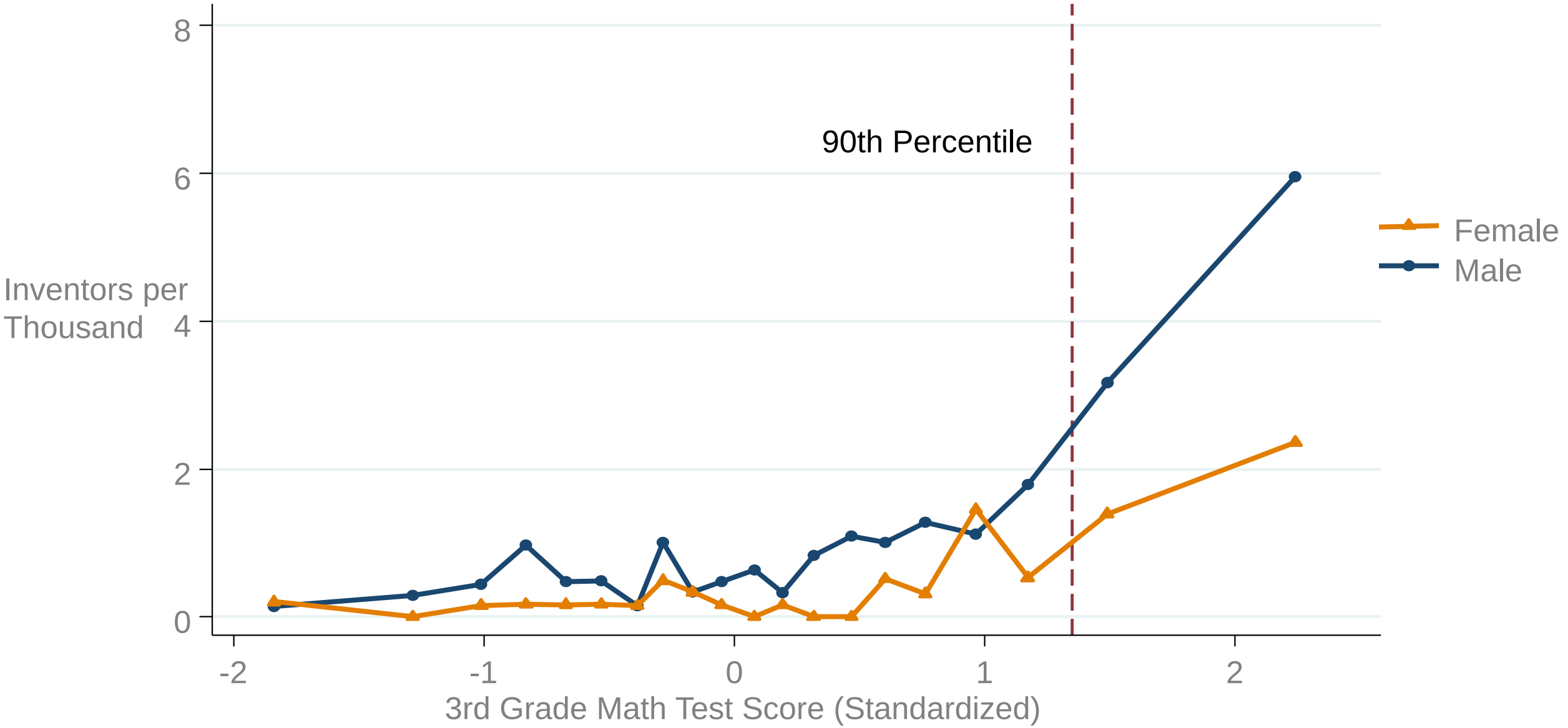
Disparities in Patent Rates by Race and Gender

- We find similar gaps in innovation not just by parental income but also by race/ethnicity and by gender…

