Lost Einsteins
Innovation and Opportunity in America

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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.
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

<table>
<thead>
<tr>
<th>Source</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent Data</td>
<td>Patent Data</td>
<td>1.2 million inventors</td>
</tr>
<tr>
<td>Tax Records</td>
<td>Tax Records</td>
<td>Parents, College, Earnings</td>
</tr>
<tr>
<td>School District Data</td>
<td>School District Data</td>
<td>Test scores</td>
</tr>
</tbody>
</table>

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

- **Birth**
- **Childhood**
- **Career**
Patent Rates vs. Parent Income

No. of Inventors per Thousand Children

Parent Household Income Percentile

Diagram showing the relationship between parent household income percentile and the number of inventors per thousand children.
Patent Rates vs. Parent Income

Patent rate for below median parent income: 0.84 per 1,000
Patent Rates vs. Parent Income

- Patent rate for top 1% parent income: 8.3 per 1,000
- Patent rate for below median parent income: 0.84 per 1,000
Lost Einsteins? Highly-Cited Patents vs. Parent Income

Highly-Cited (Top 5%) Inventors per Thousand

Parent Household Income Percentile
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

- Inventors per 1000 Children
- 3rd Grade Math Test Score (Standardized)

90th percentile
High-scoring children are much more likely to become inventors if they are from high-income families.
The Gap in Patent Rates Explained by Test Scores Grows as Children Progress Through School

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percent of Gap Explained by Math Test Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>70</td>
</tr>
</tbody>
</table>
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

- Hispanic
- Black
- White
- Asian

Inventors per Thousand

3rd Grade Math Test Score (Standardized)

90th Percentile
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

Inventors per Thousand

3rd Grade Math Test Score (Standardized)

90th Percentile
Effects of Childhood Environment on Innovation

Birth

Childhood

Career
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

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

Inventors per 1000 Children

Distance from Father's 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

Inventors per 1000 Children

- Minneapolis: 4.9
- Madison: 4.3
- Detroit: 3.8
- San Jose: 5.4
- San Francisco: 3.8

<0.4

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

- Inventors per 1000 Children
- Annual Patent Rate per Thousand Working Age Adults in CZ

Points:
- Brownsville
- Portland
- Houston
- Madison
- Minneapolis
- Newark
- San Jose
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
 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

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

If girls were as exposed to female inventors as boys are to male inventors, the gender gap in innovation would fall by half.
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

- p50 = $114k
- p95 = $497k
- p99 = $1.6m
Inventors’ Incomes vs. Patent Citations

Mean Annual Income, Ages 40-50

Inventor’s Citation Impact (Percentile)

- Bottom 20%: $196k
- 20-40: $209k
- 40-60: $207k
- 60-80: $260k
- 80-99: $377k
- Top 1%: $1.04m
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.
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)