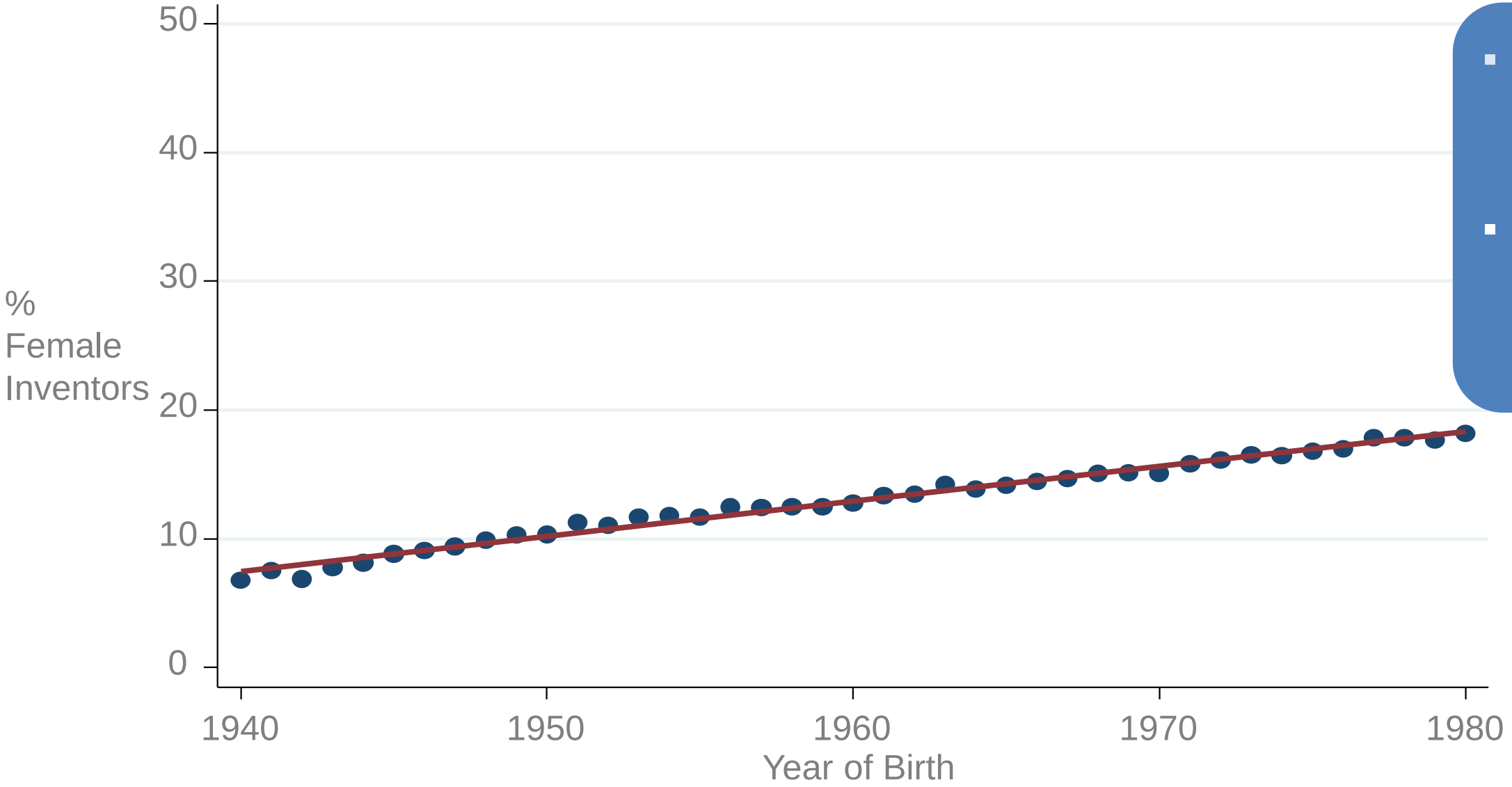
Patent Rates vs. 3rd Grade Test Scores by Race & Ethnicity



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



Percentage of Female Inventors by Year of Birth

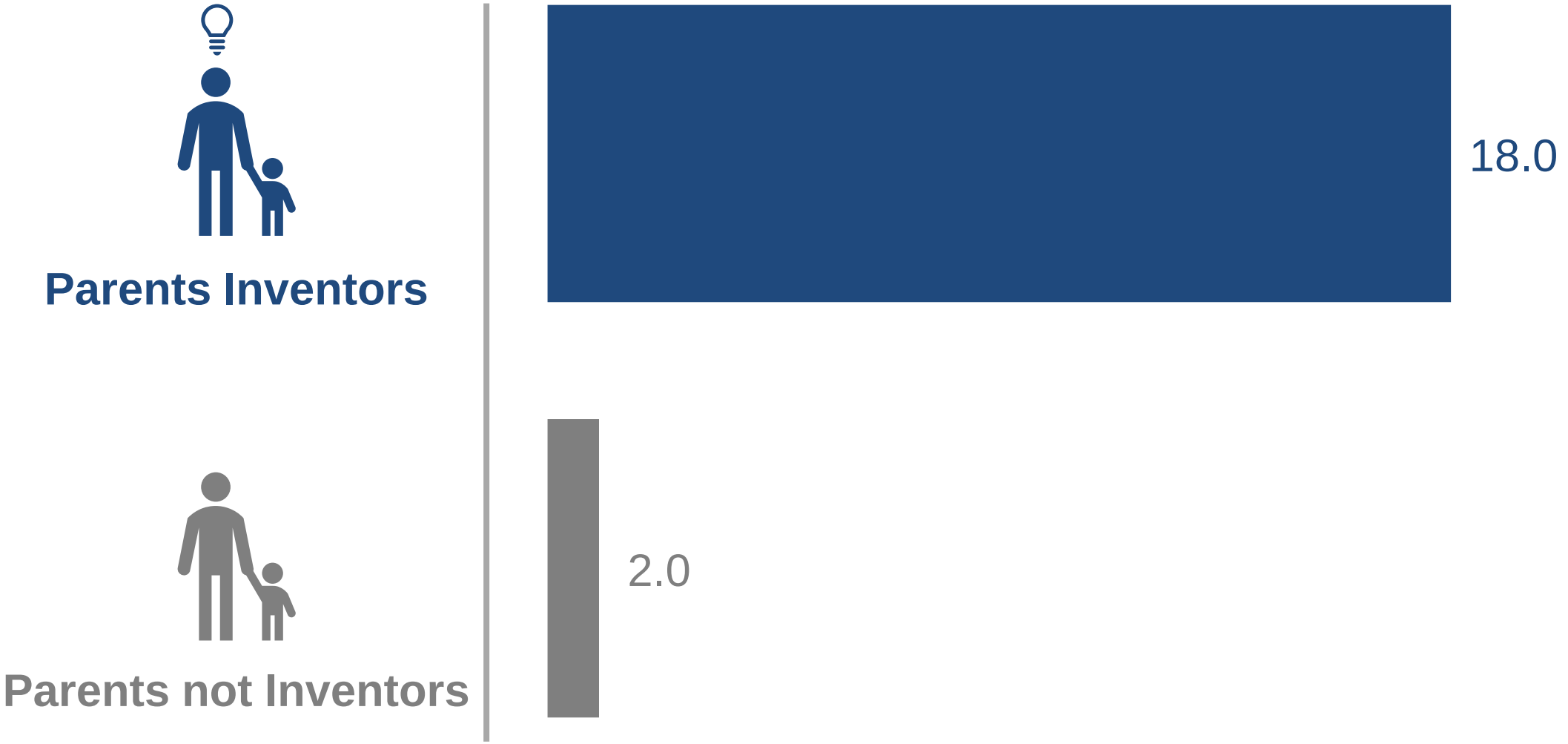


- Average change per year: **0.27%**
- **118 years** to reach 50% female share

Effects of Childhood Environment on Innovation Gap

- Test score data suggest that most of the innovation gap across income, race, and gender is not due to ability differences
  - But not conclusive because tests are imperfect measures of ability
  - And genetic ability may be better manifested in tests at later ages
- Next, turn to study effects of environment directly 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



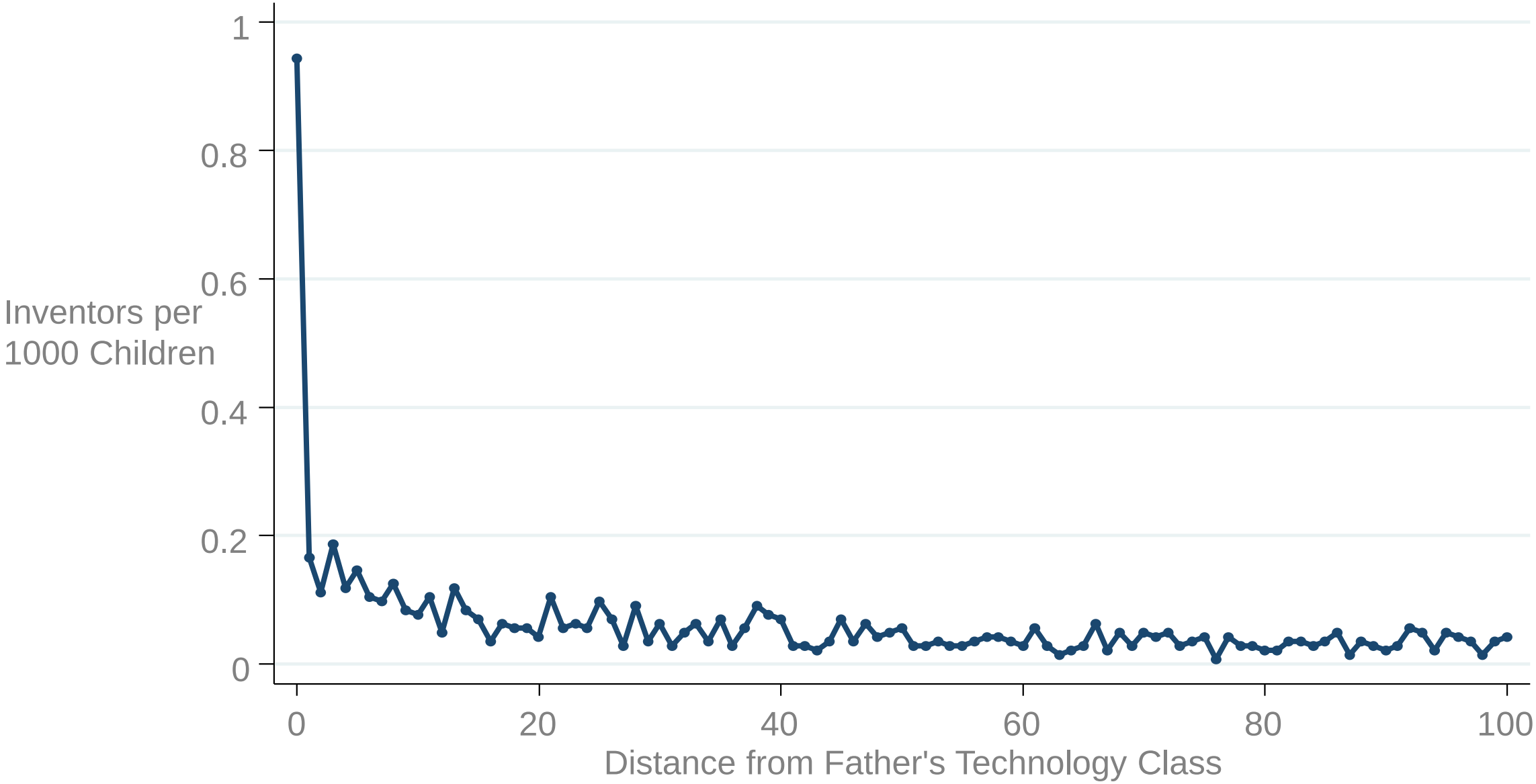
Impacts of Parents: Exposure or Genetics?

- 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

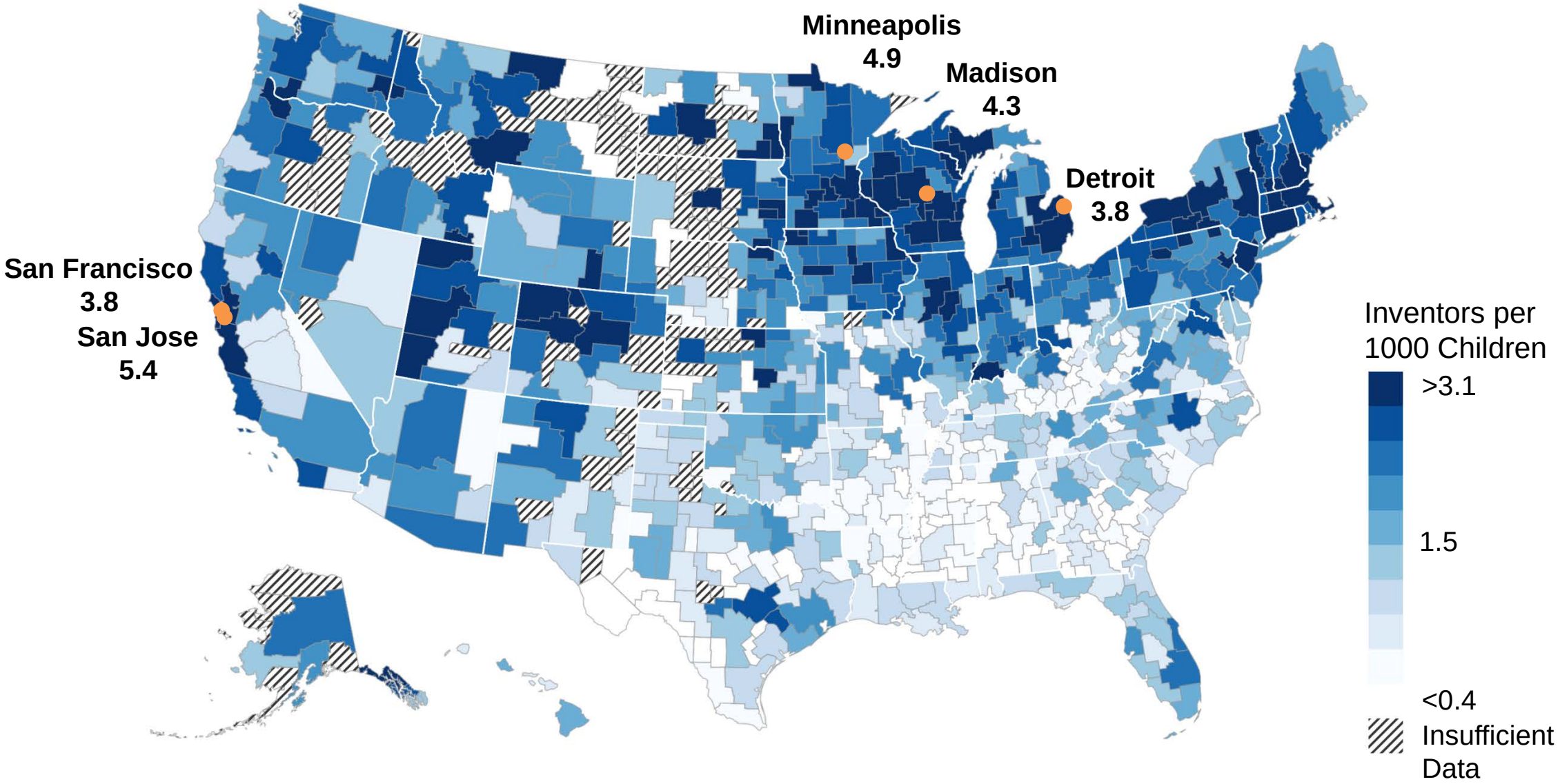


Effects of Neighborhood Environment

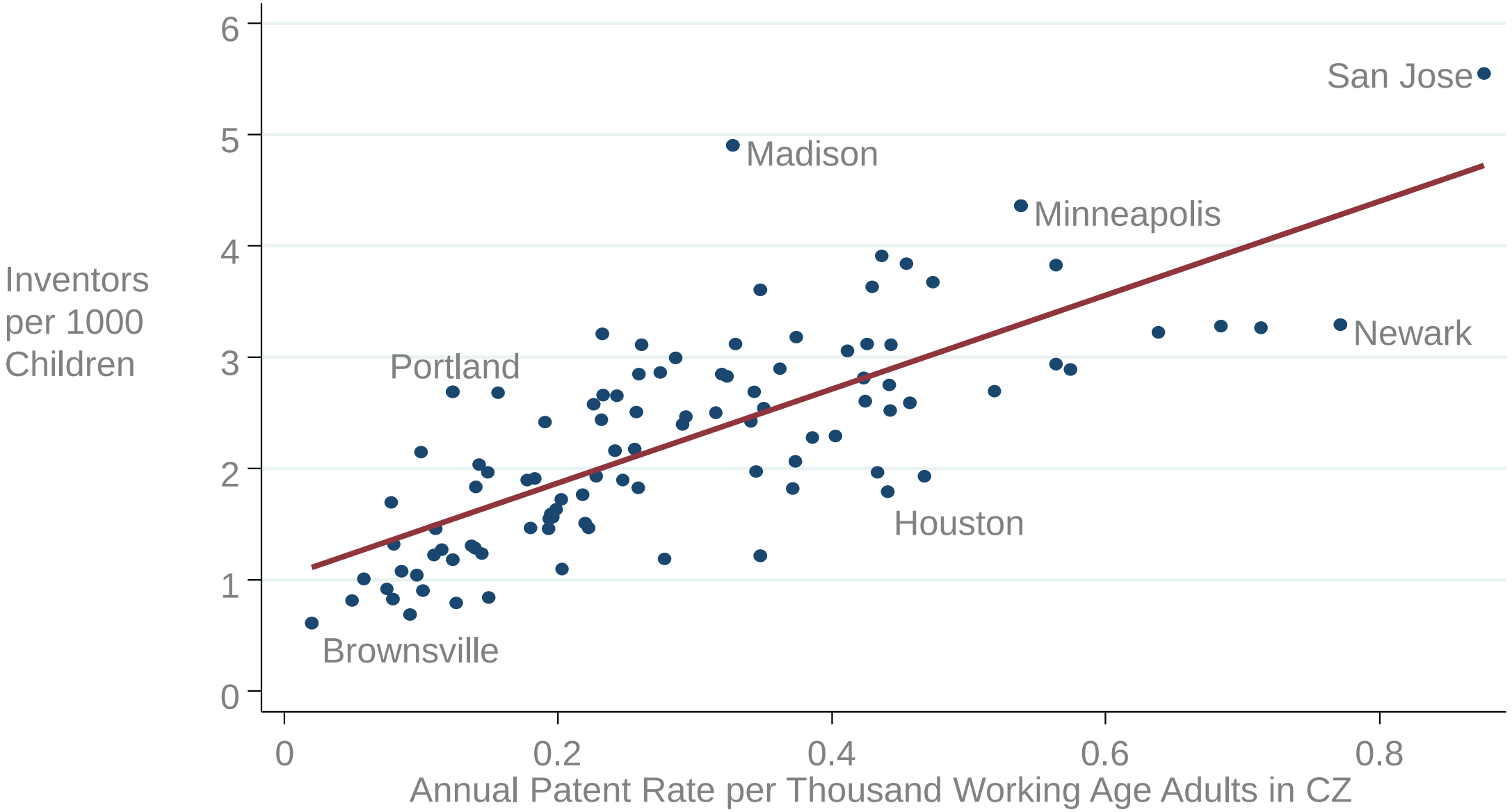
- Parents are not an easily replicable source of exposure to innovation
- Next, analyze a broader source of influence: **neighbors**
- Start by examining the geographic origins of inventors: how patent rates vary depending upon **where child grows up**

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

- How do we know these geographic differences are driven by causal effects of place rather than sorting?
- Again, show that the 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

Mechanisms Underlying Neighborhood Exposure Effects on Innovation

- Evidence on who becomes an inventor is consistent with broader evidence that neighborhood environment in childhood matters greatly for long-term success

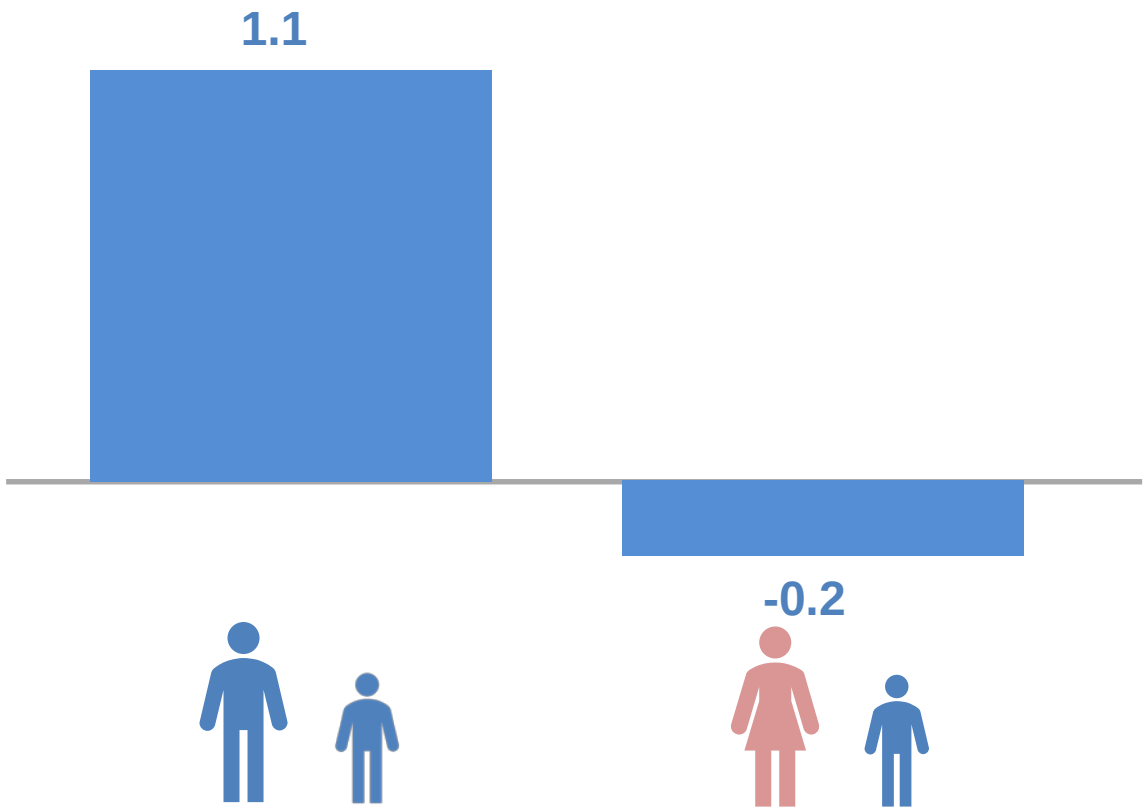
- But differences across areas in production of inventors are unlikely to be due to broad differences in school quality or resources

  - Technology-class patterns are more likely due to **direct exposure effects** such as mentoring or role models

- Further evidence supporting this view come from the fact that the impacts of exposure are **gender-specific**

Gender-Specific Innovation Exposure Effects

Change in Number of Inventors per 1000 Children

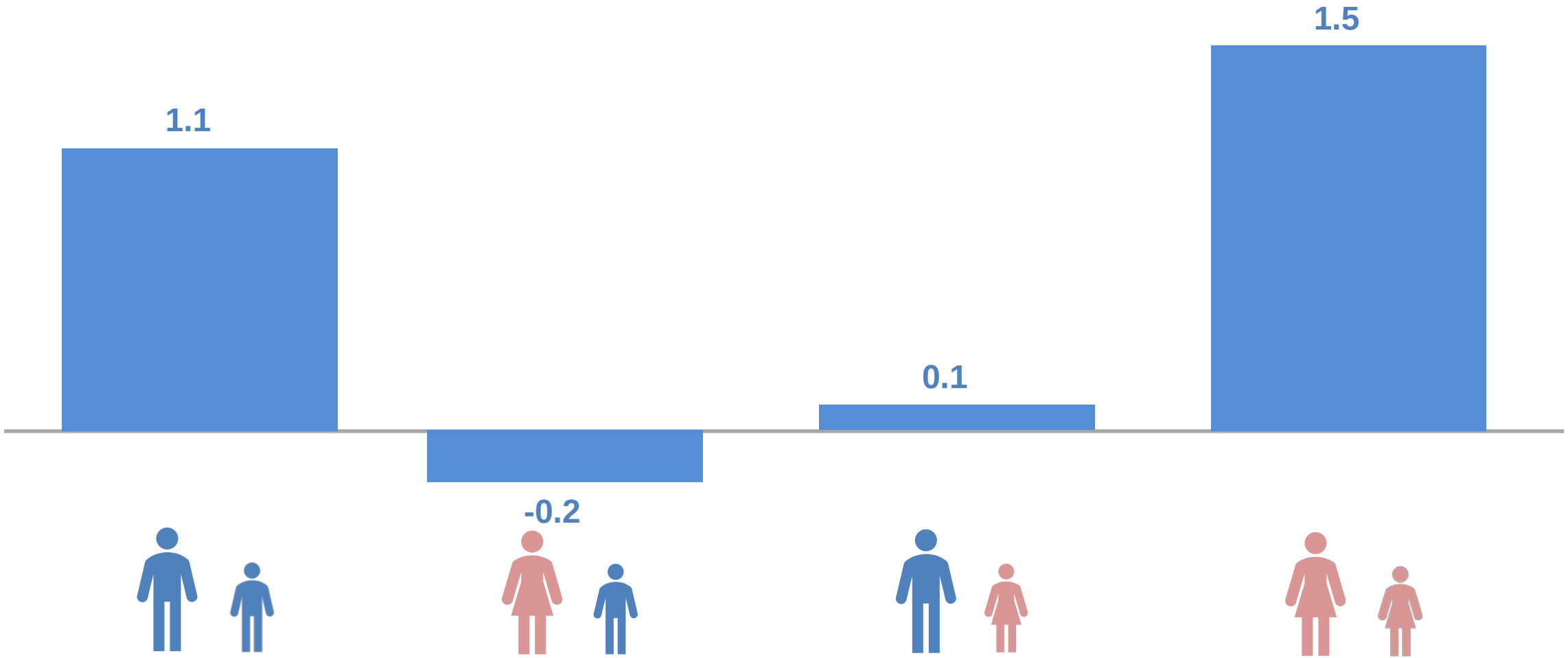


Effect of **Male** Inventors on **Boys**' Innovation Rates

Effect of **Female** Inventors on **Boys**' Innovation Rates

Gender-Specific Innovation Exposure Effects

Change in Number of Inventors per 1000 Children



Effect of **Male** Inventors on **Boys**' Innovation Rates

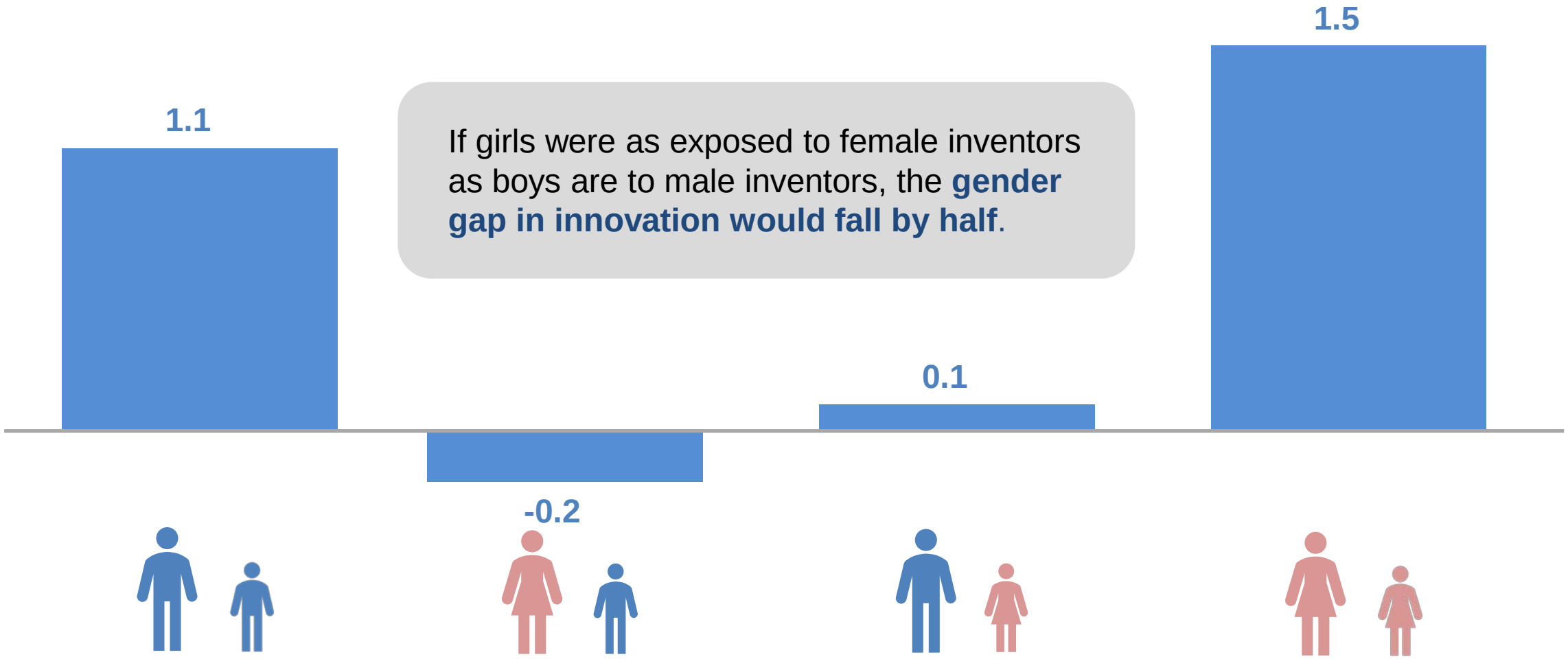
Effect of **Female** Inventors on **Boys**' Innovation Rates

Effect of **Male** Inventors on **Girls**' Innovation Rates

Effect of **Female** Inventors on **Girls**' Innovation Rates

Gender-Specific Innovation Exposure Effects

Change in Number of Inventors per 1000 Children



Development of Gender Stereotypes During Childhood

- Bian et al. (Science 2017): conduct experiments to analyze development of gender stereotypes about intellectual ability

- Present children with pictures of men and women ask them to say who is “really nice” and who is “really smart”

  - At age 5: no difference across boys and girls

  - At age 6: girls much more likely to choose man as “really smart”

- Similarly, girls less likely to choose to play games that are for “children who are really smart” at age 6 than age 5

The Dynamics of Gender Gaps in Innovation

- Evidence suggests that gender gap is self-perpetuating due to social norms and aspirations
  - Under-representation of female scientists in current generation reduces female scientists in next generation
  - Could explain why gender gap is closing at a rate of only 0.27% per year

Lost Einsteins: The Importance of Exposure to Innovation

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

The New York Times

Wanted: 'Lost Einsteins.' Please Apply.

By Steve Lohr Aug. 9, 2018

Silicon Valley has created a model for identifying and nurturing high-potential young companies. Pioneer, an experimental fund, hopes to do much the same thing for high-potential people.

The group, which is being announced on Thursday, plans to use the internet-era tools of global communication and crowdsourcing to solicit and help select promising candidates in a variety of fields, along with evaluations by experts. Its goal is to put more science and less happenstance into the process of talent discovery — and reach more people, wherever they are in the world.

"We're trying to build a kind of search engine for finding great people with talent, ambition and potential," said Daniel Gross, 27, the group's founder.

Pioneer joins a growing number of efforts by foundations, nonprofits and some companies to address the "opportunity gap" in America and worldwide. They all begin with the recognition that skills and talent are far more evenly distributed than opportunity. Talented people suffer — one study called them "lost Einsteins" — but so does the economy from the loss of ideas and wealth they could have produced.

Daniel Gross of Pioneer, center, with Rishi Narang, left, the group's operations manager, and Laura Deming, one of its advisers. Jason Henry for The New York Times

Introducing Pioneer

My name is Daniel Gross. I was born in Jerusalem, Israel. I spent most of my youth feeling like an outsider looking in. High school wasn't interesting. I didn't have many friends. And I didn't have much to be passionate about. Eight years later, I live in Silicon Valley and have built products that have touched billions of people and sold a company along the way. Today, with Pioneer, I want to help make that a possibility for anyone.

Over the past few years, I've been reading research that touches on how ambitious kids fare with a lot of interest.

For example, Raj Chetty found that "children from high-income (top 1%) families are ten times more likely to become inventors than those from below-median income families", despite low-income kids scoring just as well on early childhood tests. Chetty used the term "lost Einsteins", referring to geniuses who would have been able to do great things had they been exposed to opportunities in the right way. We'll never know what they could have achieved.

More recently, two economists showed how International Math Olympiad winners are broadly geographically distributed (talent is everywhere!), but that winners from rich countries have a much higher likelihood of going on to produce significant mathematical work. They observe that there's a lot of "lost knowledge" stemming from the structural impediments facing brilliant young mathematicians in poorer countries.

While Pioneer will provide money to people, it's not about the money. **My hope is that this experiment can broaden people's horizons of how they view themselves.** I met amazing peers and challenged myself to do what I thought I couldn't because of my environment.

PIONEER

A home for the ambitious outsiders of the world

We're building a community of creative young people working on interesting projects around the globe.

New Meet the winners of the second Pioneer Tournament »

JOIN THE FEBRUARY TOURNAMENT

Apply with any project you need help with. After 30 days, the best players will receive $1,000, a round-trip ticket to Silicon Valley, and access to mentorship from some of the world's most successful individuals.

GET STARTED

The deadline passed on February 10th, but we're temporarily accepting late submissions.